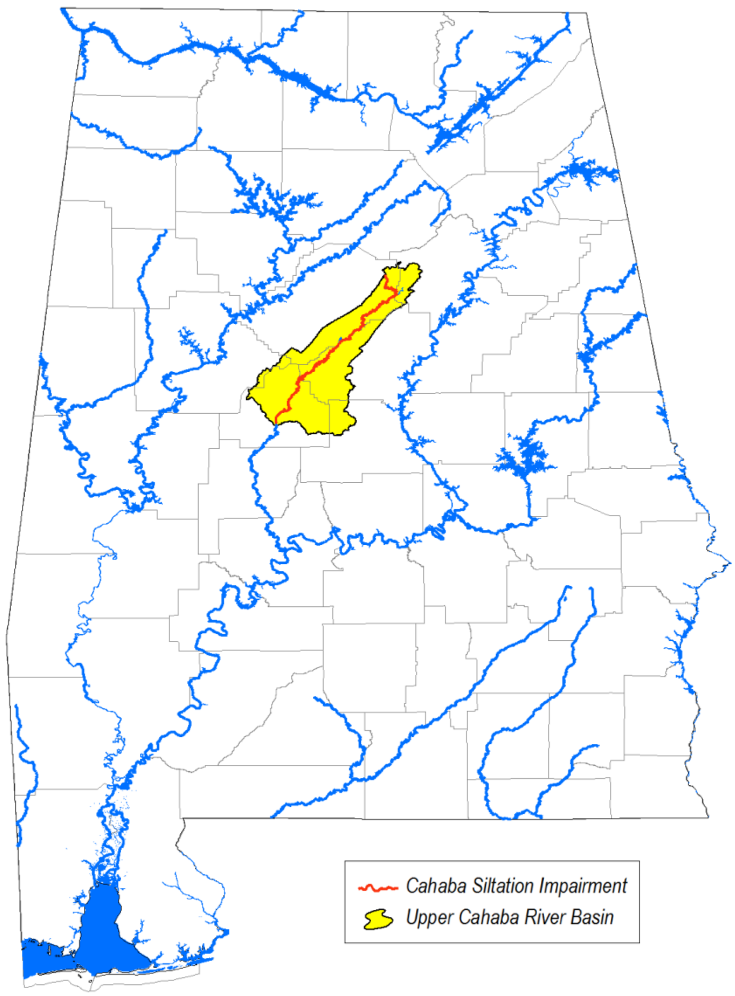
FINAL
TOTAL MAXIMUM DAILY LOAD (TMDL)
for
Siltation and Habitat Alteration
in the
Upper Cahaba River Watershed
(HUC 03150202)

Bibb, Chilton, Jefferson, Shelby, St. Clair and Tuscaloosa Counties, Alabama



Alabama Department of Environmental Management
Water Quality Branch
Water Division

August 2013

ADEM
Alabama Department of Environmental Management

TABLE OF CONTENTS

LIST OF TABLES

LIST OF FIGURES

LIST OF MAPS

LIST OF PICTURES

Useful Acronyms & Abbreviations

A

A&I - Agriculture and Industry Use Classification
AAF - Average Annual Flow
ACES - Alabama Cooperative Extension Service
ADEM - Alabama Department of Environmental Management
ADPH - Alabama Department of Public Health
AEMC - Alabama Environmental Management Commission
AFO - Animal Feeding Operation
AL - Alabama; Aluminum (Metals)
AS - Arsenic
ASWCC - Alabama Soil & Water Conservation Committee
AWIC - Alabama Water Improvement Commission

B

BAT - Best Available Technology
BCT - Best Conventional Pollutant Control Technology
BMP - Best Management Practices
BOD - Biochemical Oxygen Demand
BPJ - Best Professional Judgment

C

CAFO - Confined Animal Feeding Operation
$CBOD_5$ - Five-Day Carbonaceous Biochemical Oxygen Demand
$CBOD_u$ - Ultimate Carbonaceous Biochemical Oxygen Demand
CFR - Code of Federal Regulations
CFS - Cubic Feet per Second
CMP - Coastal Monitoring Program
COD - Chemical Oxygen Demand
COE - Corps of Engineers (US Army)
CPP - Continuing Planning Process
CWA - Clean Water Act
CY - Calendar Year

D

DA - Drainage Area
DEM - Digital Elevation Model
DMR - Discharge Monitoring Report
DNCR - Department of Conservation & Natural Resources
DO - Dissolved Oxygen

E

E. coli - Escherichia Coliform Bacteria
EOP - End of Pipe
EPA - Environmental Protection Agency (US)

F

F&W - Fish and Wildlife Use Classification
FDA - Food and Drug Administration
Fe - Iron
FO - Field Operations
FS - Forestry Service (US)
FY - Fiscal Year

G

GIS - Geographic Information Systems
GOMA - Gulf of Mexico Alliance
GPS - Global Positioning System
GSA - Geological Survey of Alabama

H

HCR - Hydrographic Controlled Release
Hg - Mercury
HUC - Hydrologic Unit Code

I

IBI - Index of Biotic Integrity
IF - Incremental Flow
IWC - Instream Waste Concentration

L

LA - Load Allocation
Lat/Long- Latitude / Longitude
LDC - Load Duration Curve
LIDAR - Light Detection & Ranging
LWF - Limited Warmwater Fishery Use Classification

M

m^3/s - Cubic Meters per Second
MAF - Mean Annual Flow (MAF = AAF)
mg/l - Milligrams per Liter
MGD - Million Gallons per Day
mi - Miles
MOS - Margin of Safety
MS4s - Municipal Separate Storm Sewer Systems
MZ - Mixing Zone

N

N - Nitrogen
NA - Not Applicable
NASS - National Agricultural Statistics Service
$NBOD_x$ - Nitrogenous Biochemical Oxygen Demand
NED - National Elevation Database
NH_3-N - Ammonia Nitrogen
NHD - National Hydrography Database
NLCD - National Land Cover Dataset
NO_3+NO_2-N -Nitrate + Nitrite Nitrogen

N (Cont.)

NOAA - National Oceanic and Atmospheric Administration
NOV - Notice of Violation
NPDES - National Pollutant Discharge Elimination System
NPS - Non-Point Source
NRCS - National Resource Conservation Service
NTUs - Nephelometric Turbidity Units
NWS - National Weather Service

0

OAW – Outstanding Alabama Water Use Classification
OE - Organic Enrichment
ONRW - Outstanding National Resource Water Designation

P

P - Phosphorus
Pb - Lead
PCBs - Polychlorinated Biphenyl
pH - Concentration of Hydrogen Ions Scale
POTW - Publicly Owned Treatment Works
ppb - Parts per Billion
ppm - Parts per Million
ppt - Parts per Trillion
PS - Point Source
PWS - Public Water Supply Use Classification
PWSS - Public Water Supply System

Q

Q - Flow (MGD / m^3/s)
QA/QC - Quality Assurance / Quality Control
QAPP - Quality Assurance Project Plan

R

RGA - Rapid Geomorphic Assessment
RRMP - River and Reservoirs Monitoring Program
RSMP - River and Streams Monitoring Program

S

S - Swimming and Other Whole Body Waters Contact Sports Use Classification
SH - Shellfish Harvesting Use Classification
SID - State Indirect Discharge
SMZ - Streamside Management Zone
SOD - Sediment Oxygen Demand
SOP - Standard Operating Procedure
SPPP - Stormwater Pollution Prevention Plan
SPCC - Spill Prevention Control & Countermeasures (plan)
SRF - State Revolving Fund
SSO - Sanitary Sewer Overflow
STP - Sewage Treatment Facility
SW - Surface Water
SWMP - Stormwater Management Plan
SWQM - Spreadsheet Water Quality Model (AL)
SWQMP - Surface Water Quality Monitoring Program

T

T&E - Threatened and Endangered (species)
TBC - Technology-Based Controls
TBD - To be Determined
TDS - Total Dissolved Solids
TKN - Total Kjeldahl Nitrogen
TMDL - Total Maximum Daily Load
TON - Total Organic Nitrogen
TOT - Time of Travel
Total P - Total Phosphorus
TSS - Total Suspended Solids
TVA - Tennessee Valley Authority

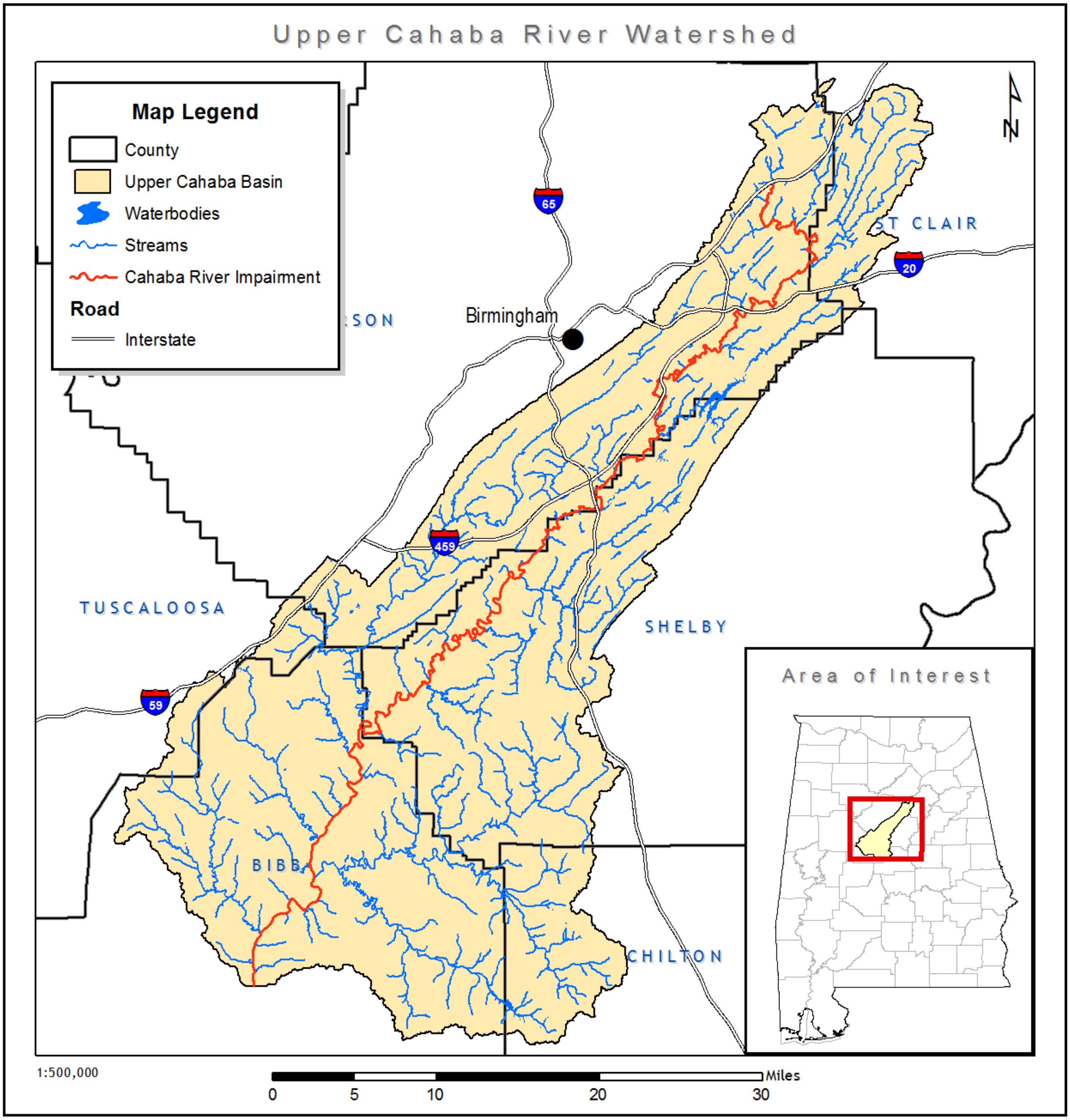
U

UAA - Use Attainability Analysis
UIC - Underground Injection Control
USDA - United Stated Department of Agriculture
USGS - United States Geological Survey
USEPA - United States Environmental Protection Agency
USFWS - United States Fish & Wildlife Services
UV - Ultraviolet Radiation

W

WCS - Watershed Characterization System
WET - Whole Effluent Toxicity
WLA - Wasteload Allocation
WMA - Wildlife Management Area
WPCP - Wastewater Pollution Control Plant
WQB - Water Quality Branch
WRDB - Water Resources Database
WTP - Water Treatment Plant
WWTF - Wastewater Treatment Facility
WWTP - Wastewater Treatment Plant
WY - Water Year

Map 1-1: Upper Cahaba River Watershed Map



Upper Cahaba River Watershed TMDL

For Siltation (Habitat Alteration)

1.0 EXECUTIVE SUMMARY

With headwaters originating just north and east of the City of Birmingham, the Cahaba River is recognized as the longest free-flowing river in the State of Alabama and boasts unique ecosystems rich in biological diversity. The Cahaba River Basin is a sub-basin of the Alabama River Basin, which eventually drains into the Mobile River, one of the largest primary stream drainage basins in North America. The Cahaba River spans nearly 194 miles through central Alabama and has a contributing drainage area of 1,824 square miles. Its headwaters are located within the Alabama Ridge and Valley physiographic region and eventually flow southwest into the East Gulf Coastal Plain. This is the only point within the 48 contiguous states where the geological landscape transitions abruptly from mountainous regions directly to a coastal plain. This accounts for the distinctive landscape and aesthetic beauty within the watershed, as well as its renowned biodiversity. The upper portion of the watershed, which drains a large part of Birmingham and surrounding suburbs, is a highly developed urban area which results in an effluent-dominated stream network.

The following report presents Total Maximum Daily Loads (TMDLs) of siltation for eight waterbody segments found on *Alabama's 2012 Section §303(d) List of Impaired Waterbodies* within the Cahaba River Watershed. Only one of the river segments (from Shades Creek to Buck Creek) was listed on the 1996 list. The original listing by the Alabama Department of Environmental Management (ADEM) in 1996 was for nutrients. In 1999, the U.S. Environmental Protection Agency (USEPA) added other parameters after reviewing ADEM's 1998 §303(d) list. In 2006, a nutrient TMDL was completed for the Cahaba River. This TMDL, however, specifically addresses the Upper Cahaba River Watershed siltation impairment, so no other pollutant parameters will be considered in this analysis.

1.1 TMDL at a Glance

- ***Hydrologic Unit Code(s):*** AL03150202-XXXX-XXX (See ***Table 2-1***)
- ***Counties:*** Bibb, Chilton, Jefferson, Shelby, St. Clair, Tuscaloosa
- ***Size of Watershed:*** 1027 mi² (2,658 km² -or- 656,882 acres)
- ***Listing Date:*** 1998
- ***Cause of Impairment:*** Siltation (Habitat Alteration)
- ***WQ Constituents of Concern:*** Total Suspended Solids (TSS), Suspended Sediment Concentration (SSC)
- ***Designated Uses Affected:*** F&W, PWS, OAW, S (See ***Table 2-1***)
- ***Major Source(s):*** Urban runoff, storm sewers, land development
- ***WQ Target:*** 220.3 lbs/ac/yr (70.5 tons/mi^2/yr –or- 24.7 /km²/yr)
- ***Required Reduction:*** 48 % (See ***Table 1-1***)
- ***Margin of Safety:*** Implicit

Past field studies demonstrate that, although fish and macroinvertebrate communities are healthy at some locations within the Cahaba River Watershed, siltation is a contributing factor to the reduced biological health at other locations. The USEPA Region 4 final report (USEPA Region 4, 2004) summarized observed habitat degradation due to nutrient over-enrichment and siltation in all eight segments presented in ***Table 2-1***. The effects of nutrient enrichment are compounded due to impacts from siltation as a result of disturbances in surrounding land uses and urban hydrology (Shephard et al, 1994b). The available chemical, physical, and biological monitoring data collected within the Cahaba River supports both the historical and present day impacts to the Cahaba River with respect to siltation and habitat alteration. Therefore, ADEM warrants that the subject TMDL is necessary to bring the Cahaba River into compliance with applicable water quality standards. This includes ensuring that water quality criteria are achieved, fully supporting the designated uses of the river, and improving/preserving healthy habitat suitable for indigenous aquatic species.

For siltation (habitat alteration), the water quality criteria are narrative and do not change depending upon the use classification of the waterbody. The use classifications for the impaired segments in the Upper Cahaba River Watershed are shown in ***Table 2-1*** and ***Map 2-2***. Excessive sedimentation has been one of the primary factors in habitat degradation within the Cahaba River Watershed. (USEPA Region 4, 2003a; O'Neil, 2002, Hartfield 2002, USFWS 2000, Shepard et al. 1994).

In general, the methodology utilized in developing this TMDL closely resembles the Shades Creek Siltation TMDL completed in 2004 by USEPA Region 4. The siltation target was based on extensive studies performed by the National Sediment Laboratory which established reference yields and concentrations for each ecoregion in USEPA Region 4. This work involved gathering all of the long-term historical suspended-sediment data and peak flow data from the United States Geological Survey (USGS) in order to develop suspended-sediment transport relationships for streams within the same ecoregion. From these studies, a TMDL target of 24.7 Tonnes/km^2/yr (70.5 tons/mi^2/yr) was established for Ecoregion 67. This value represents the median value of average annual suspended-sediment loadings for stable reference sites in Ecoregion 67 and corresponds to a concentration of 45.1 mg/l.

To develop the siltation TMDL, a sediment loading curve approach was used to represent the existing sediment yield in the Upper Cahaba River Watershed. In order to be most protective of water quality, the highest observed sediment yield of 47.4 tonnes/km^2/yr (133.9 tons/mi^2/yr) was used in calculating the percent reduction. ***Table 1-1*** below provides a summary of the TMDL.

Table 1-1: Siltation TMDL Summary for the Cahaba River[c]

WLA		LA (lbs/acre/yr)	MOS	TMDL (lbs/acre/yr)	% Reduction
TSS Concentration[a] (mg/l)	TSS Yield[b] (lbs/acre/yr)				
45	220.3	220.3	Implicit	220.3	48%

a. Existing and future NPDES permits that utilize numeric limits for TSS shall not exceed 45 mg/l applied as a monthly average.

b. The yield value of 220.3 lbs/acre/yr corresponds to 70.5 tons/mi^2/yr or 24.7 tonnes/km^2/yr.

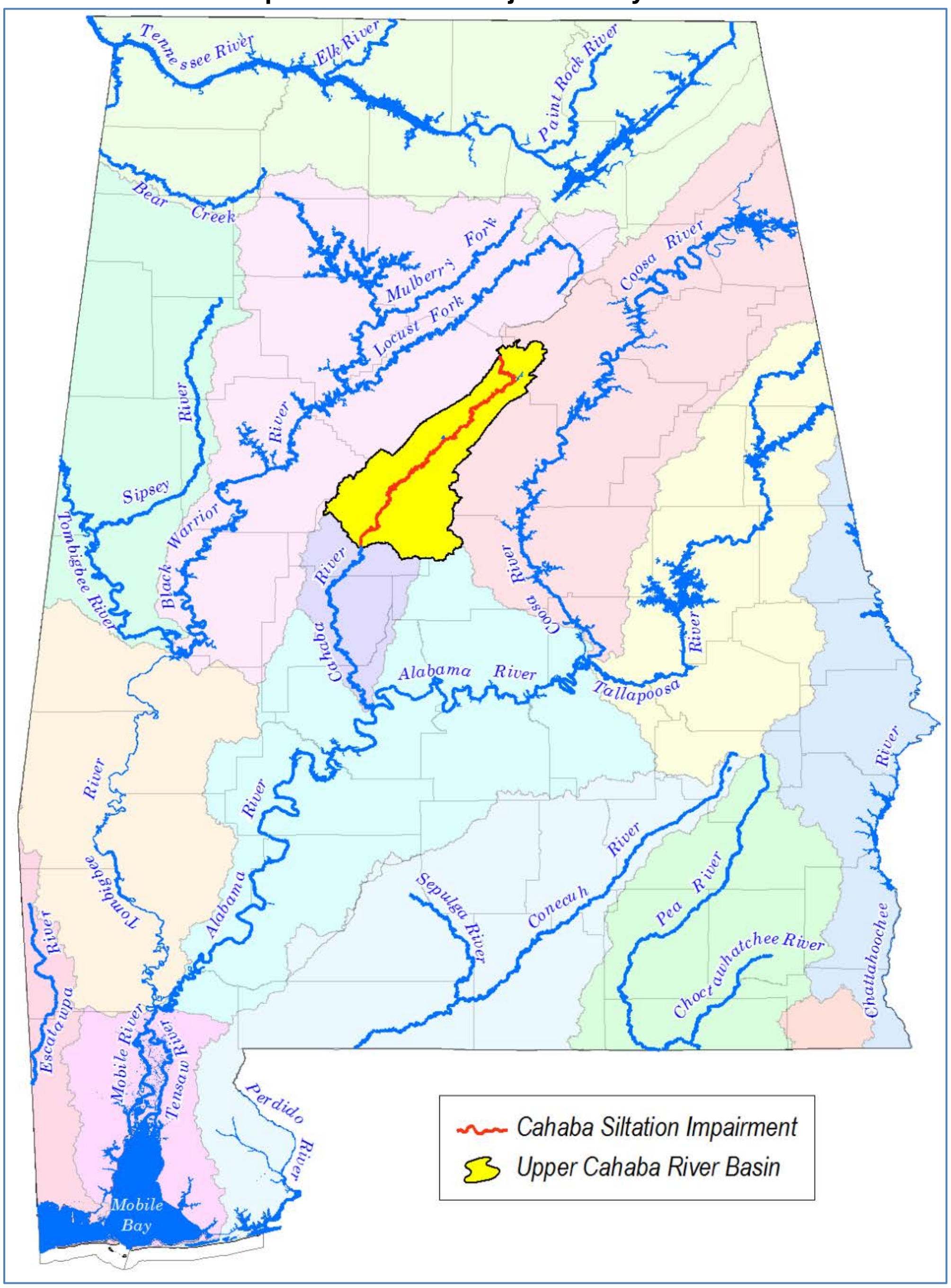
c. Existing and future NPDES permits that utilize narrative permit requirements will comply with the TMDL through implementation and maintenance of effective BMPs on a case-by-case basis.

2.0 WATERSHED DESCRIPTION

2.1 Geographical Location of the Impairment

The Cahaba River Basin is location in the central part of the State of Alabama. The siltation impairment of the Cahaba River is located in the Upper Cahaba Basin, which accounts for just over half of the total Cahaba River Basin area.

Map 2-1: Alabama's Major River Systems



2.2 Use Classification & General Information

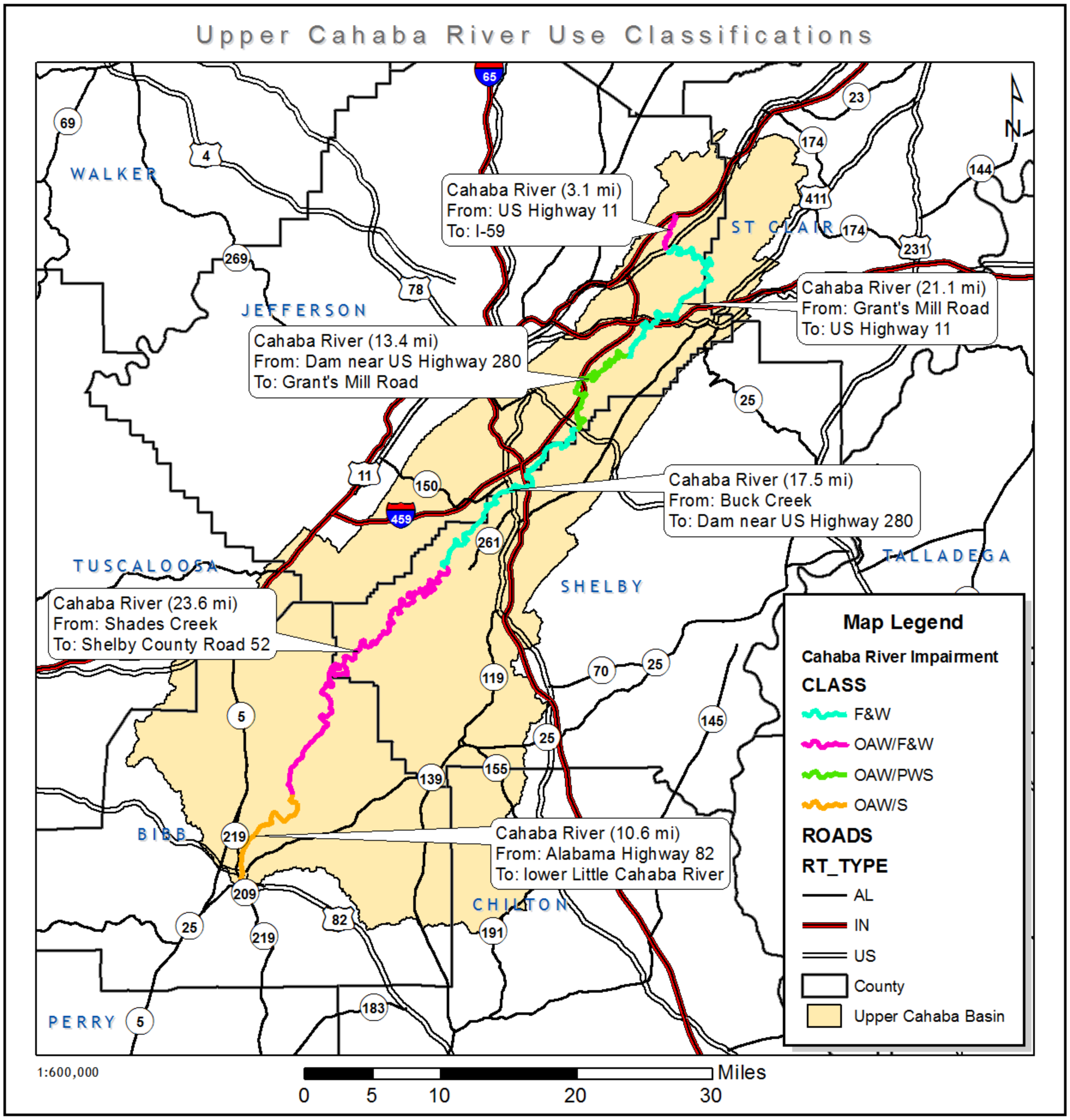
The Upper Cahaba River Watershed, which contains the §303(d)-listed segments of the Cahaba River for siltation and habitat alteration, is comprised of approximately 1,026 square miles in parts of St. Clair, Jefferson, Shelby and Bibb Counties, with small fractions in Tuscaloosa and Chilton Counties (See ***Map 2-2***). A vast majority of surface waters located within the Cahaba River Basin hold a Fish and Wildlife (F&W) use classification. More specifically, the ~106 mile-long impaired segment of the Cahaba River mainstem is primarily F&W, but is also classified as an Outstanding Alabama Water (OAW) for nearly 64 miles of the 106 mile total. In addition, there is a ~13 mile segment of the upper Cahaba River that is classified as Public Water Supply (PWS) and a ~10 mile segment listed as Swimming (S).

Of the eight listed segments of the mainstem Cahaba River, all are listed as being impaired for siltation (habitat alteration). ***Table 2-1*** presents the listed segment assessment unit IDs along with the lengths of impairment, use classifications, cause(s) of impairment, the listing year, and geographical extents. ***Map 2-2*** on the following page shows the Upper Cahaba River Watershed with the listed segments of the mainstem identified with their respective use classifications.

Table 2-1: 2012 §303(d) Listed Segments within the Upper Cahaba River Watershed

Waterbody Name	Miles	Designated Uses	Causes of Impairment	Original Listing	Segment Location (Downstream to Upstream)
Cahaba River Segment 1 (AL03150202-0101-102)	3.13	OAW / F&W	Siltation (habitat alteration)	1998	US Hwy 11 to I-59
Cahaba River Segment 2 (AL03150202-0104-102)	21.11	F&W	Siltation (habitat alteration)	1998	Grants Mill Road to US Hwy 11
Cahaba River Segment 3 (AL03150202-0204-102)	13.45	OAW / PWS	Siltation (habitat alteration)	1998	Dam near US Hwy 280 to Grants Mill Road
Cahaba River Segment 4 (AL03150202-0204-101)	17.46	F&W	Siltation (habitat alteration) Pathogens	1998	Buck Creek to Dam near US Hwy 280
Cahaba River Segment 5 (AL03150202-0206-102)	3.62	F&W	Siltation (habitat alteration Pathogens	1998	Shelby County Road 52 to Buck Creek
Cahaba River Segment 6 (AL03150202-0206-101)	23.61	OAW / F&W	Siltation (habitat alteration) Pathogens	1998	Shades Creek to Shelby County Road 52
Cahaba River Segment 7 (AL03150202-0407-100)	13.51	OAW / F&W	Siltation (habitat alteration)	1998	Lower Little Cahaba River to Shades Creek
Cahaba River Segment 8 (AL03150202-0503-102)	10.58	OAW / S	Siltation (habitat alteration)	1998	AL Hwy 82 to Lower Little Cahaba River

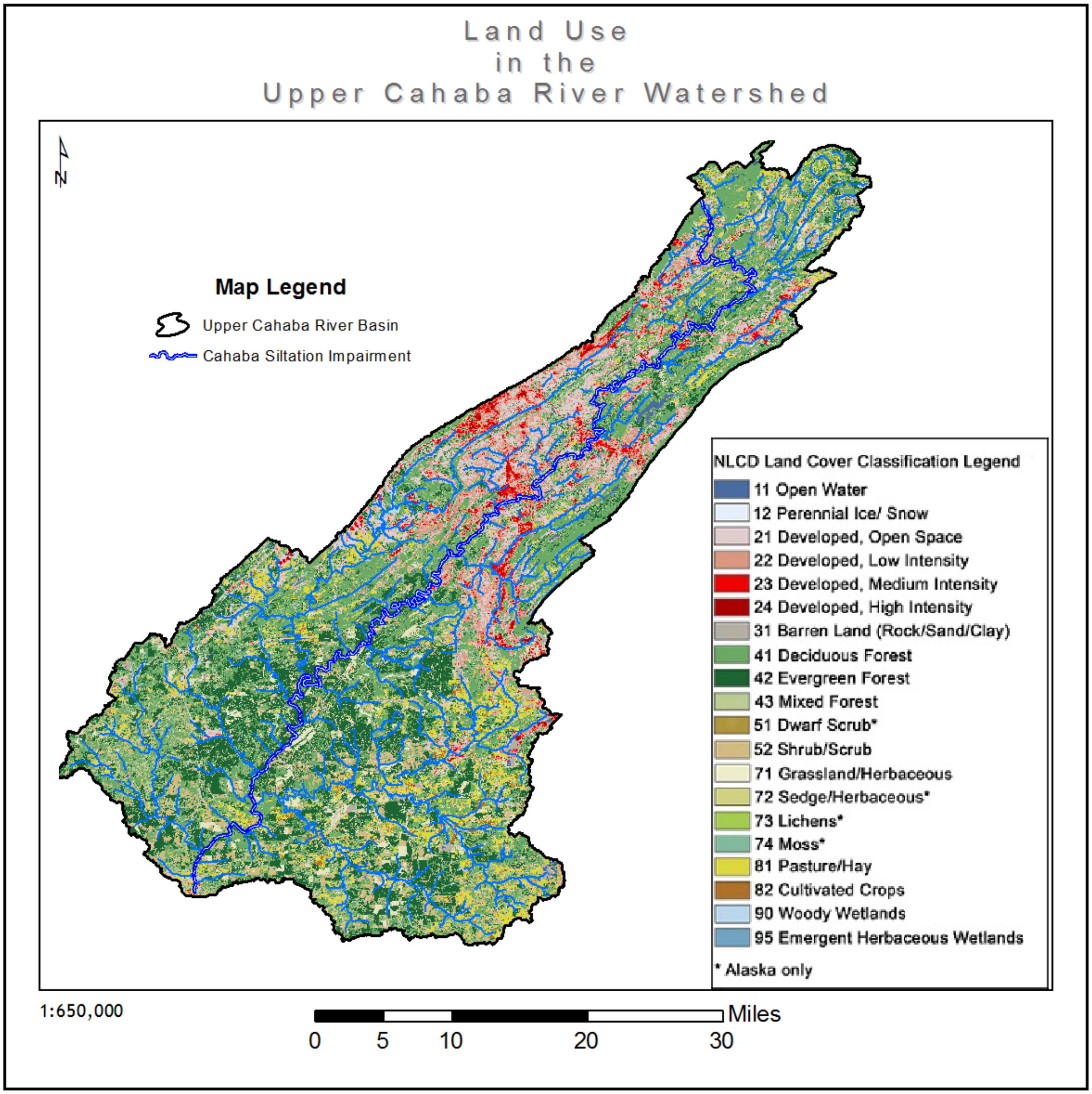
Map 2-2: §303(d) Listed Segments of the Cahaba River



2.3 Landuse Characteristics

The Cahaba River Basin is home to one of the largest residential and commercial areas in the State of Alabama. 2010 census data shows that the City of Hoover in south Jefferson County and adjacent communities in north Shelby County are some of the fastest growing areas in the state. The following land use map shows the 2006 NLCD land cover dataset for the Upper Cahaba River Watershed.

Map 2-3: Land Uses in the Upper Cahaba River Watershed



From this illustration, it is clearly evident that the developed urban areas are concentrated in the central and upper part of the sub-watershed, while the lower part is dominated by rural forested landscapes. Agricultural lands and cultivated crops are not prominent land use types in the Upper Cahaba River Watershed.

Figure 2-1: Land Uses by Percent Coverage

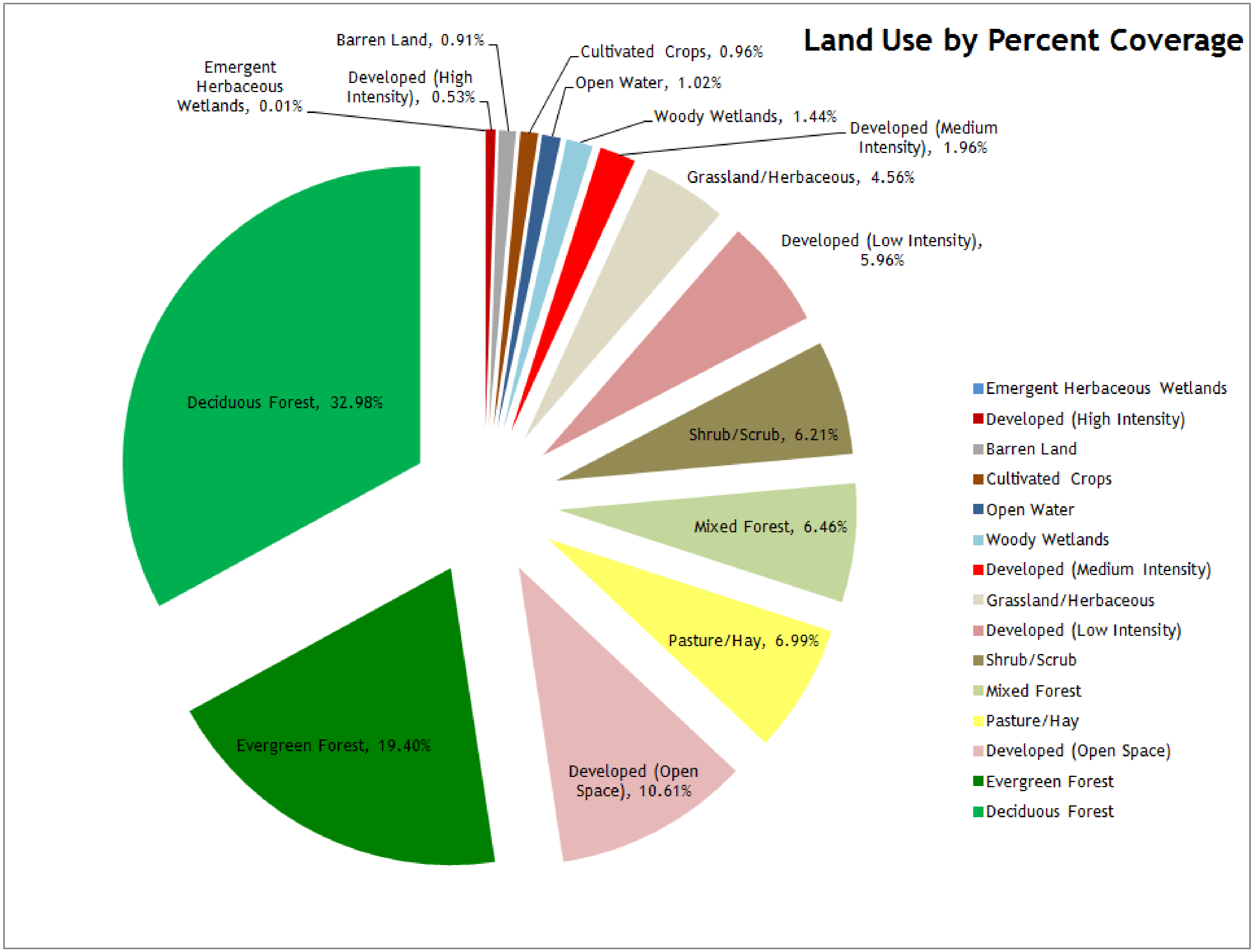


Table 2-2: Land Use Statistics

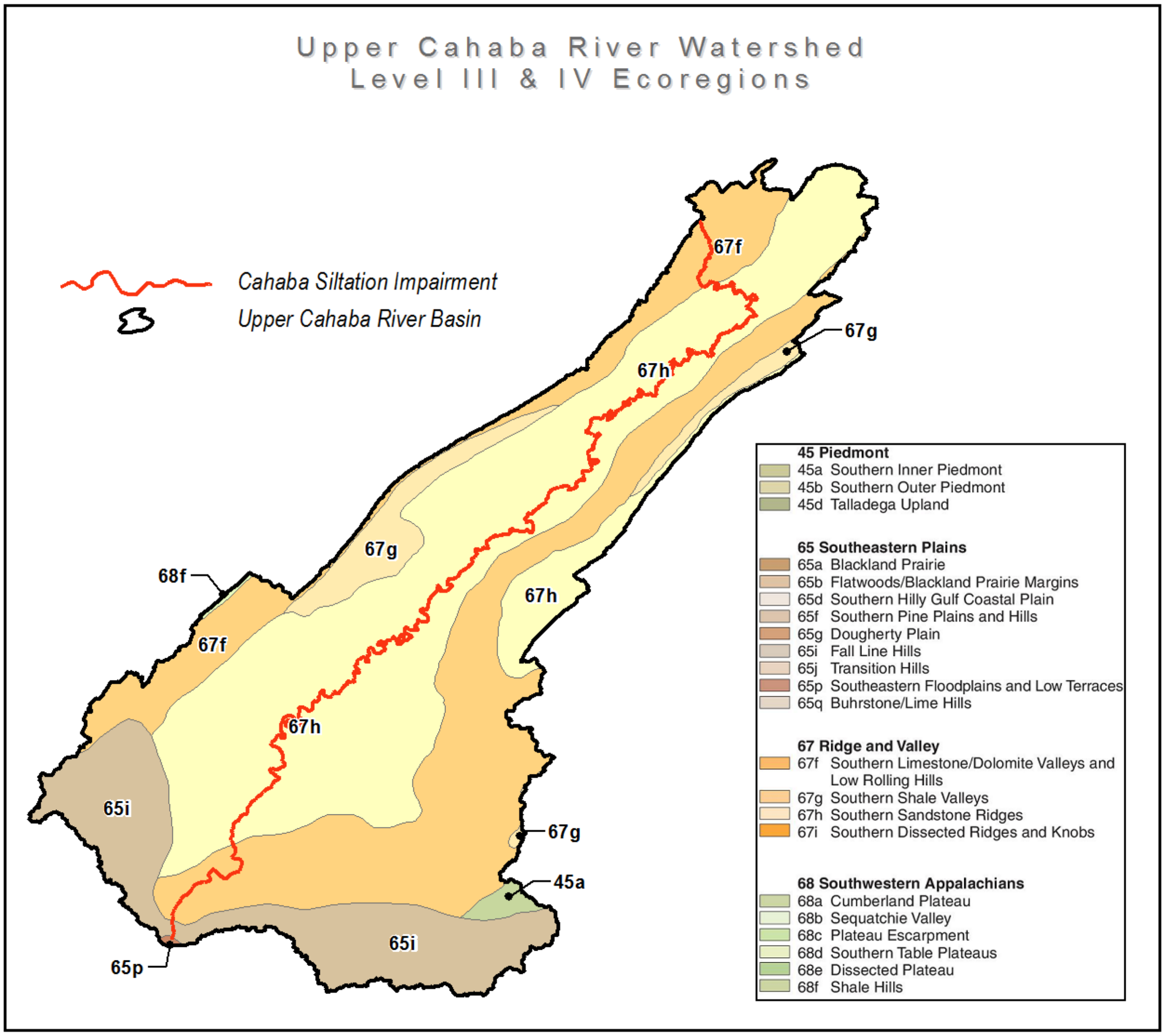
Class Description	Count (30m)	mi²	Acres	Percent
Emergent Herbaceous Wetlands	157	0.05	34.92	0.01%
Developed (High Intensity)	15590	5.42	3467.14	0.53%
Barren Land	26949	9.36	5993.32	0.91%
Cultivated Crops	28275	9.83	6288.21	0.96%
Open Water	30043	10.44	6681.41	1.02%
Woody Wetlands	42597	14.80	9473.35	1.44%
Developed (Medium Intensity)	57890	20.12	12874.44	1.96%
Grassland/Herbaceous	134695	46.81	29955.47	4.56%
Developed (Low Intensity)	176185	61.22	39182.63	5.96%
Shrub/Scrub	183525	63.77	40815.01	6.21%
Mixed Forest	190708	66.27	42412.47	6.46%
Pasture/Hay	206335	71.70	45887.83	6.99%
Developed (Open Space)	313532	108.95	69727.89	10.61%
Evergreen Forest	572943	199.09	127419.55	19.40%
Deciduous Forest	974253	338.55	216668.82	32.98%
TOTALS →	**2953677**	**1026.38**	**656882.45**	**100.00%**

2.4 Physiographic Regions & Ecoregions

The Cahaba River Basin lies within two primary physiographic regions: the Alabama Ridge and Valley Region, and the East Gulf Coastal Plain Region. The Upper Cahaba River Watershed lies almost completely within the Alabama Ridge and Valley, while the lower part of the watershed lies within the East Gulf Coastal Plain. The Ridge and Valley Ecoregion (67) is characterized by nearly parallel ridges and valleys formed by folding and faulting events. The predominant geologic materials are sandstone, limestone, shale, siltstone, chert, mudstone, dolomite, and marble.

Level III ecoregions, such as Ecoregion 67, are broken down into subregions also known as level IV ecoregions. There are four subregions in Ecoregion 67: *67f Southern Limestone/Dolomite Valleys and Low Rolling Hills, 67g Southern Shale Valleys, 67h Southern Sandstone Ridges, and 67i Southern Dissected Ridges and Knobs*. **Map 2-4** illustrates these regions and is followed by a brief description of each subregion in the Upper Cahaba River Watershed.

Map 2-4: Ecoregions in the Upper Cahaba River Watershed



45a. The Southern Inner Piedmont is rolling to hilly, well-dissected upland containing mostly schist, gneiss, and granite bedrock. Mica schist and micaceous saprolite are typical.

65i. The Fall Line Hills are composed primarily of Cretaceous-age loamy and sandy sediments. It is mostly forested terrain of oak-hickory-pine on hills with 200-400 feet of relief.

65p. Southeastern Floodplains and Low Terraces comprise a riverine ecoregion of large sluggish rivers and backwaters with ponds, swamps, and oxbow lakes.

67f. The Southern Limestone/Dolomite Valleys and Low Rolling Hills form a heterogeneous region composed predominantly of limestone and cherty dolomite. Landforms are mostly undulating valleys and rounded ridges and hills, with many caves and springs.

67g. The Southern Shale Valleys consist of undulating to rolling valleys and some low, rounded hills and knobs that are dominated by shale. The soils formed in materials weathered from shale, shaly limestone, and clayey sediments, and tend to be deep, acidic, moderately well-drained, and slowly permeable.

67h. The Southern Sandstone Ridges region encompasses the major sandstone ridges, but these ridges also have areas of shale, siltstone, and conglomerate. The steep, forested ridges tend to have narrow crests, and the soils are typically stony, sandy, and of low fertility. The chemistry of streams flowing down the ridges can vary greatly depending on the geologic material.

68f. The Shale Hills ecoregion, sometimes called the Warrior Coal Field, has more shale and less sandstone than 68e. The soils generally have silt loam surfaces rather than sandy loams and have a silty clay or clayey subsoil. Although it has the lowest elevations in ecoregion 68, the surface features are characterized by extensive hills and mostly strongly sloping topography. The shale, siltstone, and sandstone are relatively impermeable, and streams do not have the base flow found in more permeable adjacent areas, such as 65i or 67f. The region is mostly forested, but coal mining is a major industry, and the extensive open-pit mines have altered the landscape, soils, and streams.

2.5 Soil Types

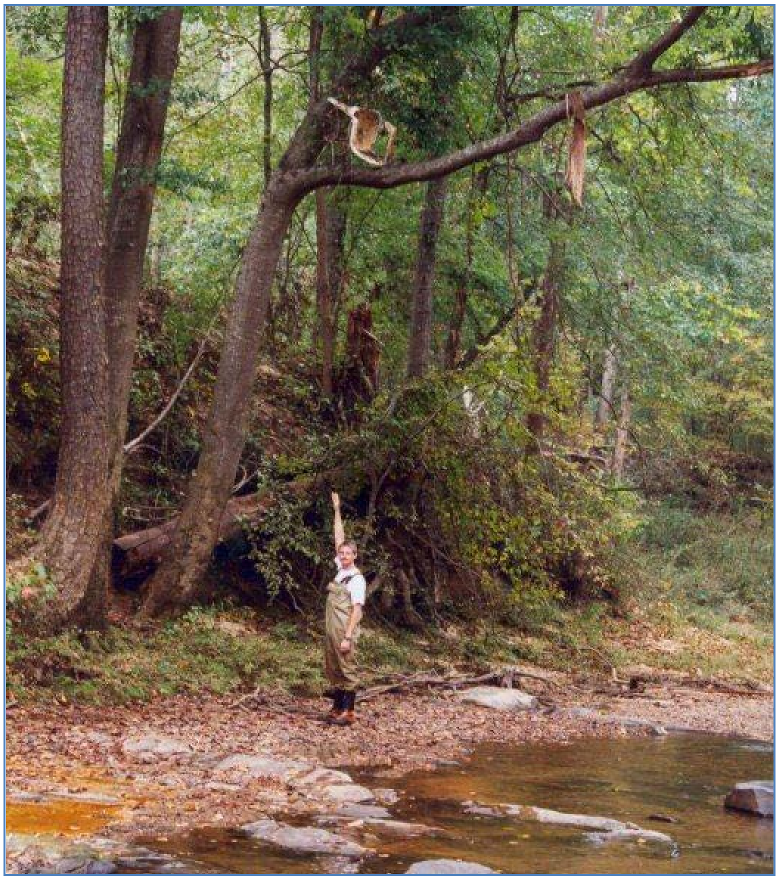
In general, the dominant soil types in the Upper Cahaba River Watershed are utilisols, which are characterized by well-developed horizons, a clay-rich B-horizon, and typically red or yellow colors due to the presence of iron. As a result of the drastic changes in geological formations and topography from the upper part of the watershed to the lower, there are five major soil provinces represented in the basin: soils of the limestone valley and uplands, soils of the Appalachian Plateau, soils of the Coastal Plain, soils of the Black Belt, and soils of the flood plains and terraces. In the Upper Cahaba River Watershed, soils of the limestone valleys and uplands are typically red clay loams, while the soils of the Appalachian Plateau are typically sandy loams.

2.6 Hydrology

The Cahaba River drains 1824 square miles and is the third largest tributary of the Alabama River in the Mobile River Basin. Over the 194 miles the river spans, elevation in the watershed varies from nearly 1100 feet above mean sea level in Shelby County to around 100 feet at the confluence of the Cahaba and Alabama Rivers in Dallas County.

Typical of many streams in Alabama, the Cahaba River displays high variability in streamflow, characterized by extreme low flows in late summer and early fall. The Cahaba River also exhibits increased peak flows and velocities due to the abundance of impervious surfaces within the upper part of the watershed, relatively low groundwater infiltration and retention rates, and large swings in streamflow due to the effluent-dominated nature of the watershed. All of these factors have the potential to exacerbate the siltation and habitat alteration issues present.

Picture 2-1: Debris Deposited in Tree during Extreme Flow Event



Picture 2-2: Cahaba River Before & After Storm Event (West Blockton, AL)

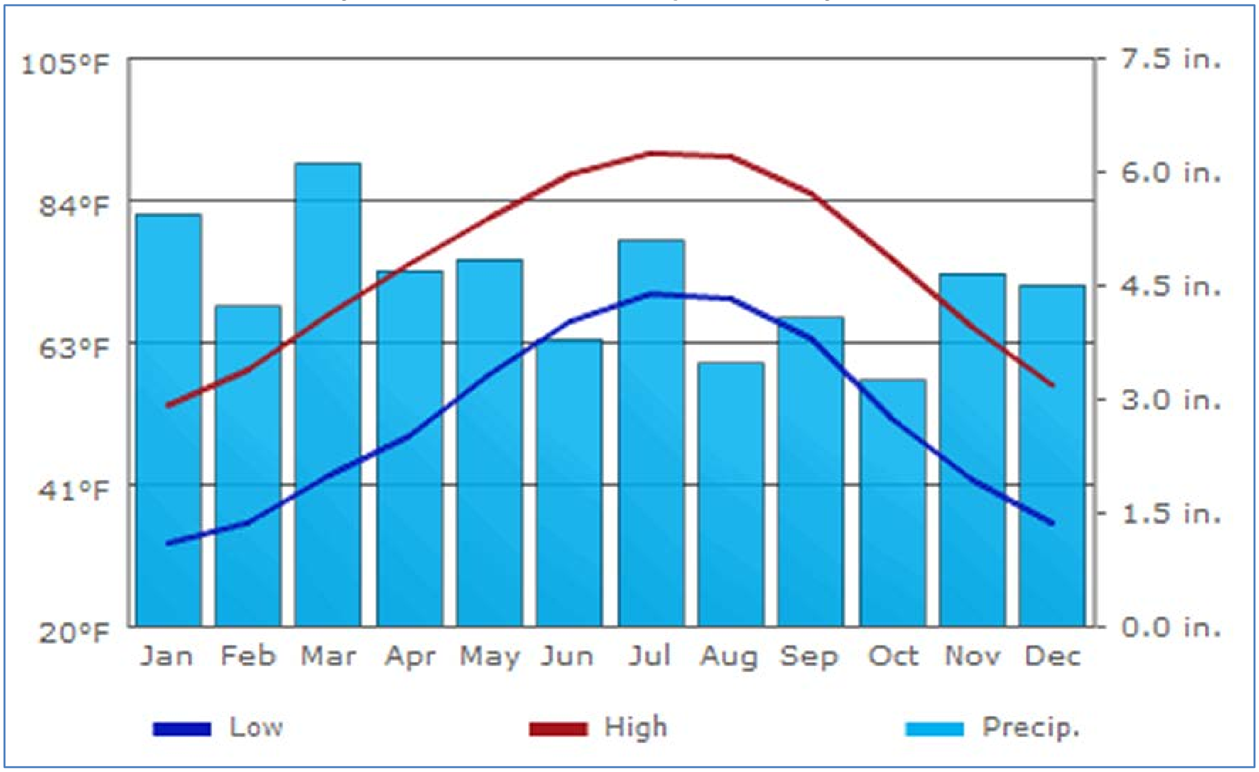
2.7 Slope and Erodibility

Due to the large changes in topography, the hydrological conditions listed in section ***2.6***, and the amount of land disturbance present, the Upper Cahaba River Watershed is very susceptible to erosional processes which contribute to the siltation impairment.

2.8 Climate and Rainfall

The climate in central Alabama is typical of the southern temperate rainforests, which are characterized by long growing seasons, periods of intense rainfall, and generally mild temperatures. The annual average precipitation in the greater Birmingham area is around 54 inches. Average rainfall is typically higher during the winter and spring and slightly lower during summer and fall.

Figure 2-2: Climate Summary for Birmingham, AL



(Climate Birmingham, 2012)

3.0 TMDL INTRODUCTION

3.1 Basis for §303(d) Listing Introduction

Section 303(d) of the Clean Water Act (CWA) as amended by the Water Quality Act of 1987 and USEPA's Water Quality Planning and Management Regulations *(Title 40 of the Code of Federal Regulations (CFR), Part 130*) requires states to identify waterbodies which are not meeting water quality standards applicable to their designated use classifications. The identified waters are prioritized based on severity of pollution with respect to those use classifications. TMDLs for all pollutants causing violation of applicable water quality standards are required to be determined for each identified segment. Such loads are established at levels necessary to implement the applicable water quality standards with seasonal variations and margins of safety. The TMDL process establishes the allowable loading of pollutants, or other quantifiable parameters for a waterbody, based on the relationship between pollution sources and instream water quality conditions. As a result, states can establish water-quality based controls to reduce pollution from both point and non-point sources in order to restore and maintain the quality of their water resources.

In 1996, ADEM identified one segment of the Cahaba River (Shades Creek to Buck Creek) on the 1996 §303(d) list as impaired for nutrients. In 1999, after consultation with the U.S. Fish and Wildlife Service (USFWS) and in consideration of impacts to threatened and endangered (T&E) species of mussels, snails, and fishes as required by the Endangered Species Act, the USEPA listed four segments of the mainstem Cahaba River to the 1998 §303(d) list as impaired for siltation, three of which were listed for other habitat alteration and two additional segments as impaired for nutrients. In addition, ADEM added the segment from Buck Creek to Shades Creek as impaired for pathogens. The Cahaba Nutrient TMDL was completed and approved by EPA in 2006. A pathogen TMDL is scheduled to be completed in 2013. More information, including TMDL program information, Alabama's water quality standards, and the §303(d) list, can be found on ADEM's website:
http://adem.alabama.gov/programs/water/waterquality.cnt.

In 2004, ADEM restructured its assessment unit IDs in order to more precisely identify and track waterbody segments with respect to designated uses and to be consistent with new listing and reporting guidelines under Sections §303(d) and §305(b) of the Clean Water Act. As a result, the original four (4) listed segments have been broken into eight (8) segments. Though the segmentation and assessment unit IDs have changed, the use classifications of these waterbodies have remained the same as well as the corresponding water quality criteria necessary to support those uses. Once again, ***Table 2-1*** and ***Map 2-2*** show these segments, their use classifications, and the water quality parameters listed as impaired.

Table 3-1*: *List of Existing or Extirpated Threatened and Endangered Species in the §303(d) listed Segments of the Cahaba River (USFR, 1998) on the following page shows the threatened and endangered species cited by USFWS as being impacted in the Upper Cahaba River Watershed. In 2003, USFWS designated critical habitat in the Cahaba River extending from AL Hwy 82 at Centreville to Jefferson County Road 143 (and a few tributaries) for the southern acornshell, ovate clubshell, southern clubshell, upland combshell, triangular kidneyshell, Alabama moccasinshell, fine-lined pocketbook, and orange-nacre mucket mussels (USFWS, 2004).

Table 3-1: List of Existing or Extirpated Threatened and Endangered Species in the §303(d) listed Segments of the Cahaba River (USFR, 1998)

Listed Species	Common Name	Type	ESA Status	Found in Cahaba Basin
Lampsilis altilis	Fine-Lined Pocketbook	Mussel	Threatened	Yes
Ptychobranchus greeni	Triangular Kidneyshell	Mussel	Endangered	Yes
Lioplax cyclostomaformis	Cylindrical Lioplax	Snail	Endangered	Yes
Lepyrium showalteri	Flat Pebblesnail	Snail	Endangered	Yes
Leptoxis ampla	Round Rocksnail	Snail	Threatened	Yes
Medionidus acutissimus	Alabama Moccasinshell	Mussel	Threatened	No, Extirpated since 1973
Pleurobema decisum	Southern Clubshell	Mussel	Endangered	No, Extirpated since 1973
Epioblasma metatstiata	Upland Combshell	Mussel	Endangered	No, Extirpated since 1973
Notropis cahabae	Cahaba Shiner	Fish	Endangered	Yes
Percina aurolineata	Goldline Darter	Fish	Threatened	Yes
Lampsilis perovalis	Orange-nacre Mucket	Mussel	Threatened	Yes

3.2 Problem Definition

Even though T&E species were the primary driver for the listing in 1998, there has been an abundance of data and studies to affirm the listing decision. There have been several biological studies documenting impairment, a rapid geomorphic assessment (RGA), and bed material studies. In addition, water chemistry sampling results from Cahaba stations showed elevated turbidity and TSS levels when compared to ADEM's 2010 ecoregional reference stream guidelines. Both of these parameters are highly correlated with suspended-sediment and siltation issues.

Picture 3-1: Mid-channel Sediment Bar in the Cahaba River

3.2.1 Biology

There have been numerous biological studies performed in the Cahaba River Basin. *Table* 3-2 presents several examples of these studies. Although all the studies do not agree in every aspect, the vast majority of biotic assessments and studies continue to signify that these segments are indeed impaired for siltation and habitat alteration - thus validating the initial §303(d) listing and subsequent TMDL development.

Table 3-2: Biological Studies in the Upper Cahaba River Watershed

Author	Year	Study Name	Data Years
Howell, W.M. and Davenport, L.J. Samford University	2001 2002	Report on Fishes and Macroinvertebrates of the Upper Cahaba River and Three Additional Sites	2001
Geological Survey of Alabama	1994	Biomonitoring and Water Quality Studies in the Upper Cahaba River Drainage of Alabama, 1989-1994	1989-1994
Geological Survey of Alabama	1997	Water-Quality Assessment of the Lower Cahaba River Watershed, Alabama	1996
Geological Survey of Alabama	2002	A Biological Assessment of Selected Sites in the Cahaba River System, Alabama	2002
Jefferson County ESD	1999-2002	Cahaba River Water Quality Assessment Project + MOA Data	1999-2002
USEPA Region 4 SESD	2001	Cahaba and Little Cahaba Rivers: Biological and Water Quality Studies, Birmingham, AL	August 27-31, 2001
USEPA Region 4 SESD	2002	Cahaba River: Biological and Water Quality Studies, Birmingham, AL	March/April, July and September, 2002
Geological Survey of Alabama	2005	Hatchet Creek Regional Reference Watershed Study	2004
ADEM	2012	2005 Cahaba River Report (Results of Macroinvertebrate Community Assessments)	2005

Picture 3-2: Field Crew Using Seine Net in the Cahaba River

USEPA field studies during August 2001 and 2002 confirmed that all Cahaba River stations were affected by excessive sedimentation (USEPA Region 4 2001, USEPA Region 4 2003a). Habitat scores were ranked in the sub-optimal range because of a high degree of embeddedness and sediment deposition. Wolman pebble counts indicated a high percentage of fine sediments (<2 mm) as a quantitative measure of embeddedness.

Overall, the biological habitat impacts of excessive siltation are summarized as follows:

- Inhibits fish reproduction for certain species
- Inhibits mussel feeding and reproduction
- Threatens propagation and health of macroinvertebrates
- Alters of biological community structure
- Degradation of primary producers

Historical impacts of siltation in the Cahaba are well-documented by Shepard et al. (1994), noting “many pooled areas were filled with sand and gravel, smothering whatever cobble and rocky microhabitats existed at one time.” GSA reports that the section of river in closest proximity to the most highly-urbanized area featured a “poor substrate structure with few boulders and rubble, extensive silt and sand shoals, poor bank stability, and a generally uniform channel configuration.” These habitat conditions corresponded to very poor to fair biological conditions. Conclusions were that “habitat degradation originated from excessive sedimentation due to residential, commercial, and road construction activities” and from siltation (embeddedness and bed load) from urbanized land areas, nutrients/eutrophication from nonpoint sources and municipal wastewater (O’Neil 2002, USEPA Region 4, 2003a).

The most recent USEPA field assessment report (USEPA Region 4, 2003a) describes how their field observations corroborate the theory of Lenat et al. (1979) that “greater sediment amounts that drastically change substrate type (i.e. from cobble-gravel to sand-silt) will change the number and type of taxa, thus altering community structure and species diversity.” As siltation smothers the natural substrate, more sensitive macroinvertebrate taxa such as *ephemeroptera*, *plecoptera*, and *trichoptera* (EPT) that are potential “fish-food organisms” are displaced by burrowing species such as chironomid larvae (Erman and Erman, 1984). Hartfield (2002) describes how the life cycle of the threatened and endangered mussels requires a host fish for mussel glochidia (larva) to parasitize prior to the juvenile phase. Thus, in addition to being smothered or buried by excessive sedimentation, mussel decline in the Cahaba Basin is linked to the survival of fish species, though which species may serve as host is unknown.

The comprehensive 2005 *Hatchet Creek Regional Reference Watershed Study* provided to ADEM by GSA presents compelling evidence of the suitability of Hatchet Creek as a regional reference watershed for large flowing river systems in upland regions of Alabama. Land disturbance within the Hatchet Creek Watershed is limited, as is urban development. In addition, the highly forested areas and healthy stream system lend well to production of biotic communities. This study asserts that Hatchet Creek is indeed a suitable reference stream for the Cahaba River and goes on to say that under normal conditions, both Hatchet Creek and the Cahaba River function in similar fashion. Habitat assessments of streams in the Hatchet Creek Watershed were generally in the optimal to sub-optimal range with low percentages of embeddedness and sediment deposition. When comparing these reference sites in the Hatchet Creek Watershed with selected sites in the Cahaba River Watershed, the Cahaba sites scored notably lower with respect to current biological conditions. Though species richness was nearly identical between the two systems, a lower abundance of specific species strongly indicates that biological condition is impaired in the Cahaba River and is ambient ("normal") in Hatchet Creek. Index of biotic integrity (IBI) scores for Hatchet Creek were in the *good* biological condition range, whereas only one Cahaba site scored in this range. The other Cahaba sites scored *fair* (O'neil & Shepard, 2005).

Following the 2004-2005 comparison of Hatchet Creek and the Cahaba River, additional intensive studies were performed by ADEM on the Cahaba mainstem to further assess the condition of macroinvertebrate communities. This study again confirmed that macroinvertebrate communities in the Cahaba River have consistently lower ratings when compared to reference streams. For instance, the additional Hatchet Creek macroinvertebrate assessments resulted in *excellent* ratings for most sites, while only two Cahaba sites received a *fair* rating and the remaining received *poor* or *very poor*. Likewise, EPT taxa richness metrics, or the number of Ephemeroptera (mayfly), Plecoptera (stonefly), and Trichopera (caddisfly), showed that the Cahaba sites displayed consistently lower numbers of Trichoptera than the reference streams and that the Plecopteran taxa were completely absent from all Cahaba River stations sampled. Following are illustrations highlighting results of the Biological Condition Scoring Criteria (BCSC) and EPT taxa richness metrics.

Figure 3-1: BCSC Comparison (ADEM, 2012)

(Results shown upstream to downstream with Hatchet on left & Cahaba on the right)

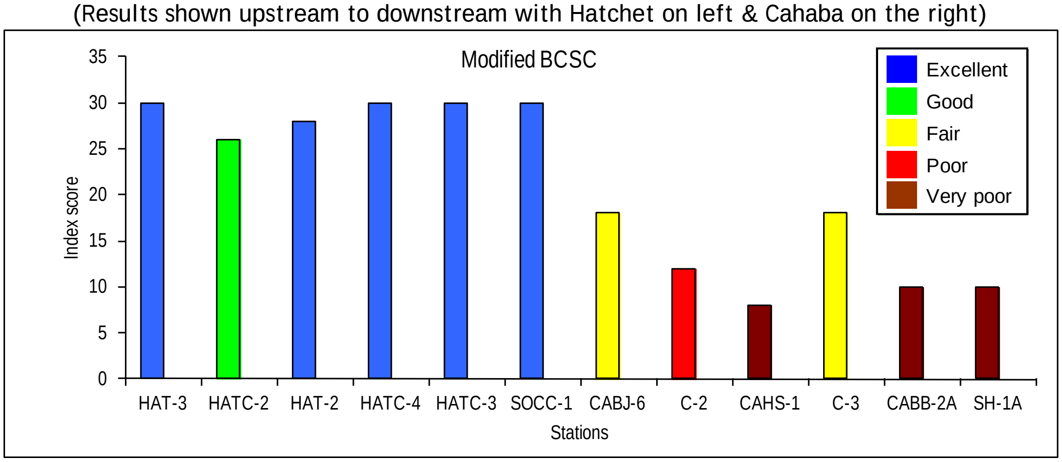
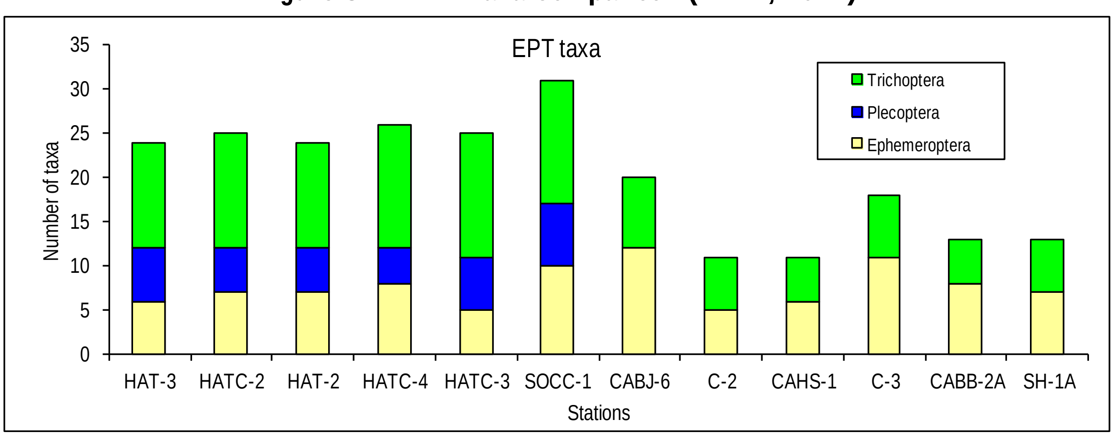


Figure 3-2: EPT Taxa Comparison (ADEM, 2012)



It should noted that the Hatchet Creek study was used for comparison only and was not used in the development of the TMDL target or load reduction requirements. These were established using stable reference sites within the same ecoregion. Target identification is further discussed in ***4.1 Water Quality Target Identification.***

In conclusion, the most recent Cahaba River Report states "The Cahaba River is listed as impaired by sedimentation (with respect to macroinvertebrate communities) due to indirect effects of attached filamentous algae and excessive bed load sedimentation covering stream substrates and filling the interstitial spaces critical for reproduction and feeding"(ADEM, 2012).

3.2.2 Morphology

In order to assess stream stability characteristics in the Cahaba River watershed, rapid geomorphic assessments (RGAs) were performed on the Cahaba River by Tetra Tech and Mississippi State University (Dr. William McAnally) with assistance by the National Sediment Laboratory. An RGA is a semi-quantitative assessment described by Simon et al. (2002) as a technique to utilize diagnostic criteria of channel form to infer dominant channel processes and the magnitude of channel instabilities. Granted that evaluations of this sort do not include an evaluation of watershed or upland conditions, however, stream channels act as conduits for energy, flow and materials as they move through the watershed and will reflect a balance or imbalance in the delivery of flow and sediment.

Picture 3-3: Example of an Unstable Bank on the Cahaba River

As such, unstable channels with failing streambanks are inherently a chronic source of sediment loading. When developing siltation TMDLs, it is necessary to determine if the majority of sediment in the stream is from land-based sources or evolving stream channels themselves. The RGA is a semi-quantitative tool that is useful for determining where in the Cahaba River watershed the dynamics of perturbed stream channel equilibrium and channel evolution dominate the total sediment loading to the Cahaba River.

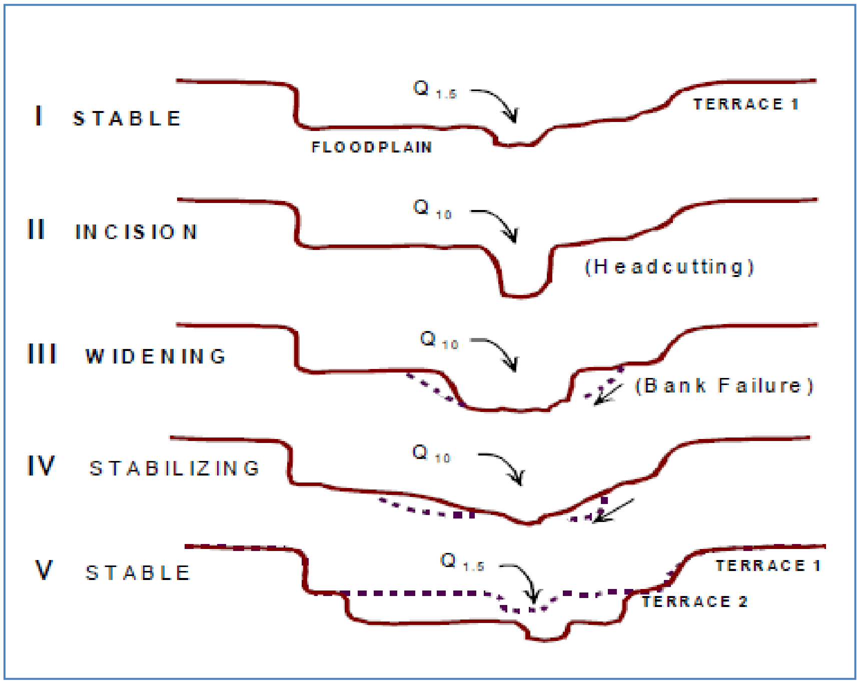
The RGA employs a standard form by which each of the following criteria are evaluated and assigned a score:

- Primary bed material
- Bed/bank protection
- Degree of incision
- Degree of constriction
- Streambank erosion
- Streambank instability
- Established riparian vegetative cover
- Occurrence of bank accretion
- Stage of channel evolution

Figure 13-1 in the appendix shows this form and gives a brief description of each criterion. Points are assigned for each of the nine criteria and their sum – the channel stability index – indicates the degree of stability/instability. Indices less than 10 indicate a relatively stable reach and values above 20 indicate significant instability.

RGAs were performed at each of 29 sites on the Cahaba River and its tributaries during September 2003. ***Map 3-1*** depicts the RGA sites sampled which are also listed in ***Table 3-3***. The analysis identified five sites as unstable, eleven sites as marginally stable, and thirteen as stable. In the Cahaba Basin, based on best professional judgment and field assessment, scores of less than 13.5 were determined to be comparatively stable, and scores between 13.5 and 20 are considered as marginally stable.

Figure 3-3: Five Stages of Channel Evolution (Schumm, 1977 & 1984)



Map 3-1: Rapid Geomorphic Assessment (RGA) Sites in the Cahaba River Watershed

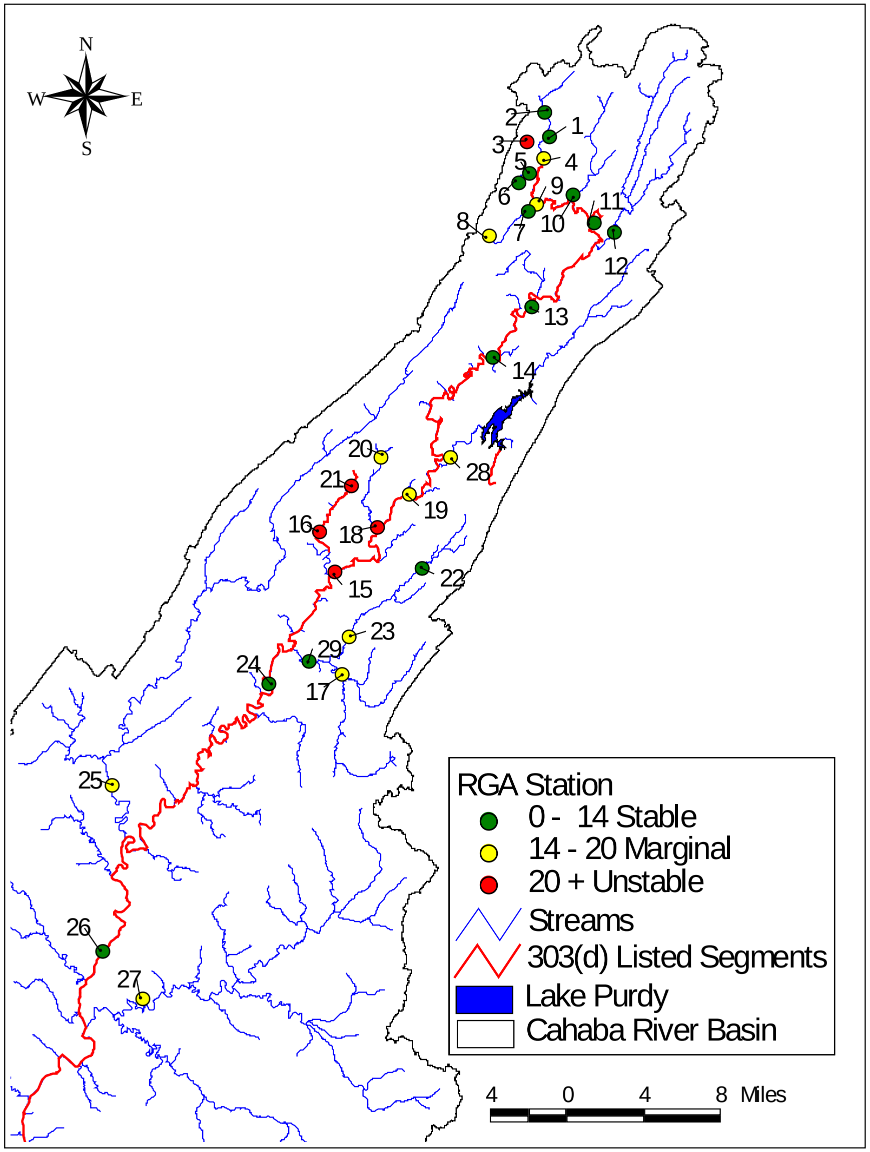


Table 3-3: RGA Sites in the Cahaba River Watershed

Station	Station Location
1	Cahaba R. @ Deerfoot Parkway
2	Cahaba R. next to Camp Rd off Deerfoot Pkwy
3	Unnamed Trib @ Cooper and Memory
4	Cahaba R @ HT Junior High, Trussville
5	Dry Creek off Green Rd
6	Dry Creek @ Chalkville Rd
7	Pinchgut Cr off Hwy 11 @ Roper
8	Pinchgut Cr off Hwy 11 @ Morris Spring
9	Cahaba R @ US Hwy 11 (USGS 02423130)
10	Little Cahaba Cr. @ Camp Coleman Road
11	Cahaba R. @ Roper Rd
12	Big Black Cr @ M. A. Lee
13	Cahaba R @ US Hwy 78
14	Cahaba R @ Grants Mill Rd
15	Cahaba R @ Bain's Bridge (USGS 02423500)
16	Patton Cr @ HW 150
17	Buck Cr @ Shelby County Rd 52
18	Little Shades Cr @ Old Rocky Ridge Rd
19	Cahaba @ Caldwell Mill Rd (USGS 02423425)
20	Little Shades Cr @ Sagewood Trace
21	Patton Cr @ Montgomery Hwy & Badham Dr.
22	Cahaba Valley Cr @ Hwy 119
23	Cahaba Valley Cr @ Cross Creek Rd
24	Cahaba R @ Shelby Co 52 (USGS 02423555)
25	Shades Cr @ Bibb Co 13
26	Cahaba R @ Bibb Co 24
27	Little Cahaba R @ Bibb Co 65
28	Little Cahaba R @ Cahaba Beach Lane
29	Buck Cr @ Hwy 261

In general, sites in the top and bottom of the Upper Cahaba River have stable banks compared to sites at Bain's Bridge (15), Little Shades Creek (18), and Patton Creek (16 and 21). This is an indication that chronic effect of unstable banks (as a result of elevated total volume runoff) is not the main source of impairment in the top of the watershed. Studies referenced in this report will document that the top of the watershed is impaired more as a result of acute pulses of sediment most likely from construction activities. Assessments were made in September 2003 after a wet spring and 100-year flood that occurred in May 2003. Although upper watershed streambanks were determined to be largely stable, significant hydraulic scour was observed in the vicinity of bridges, presumably exacerbated by the flood. ***Table 3-4*** summarizes the RGA results.

Table 3-4: Rapid Geomorphic Assessment (RGA) Stability Indices

Station*	Bed Material	Bed/Bank Protection	Incision	Constriction	Streambank Erosion		Streambank Instability		Vegetative Cover		Bank Accretion		Channel Evolution		Total Score	Evaluation
					L	R	L	R	L	R	L	R	Stage	Points		
1	1	1	3	1	0	0	0	0	1	1	1.5	1.5	VI	1.5	12.5	Stable
2	0	1	3	1	1	1	0	0	1	1	0.5	1	VI	1.5	12	Stable
3	1	1	4	2	1	2	1	1.5	1.5	1.5	1	0.5	III	2	20	Unstable
4	1	1	3	2	2	0	2	0.5	1	0.5	1	0	V	3	17	Marginal
5	1	0	2	1	0	1	0	0.5	0.5	0	0.5	0.5	II	1	8	Stable
6	1	0	2	0	0	0	0	0	2	2	1	1	II	1	10	Stable
7	1	1	3	1	0	1	0	0.5	0	0.5	1	1	VI	1.5	11.5	Stable
8	1	1	3	2	0	1	0.5	1	1	1.5	1.5	0.5	III	2	16	Marginal
9	3	0	4	1	1	0	0.5	0	0.5	0.5	1	1	IV	4	16.5	Marginal
10	0	1	4	0	0	1	0	0	0	0.5	1	0.5	I	0	8	Stable
11	1	1	4	0	0	1	0	0	0.5	0.5	2	2	I	0	12	Stable
12	1	1	3	0	1	1	0.5	0.5	1	1	2	1	I	0	13	Stable
13	4	1	2	0	1	0	0	0	1	0.5	2	2	I	0	13.5	Marginal
14	0	1	3	0	0	0	0	0	2	2	2	2	I	0	12	Stable
15	4	1	2	1	2	2	1.5	1.5	1.5	1.5	2	2	IV	4	26	Unstable
16	4	1	4	2	2	2	1.5	1.5	1.5	1.5	1.5	1.5	IV	4	28	Unstable
17	4	1	1	0	1	1	0.5	0.5	0.5	0.5	2	2	VI	1.5	15.5	Marginal
18	4	1	4	2	2	2	1.5	1.5	1.5	2	1	1	V	3	26.5	Unstable
19	3	1	4	1	1	1	0	0	1.5	1.5	1.5	0.5	V	3	19	Marginal
20	1	1	3	2	2	1	1.5	0	2	0.5	0.5	2	V	3	19.5	Marginal
21	1	1	4	0	2	2	1.5	1.5	2	2	1.5	1	V	3	22.5	Unstable
22	1	1	1	1	1	1	0.5	0.5	0.5	0.5	1.5	1.5	III	2	13	Stable
23	4	0	1	1	0	1	0	0.5	0.5	1	2	2	II	1	14	Marginal
24	4	1	1	1	0	0	0.5	0.5	0.5	0.5	1	1	I	0	11	Stable
25	2	1	3	1	1	1	0.5	0.5	0.5	1	1	2	I	0	14.5	Marginal
26	4	1	1	1	0	0	0.5	0.5	0.5	0.5	2	2	I	0	13	Stable
27	4	1	2	1	1	1	1	0.5	1	1	2	2	I	0	17.5	Marginal
28	1	1	4	1	1	0	1	0.5	1	1.5	1.5	0.5	VI	1.5	15.5	Marginal
29	3	1	3	0	1	0	0	0	0.5	0.5	1	0.5	VI	1.5	12	Stable

In addition to the RGAs, the comparative analysis in the 2005 Hatchet Creek study also illustrated the Cahaba's susceptibility to erosional processes as well as its current impairment for siltation and habitat alteration. Compared to reference sites, the Cahaba sites exhibited a higher degree of embeddedness, marginal to poor bank condition/stability, and higher sediment deposition rates. The study goes on to state that about 50% of the sample reaches displayed intense bank scouring and that the effluent-dominated urban hydrology and sedimentation were adversely impacting these sites (O'neil & Shepard, 2005).

3.2.3 Bed Material

According to the Simon et al, 2004 report with regards to bed material in the Ridge and Valley Region and the Cahaba River Basin:

> *Using the same concept for bed material as was used for suspended sediment, sites from the Ridge and Valley (Ecoregion 67) were sorted into stable and unstable sites to determine a reference bed-material composition for coarse-grained reaches. Coarse-grained reaches are singled out because streams designated as impaired due to siltation impact spawning habitats and other biologic life functions by clogging interstitial spaces in gravel-cobble beds. Because a reasonably large number of stable sites were also located on Shades Creek, reference conditions developed for the Ridge and Valley can be directly compared to reference conditions along Shades Creek itself.*
>
> *A reference bed-material composition, therefore, is based on a measure of embeddedness; the percentage of materials finer than 2 mm (sand, silt and clay) in gravel or gravel/cobble-dominated streambeds. This applies then to 53 of the sites evaluated along Shades Creek. An implicit assumption in this technique is that the bi-modal particle-size distributions indicative of embeddedness are representative of the entire streambed and not characterizing coarse materials in one location on the bed and the fines in another. Bed-material data from both the Ridge and Valley and Shades Creek were filtered to include only those sites that are dominated by coarse-grained sediment (more than 50% of the streambed composed of materials coarser than 2 mm). Further sorting of the data into stable and unstable sites provided a means of comparing the degree of embeddedness in coarse-grained stream reaches. A reference value of 4%, based on the median percentage of streambed material finer than 2 mm, was determined for not only the Ridge and Valley but for Shades Creek as well.*

According to Ecoregion 67 reference site data cited by USEPA (USEPA Region 4 2003a), Ridge and Valley reference streams exhibit percent embeddedness in the range of 9 to 19 % with a mean of 11 % sand, silt and clay (<2 mm). Furthermore, according to the Simon et al, 2004 report the median value of the third quartile of reference streams in the Ridge and Valley is 16.6 % sand, silt and clay (<2mm). Findings at the most upstream Cahaba River site CR-1 at Goodner Mountain Road, near the most upstream extent of the §303(d)-listed segment, had 13.89 % fines (< 2 mm) and the best habitat scores of Cahaba River sites. Generally, evidence supports that low embeddedness levels of reference sites, corresponding to the approximate range of 11 to 16.6 % fines (< 2 mm) should be protective of reference conditions in gravel/cobble-dominated streambeds such as the Cahaba River. Sites whose embeddedness is significantly greater than this range may not be conducive to sensitive species.

The USEPA field personnel measured the particle size distributions (Wolman pebble counts) for bed-material on the Cahaba River in 2002. ***Table 3-5*** presents the percentage of bed-material finer than 2 mm (sand, silt and clay) collected at various stations on the Cahaba River and in its tributaries.

Table 3-5: Percentage of Bed Material Finer than 2 mm at Cahaba River Sites

Station	Date	Station Name	Water Surface Slope	Median Particle Size (D50) in mm	% Sands, Silts, & Clays (Particles < 2mm)
CR-1	9/11/2002	Cahaba River at CR 132	0.25%	20	13.89
CR-AT	9/11/2002	Cahaba River at US 11/SR 7	0.13%	15	29.73
CR-BT	9/11/2002	Cahaba River at CR 10 (Roper Rd)	0.24%	12	39.64
CR-AH	9/10/2002	Cahaba River at CR 29	0.07%	20	37.76
CR-BH	9/12/2002	Cahaba River off Old Rocky Ridge Rd; Riverford Dr.	0.01%	1	58.96
CR-6	9/9/2002	Cahaba River at Bains Bridge	0.02%	4	40.48
CR-7	9/10/2002	Cahaba River at CR 52	0.28%	2	50.00
SC-1	9/10/2002	Shades Creek at CR 12	0.27%	37	24.81

Map 3-2: Locations Sampled for Wolman pebble counts (USEPA R4)

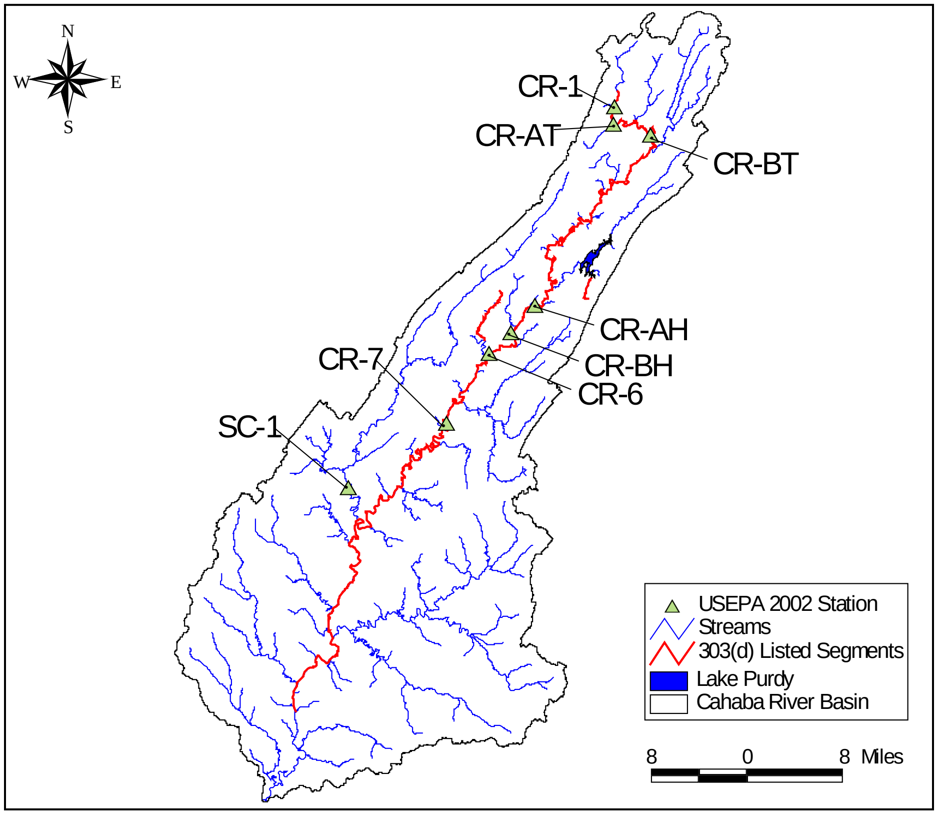


Table 3-6: Reference percent fines sands, silts, & clays (<2mm)

Station	Station Name	Water Surface Slope	Measured Percent Sands, Silts, & Clays (< 2mm)	Reference Percent Sands, Silts, & Clays (< 2mm)
CR-1	Cahaba River at CR 132 (Cahaba Reference Site)	0.25%	13.89	11-16.6
CR-AT	Cahaba River at US 11/SR 7	0.13%	29.73	11-16.6
CR-BT	Cahaba River at CR 10 (Roper Rd)	0.24%	39.64	11-16.6
CR-AH	Cahaba River at CR 29	0.07%	37.76	11-16.6
CR-BH	Cahaba River off Old Rocky Ridge Rd; Riverford Dr.	0.01%	58.96	11-16.6
CR-6	Cahaba River at Bains Bridge	0.02%	40.48	11-16.6
CR-7	Cahaba River at CR 52	0.28%	50.00	11-16.6
SC-1	Shades Creek at CR 12	0.27%	24.81	11-16.6

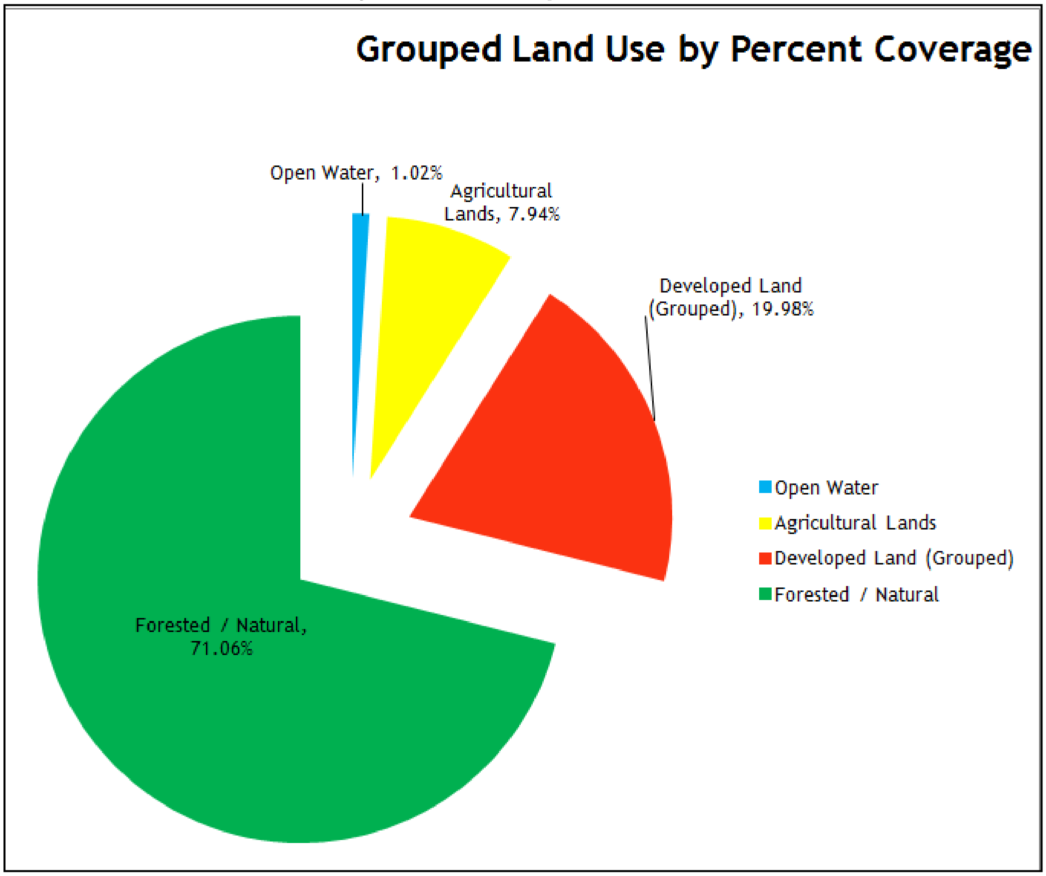
This study provides valuable insight into the discussion of sediment impairment caused by chronic loading versus acute loading. The RGA study referenced here is primarily a study of the stream structure and identifies chronic loading impacts as a result of total volume runoff. The RGA indicated that the top of the Upper Watershed around Trussville has stable banks. The Wolman USEPA study of bed material does not identify the source of sediment loading, but simply indicates impairment. Therefore, in a situation where a stream has a stable score for RGA and a negative score for bed material, it is a clear that the impairment is due to acute loadings.

Picture 3-4: Substrate in Riffle-run of the Cahaba River

3.2.4 Urbanization and Land Use Change

Land Use in the Upper Cahaba River Watershed was discussed earlier. For this TMDL analysis, it is important to look at specific land uses that affect siltation and habitat alteration the greatest. After grouping the individual land uses, about 20% of the Upper Cahaba River Watershed is considered developed land (including barren land and active/abandoned mining operations), the vast majority of which is intensely concentrated in the upper portion of the watershed near the cities of Birmingham and Hoover.

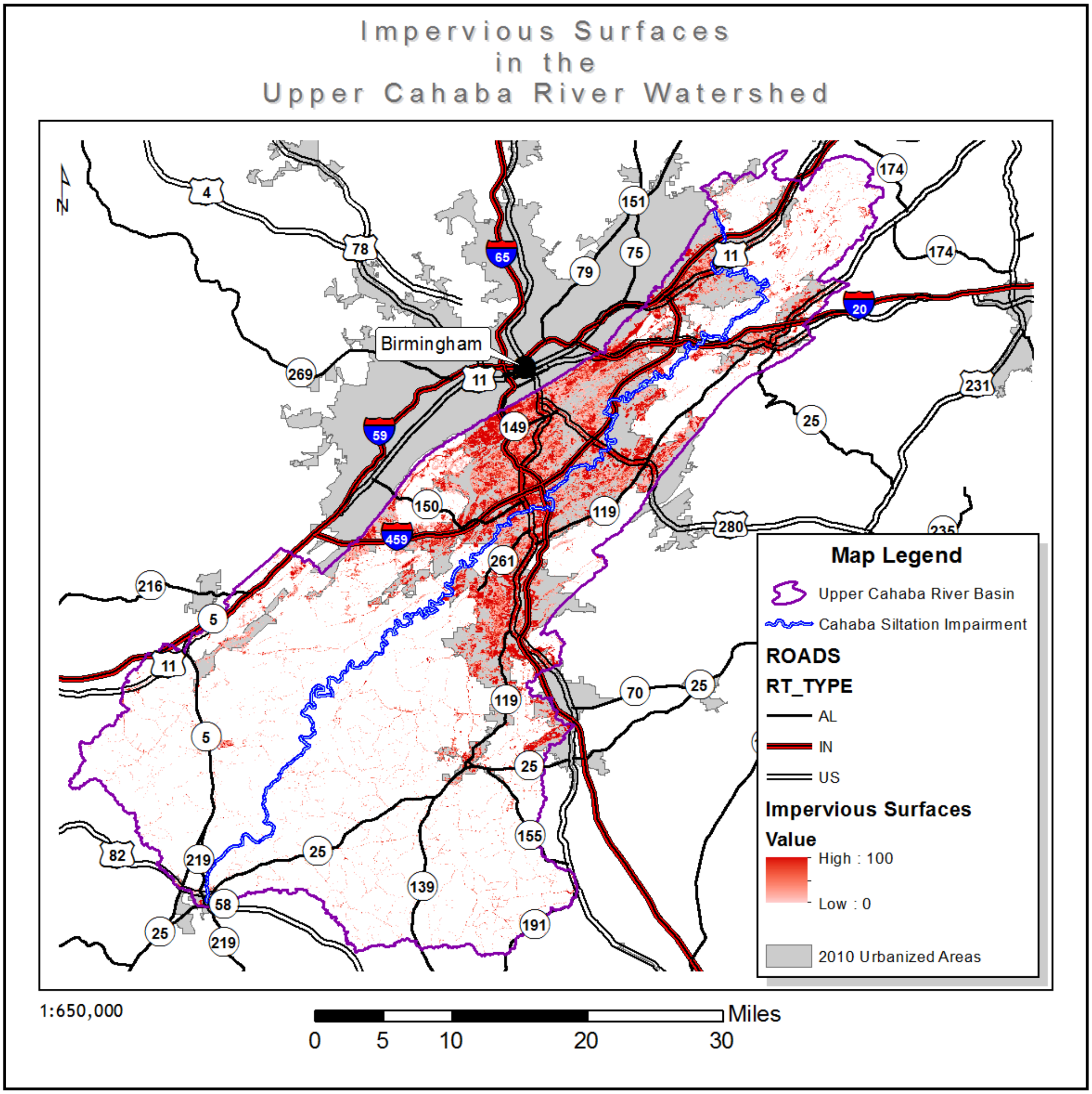
Figure 3-4: Grouped Landuses



By focusing on these developed lands as source of urban runoff and increased stream velocities and peak flow during storm events, we can better identify areas in the watershed that have the highest potential for these factors to adversely affect water quality and habitat health.

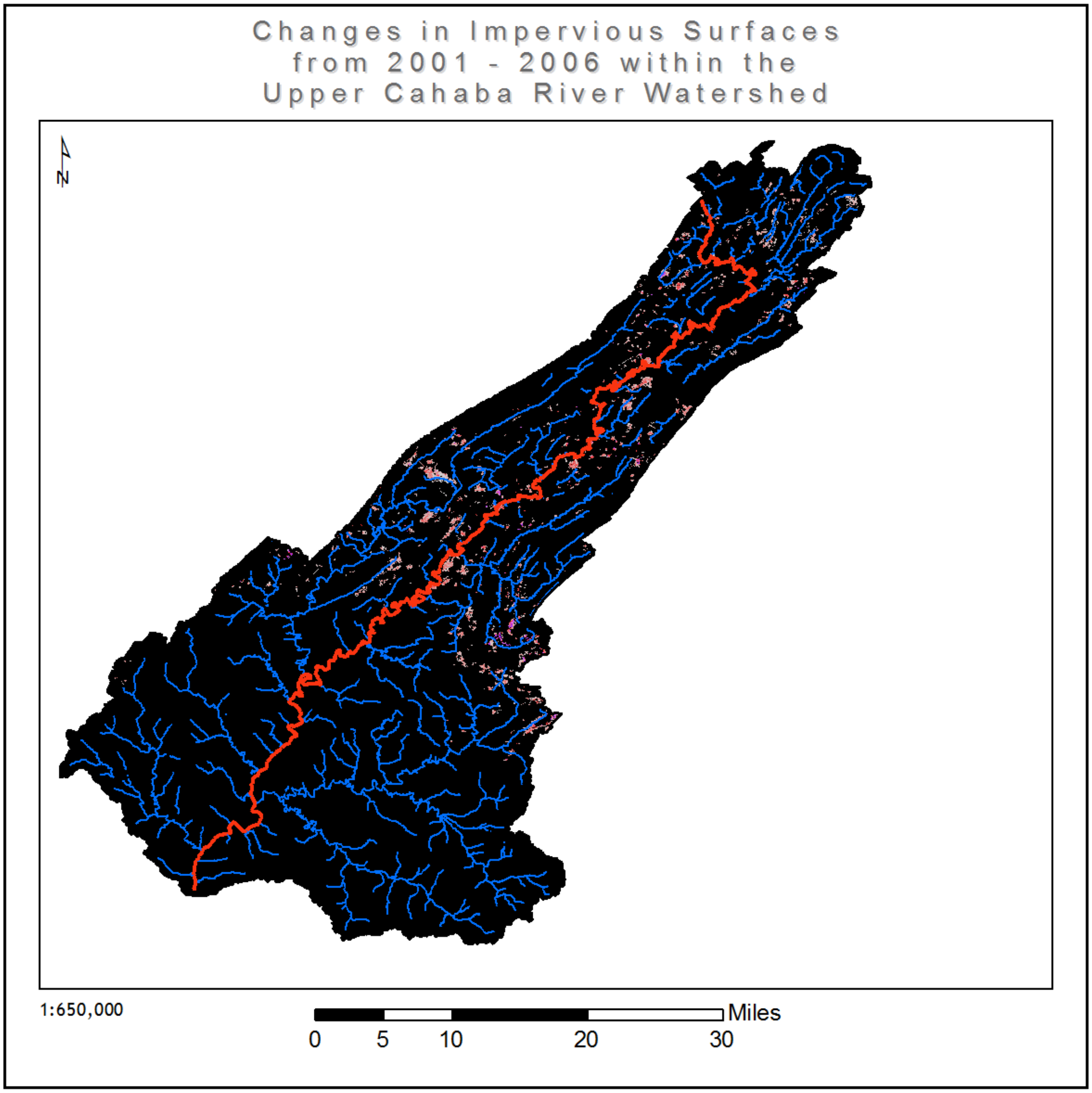
The following map, ***Map 3-3***, depicts the impervious surfaces resulting from intensely developed areas in the Upper Cahaba River Watershed. By reducing infiltration rates, increasing overall volume of stormwater, and lessening the total amount of retention areas, impervious surfaces play a large role in the hydrology of this urban watershed.

Map 3-3: Impervious Surfaces in the Upper Cahaba River Watershed



Finally, ***Map 3-4*** shows the increase in impervious surfaces over a relatively short 5-year period (2001 to 2006). Areas in black represent areas with no increase in impervious surfaces, while changed areas shaded in red based on the degree of imperviousness of the development. This shows that the changes in the Upper Cahaba Watershed have been almost completely residential and commercial development and are concentrated in the upper part of the watershed. This figure is an indication that urbanization of the Cahaba River Watershed is certainly increasing over time and thus is considered one of the primary causes of habitat loss due to excess sediment and instream erosion.

Map 3-4: Increase in Impervious Surfaces (2001 - 2006)



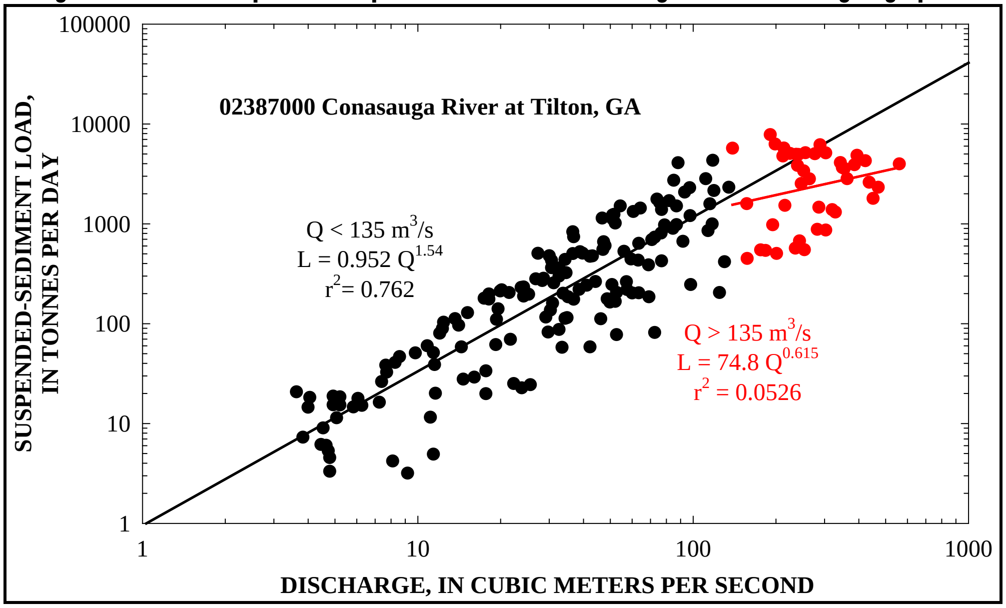
4.0 BASIS FOR TMDL DEVELOPMENT

4.1 Water Quality Target Identification

As stated previously, Alabama's water quality criteria do not include numeric water quality criteria for aquatic life protection due to sediment. Therefore, it is necessary to develop numeric targets based upon narrative criteria. In this TMDL report, numeric targets were established through the use of reference streams with a high-quality set of historical flow and suspended-sediment data available for each site. Reference stream sites were selected based on a set of criteria which indicated that the channels were not generating, transporting, or accumulating an excess of sediment. Historical suspended-sediment concentrations and streamflow from long-term USGS data were analyzed by personnel of the Channel and Watershed Process Research Unit (CWP) of the U.S. Department of Agriculture (USDA), Agricultural Research Service, and National Sedimentation Laboratory (ARS-NSL) on behalf of USEPA Region 4 to determine applicable suspended-sediment reference conditions and characteristic sediment yields for streams within the Ridge and Valley ecoregion streams. In the winter and spring of 2003 an extensive field study was conducted by the ARS-NSL to assess streambank stability, geotechnical characteristics of bank and bed materials, and the physical processes governing the sediment loads occurring in Shades Creek, a major tributary of the Cahaba River. Description of the siltation target identification and reference stream approach is as follows (Simon et al, 2004):

> *A suspended-sediment transport rating is developed (Porterfield, 1972; Glysson, 1987; Simon, 1989a) by plotting discharge versus concentration in log-log space and obtaining a power function by regression. Trends of these data (in log-log space) often increase linearly and then break off and increase more slowly at high discharges. A transport rating developed with a single power function commonly over-estimate concentrations at high flow rates, leading to errors in calculating the effective discharge. To alleviate this problem, a second or third linear (in log-log space) segment is sometimes developed with the upper end of data set (Figure 4-1). The division point between these data ranges was identified by eye, and a manual iterative procedure was carried out to ensure the division point was optimal. This procedure was followed for each of the 74 sites in the Ridge and Valley.*

Figure 4-1: Example of suspended-sediment rating relation in log-log space



Because the "effective discharge" is that discharge or range of discharges that shape channels and perform the most geomorphic work (transport the most sediment) over the long term it can serve as a useful indicator of regional suspended-sediment transport conditions for "reference" and impacted sites. In many parts of the United States, the effective discharge is approximately equal to the peak flow that occurs on average, about every 1.5 years ($Q_{1.5}$; for example, Andrews, 1980; Andrews and Nankervis, 1995) and may be analogous to the bank full discharge in stable streams. The recurrence interval of the effective discharge calculated for 10 streams in Mississippi was about 1.5 years (Simon et al., 2002). For 17 ecoregions across the United States, the recurrence interval of the effective discharge ranged from 1.1 years to 2.3 years (Simon et al., 2003). The value for the Ridge and Valley was 1.1 years. Still, for consistency of analysis between ecoregions, the $Q_{1.5}$ was used as a measure of establishing the effective discharge at the remaining study sites in the Ridge and Valley.

The suspended-sediment load at the $Q_{1.5}$ was then obtained by using the transport rating developed for the site and by solving for the discharge of the $Q_{1.5}$. For sites in Ecoregion 67 with peak flow and sediment-transport data, sediment load at the effective discharge was obtained directly from the rating relation. To normalize the data for watersheds of different size, the sediment load is divided by drainage area to obtain sediment yield (in T/d/km^2). All rating relations are checked to be sure that the $Q_{1.5}$ was within the measured bounds of the data set. If the $Q_{1.5}$ is more than 100% greater than the maximum sampled discharge, the calculated sediment yield is not included in the data set. This was the case for six of the 74 stations in the Ridge and Valley leaving 68 stations where suspended-sediment loads could be calculated at the $Q_{1.5}$.

Suspended-sediment yields at the effective discharge were calculated for each of the sites in the Ridge and Valley). The median suspended-sediment yield value at the $Q_{1.5}$ for all sites is 2.78 T/d/km^2. Mean annual suspended-sediment yield for stable/reference sites in the Ridge and Valley is 24.7 T/y/km^2.

Figure 4-2 and ***Figure 4-3*** show the distribution of reference suspended-sediment yields and annual average yields at $Q_{1.5}$ for the reference streams used in the 2003 Shades Creek Siltation TMDL.

Figure 4-2: Suspended-Sediment Yield at $Q_{1.5}$ for Ecoregion 67 reference sites (Simon et al., 2004)

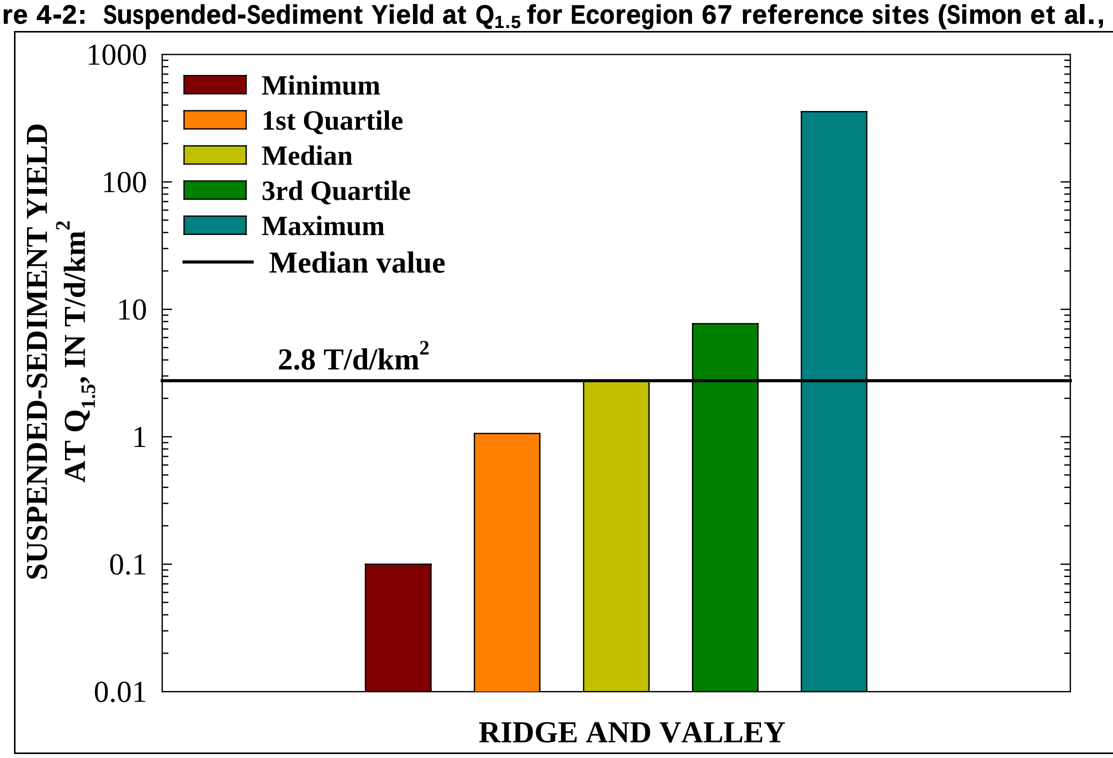
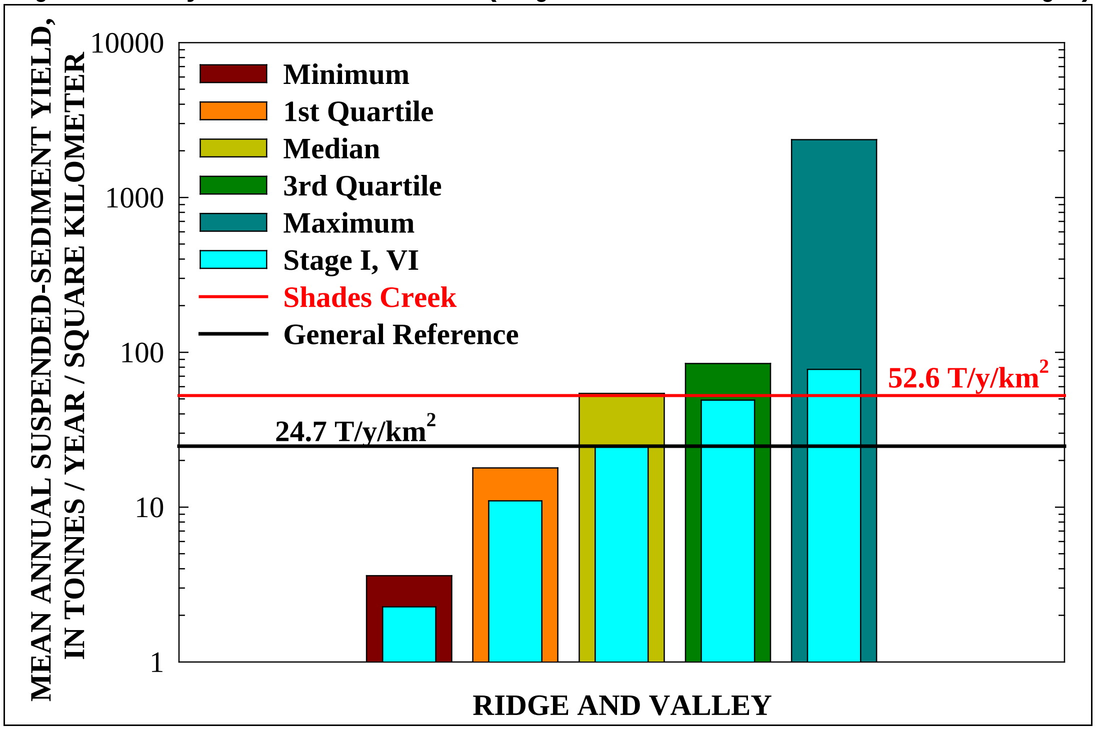


Figure 4-3: Comparison of mean annual suspended-sediment yield in "reference" streams in the Ridge and Valley and in Shades Creek. (Stage I and VI are stable stream channel stages).



These reference conditions were compared to existing loads in Shades Creek to determine the necessary load reductions in the TMDL. The same reference conditions were compared to the listed segments of the Cahaba River using historical flow data from certain U.S. Geological Survey (USGS) gaging stations in the Cahaba River and total suspended solids (TSS) data collected by the Jefferson County Environmental Services Department (JCESD), ADEM, and USGS. The resulting dataset ranges from 1990 to 2012. The target of 24.7 metric tons per square kilometer per year corresponds to 70.5 US short tons per square mile per year, and a concentration of 45 mg/l. These calculations can be found in ***Appendix 13.1: Target Calculations.*** This concentration limit represents an annualized value calculated based on a long-term flow and TSS data. Therefore, for permitting purposes, it will apply to monthly average TSS limits but not to daily maximum requirements.

It has been noted that the long-term sediment data collected for the development of the ecoregion reference yield in the form of SSC is not precisely the same analytical technique as TSS. USGS researchers have cautioned that there are factors that contribute to differences between SSC and TSS datasets (Gray et al. 2000). Yet, both metrics are essentially measures of instream sediment loading that compare at very close to a 1:1 ratio. For the purposes of this TMDL, and since ADEM and the regulated community in the Cahaba River measured TSS only and not SSC, the TSS datasets from ADEM and Jefferson County ESD were used to estimate the existing sediment loads in the Cahaba.

4.1.1 $Q_{1.5}$ Discussion

The bankfull stage (or effective discharge) is defined as the maximum discharge that can be contained within the stream channel without overtopping the banks. It is generally accepted in this ecoregion that the bankfull stage corresponds to a streamflow event that occurs, on average, every 1.1 to 1.5 years. In order to be most conservative, the highest reoccurrence interval of 1.5 years was used ($Q_{1.5}$). This value is important because it represents the discharge at which the largest proportion of suspended-sediment is transported over a long-term period.

By using the $Q_{1.5}$ values for stable reference sites to set the TMDL target, a maximum sediment loading and corresponding concentration was established. When comparing the target, 45 mg/l, to calculated $Q_{1.5}$ values using the site-specific regression equations for the Cahaba River; it is easy to see that this number is considered very conservative and is protective of water quality. For instance, using the regression equation and the $Q_{1.5}$ for the Cahaba River near Helena (USGS 02423555) site yields a concentration of over 250 mg/l. This illustrates that for larger storm events and during periods of high flow, the 45 mg/l concentration-based limit is clearly a conservative target. As the data shows, during dry periods with little or no rainfall, instream TSS concentrations in the Cahaba River are typically well below the 45 mg/l benchmark. TSS concentrations typically increase with flow even in healthy streams, but usually have a much lower proportion of suspended-sediment due to their stable banks and relatively undisturbed channel hydraulics. In contrast, heavily impacted streams with poor stability and degraded channel features have a much higher proportion of suspended-sediment during higher flow events.

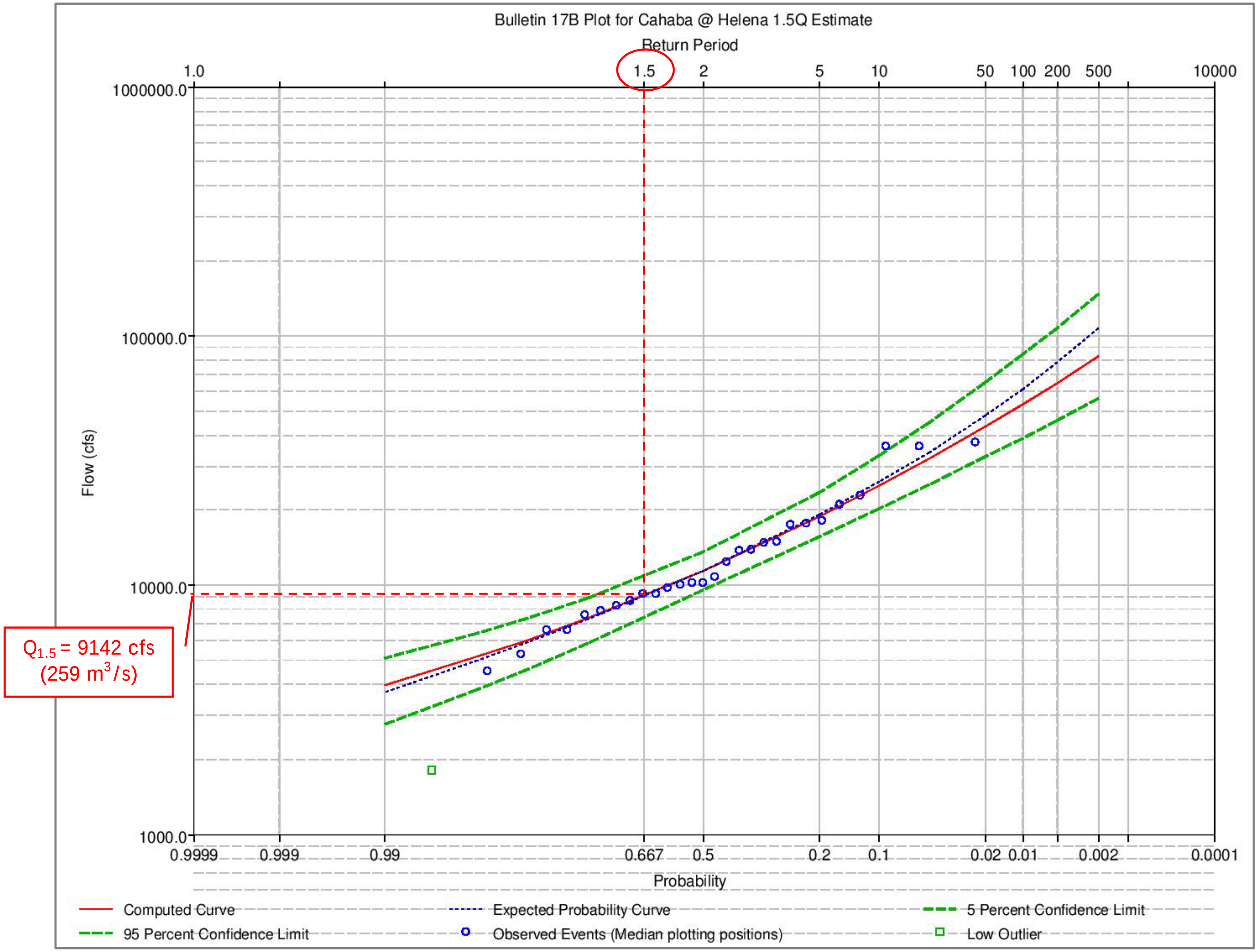
While the $Q_{1.5}$ values were used in identifying a target yield and concentration, the existing conditions were found using annual average loadings calculated using real streamflow data. Using a $Q_{1.5}$ statistic to calculate existing conditions would grossly overestimate the sediment transport relationship. The $Q_{1.5}$ value for each gaging site is displayed on the regression analysis only as a point of reference for bankfull stage. It should be noted that since the $Q_{1.5}$ values are calculated using actual peak streamflow data records for each gage, the results will vary depending on period of record, drainage area, etc.

Figure 4-4 on the following page shows an example of a $Q_{1.5}$ analysis performed for USGS gaging site #02423555 (Cahaba River near Helena). The $Q_{1.5}$ analyses were performed for all 6 USGS locations referenced in this report using the U.S. Army Corps of Engineers' (USACE) HEC-SSP software based on peak flow input data from USGS. ***Table 4-1*** below displays the results for each USGS site. The remaining $Q_{1.5}$ curves can be found in ***Appendix 13.3: Q1.5 Approximation & Results***.

Table 4-1: $Q_{1.5}$ Estimates for Selected USGS Stations

USGS Site ID	Site Description	Drainage Area (mi^2)	$Q_{1.5}$ (cfs)
02423130	Cahaba River @ Trussville, AL	19.7	2577
02423425	Cahaba River Near Cahaba Heights, AL	201	7475
02423496	Cahaba River Near Hoover, AL	226	7129
02423500	Cahaba River Near Acton, AL	230	9194
02423555	Cahaba River Near Helena, AL	335	9142
02424000	Cahaba River Near Centreville, AL	1027	22965

Figure 4-4: $Q_{1.5}$ Effective Discharge for USGS 02423555 (Cahaba River near Helena, AL)



4.2 Source Assessment

4.2.1 NPDES-Regulated Point Sources

An important part of the TMDL analysis is the identification of individual sources, source categories, or source subcategories of siltation in the watershed and the amount of pollutant loading contributed by each of these sources. Under the Clean Water Act, sources are broadly classified as either point or nonpoint sources. In 40 CFR 122.2, a point source is defined as a discernable, confined and discrete conveyance from which pollutants are or may be discharged to surface waters. The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Regulated point sources include: 1) municipal and industrial wastewater treatment facilities (WWTFs); 2) stormwater discharges associated with industrial activity (which includes construction activities); and 3) certain discharges from Municipal Separate Storm Sewer Systems (MS4s). A TMDL must provide Waste Load Allocations (WLAs) for all NPDES regulated point sources. For the purposes of this TMDL, all sources of sediment loading that are not subject to NPDES regulation will be considered nonpoint sources and addressed by the Load Allocation (LA) component of the TMDL.

Though ADEM will do its due diligence in identifying and notifying discharges located within the impaired area, it is the ultimately the responsibility of the NPDES permit holder or applicant. ***Map 12-1*** and ***Appendix Table 2*** present a summary of the hydrologic unit codes (HUCs) included in the Upper Cahaba River Watershed. NPDES Regulated discharges located within these HUCs are subject to the TMDL.

4.2.1.1 NPDES-Regulated Municipal, Semi-Public, & Private Facilities

There are many municipal, semipublic, and private wastewater treatment facilities (WWTFs) located within the Upper Cahaba River Watershed. Typically, these types of facilities are required to maintain monthly average TSS concentrations less than 30 mg/l. With respect to overall sediment loading, these levels are not significant compared to loadings generated during wet weather events. In addition, the TSS component of sewage treatment plant discharges is composed primarily of organic material different in nature than sediment produced from erosional processes. Therefore, these types of facilities are not considered to be significantly impacting the Cahaba River with respect to sediment impairment and will not be included in the WLA of this TMDL.

4.2.1.2 NPDES-Regulated Industrial Facilities

NPDES-regulated industrial facilities typically discharge TSS that is inorganic in nature. Within the Upper Cahaba River Watershed, most industrial discharges are covered under general permits. The heavily industrialized areas of Birmingham are historically on the north and west areas of the city. The south and east areas of the city have been the primary areas of residential growth over the last 50 years. Considering these demographics, municipal and residential sources of sediment are more of a problem in the Upper Cahaba Watershed than industrial sources.

4.2.1.2.1 Industrial General Permits

There are fourteen types of general permits represented in the Upper Cahaba River Watershed; namely asphalt, lumber and wood, concrete, metals, transportation, food, landfill, paint, salvage/recycling, plastics and rubber, stone/glass/clay, NCCW (non-contact cooling water), petroleum, and water treatment. These operations comprise a total of ~424 active permits to approximately 890 discharge locations. These facilities have process water and/or stormwater discharges with the potential to have TSS loading.

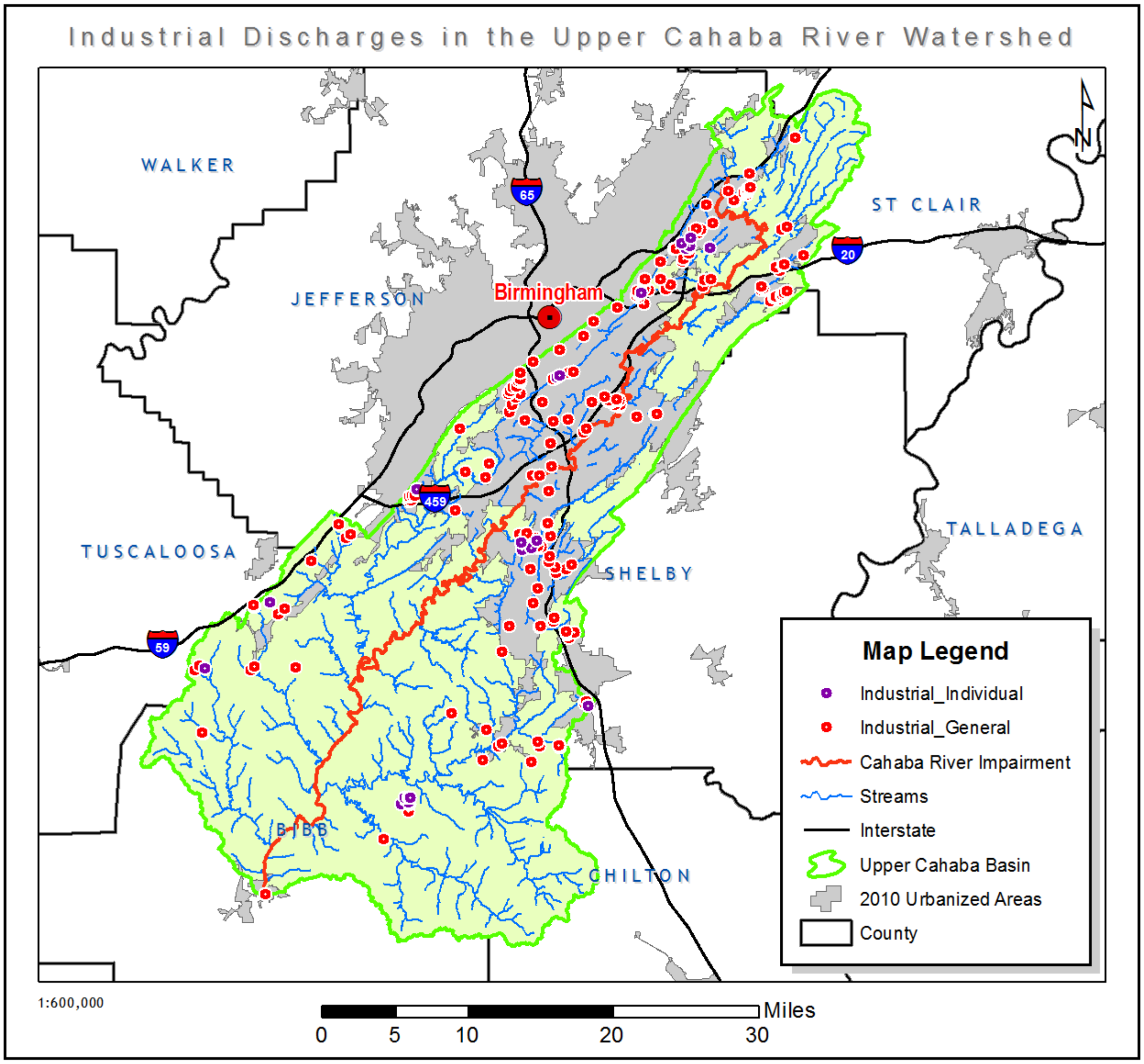
Facilities, such as concrete ready mix facilities, that produce process water must have operational containment in place and establish specific best management practices for the proper on-site handling of any sludge/solids removed from the process wastewater containment systems. The TSS limit on process water discharges is a daily maximum limit of 50 mg/l. Facilities that have potential stormwater sources of sediment must develop a Best Management Practices (BMP) Plan and implement the proper BMPs. They must identify potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges associated with industrial activity from the facility. In addition, the Stormwater Pollution Prevention Plan (SPPP) shall describe and ensure the implementation of practices which are to be used to reduce the pollutants in stormwater discharges associated with industrial activity at the facility and to assure compliance. On stormwater discharges, TSS is a “monitor only” parameter. New discharges shall have in place an impermeable containment and reclamation procedure/system for all process wastewater. See ***Map 4-1*** on the following page for an illustration of all the industrial facilities with a general permit.

4.2.1.2.2 Industrial Individual Permits

There are eleven industrial individual permits in the Upper Cahaba River Watershed. These facilities have process water and/or stormwater discharges with the potential to have TSS loading. Individual permits are more stringent than general permits as they have lower limits and/or have a higher frequency requirement for reporting. In the subject watershed, the limits for individual industrial permits vary from “report” to 30 mg/l. The facilities with “report” only are not believed to have consistent and/or significant sediment concentrations in their discharge water.

Similar to general permits, individual permits must develop a Stormwater Pollution Prevention Plan (SPPP) and implement the proper BMPs. They must identify potential sources of pollution which may reasonably be expected to affect the quality of stormwater discharges associated with industrial activity from the facility. In addition, the SPPP shall describe and ensure the implementation of practices which are to be used to reduce the pollutants in stormwater discharges associated with industrial activity at the facility and to assure compliance. See ***Map 4-1: Industrial Discharges in the Upper Cahaba River Watershed*** for an illustration of all industrial facilities in the Upper Cahaba River Watershed.

Map 4-1: Industrial Discharges in the Upper Cahaba River Watershed



4.2.1.3 NPDES-Regulated Mining Facilities

NPDES-regulated mining facilities have the potential to discharge inorganic sediment and therefore are subject to this TMDL. The Upper Cahaba River Watershed has a diverse geologic landscape, and minerals mined include limestone, coal, sand and gravel, clay, and metallic ores. The discharges from these facilities are typically stormwater driven and, in nearly all cases, require a sediment treatment pond. Mining activities are permitted in cooperation with the Alabama Surface Mining Commission (ASMC), Alabama Department of Industrial Relations (ADIR) and ADEM. There are approximately 40 active mining permits with 465 permitted outfalls located within the watershed.

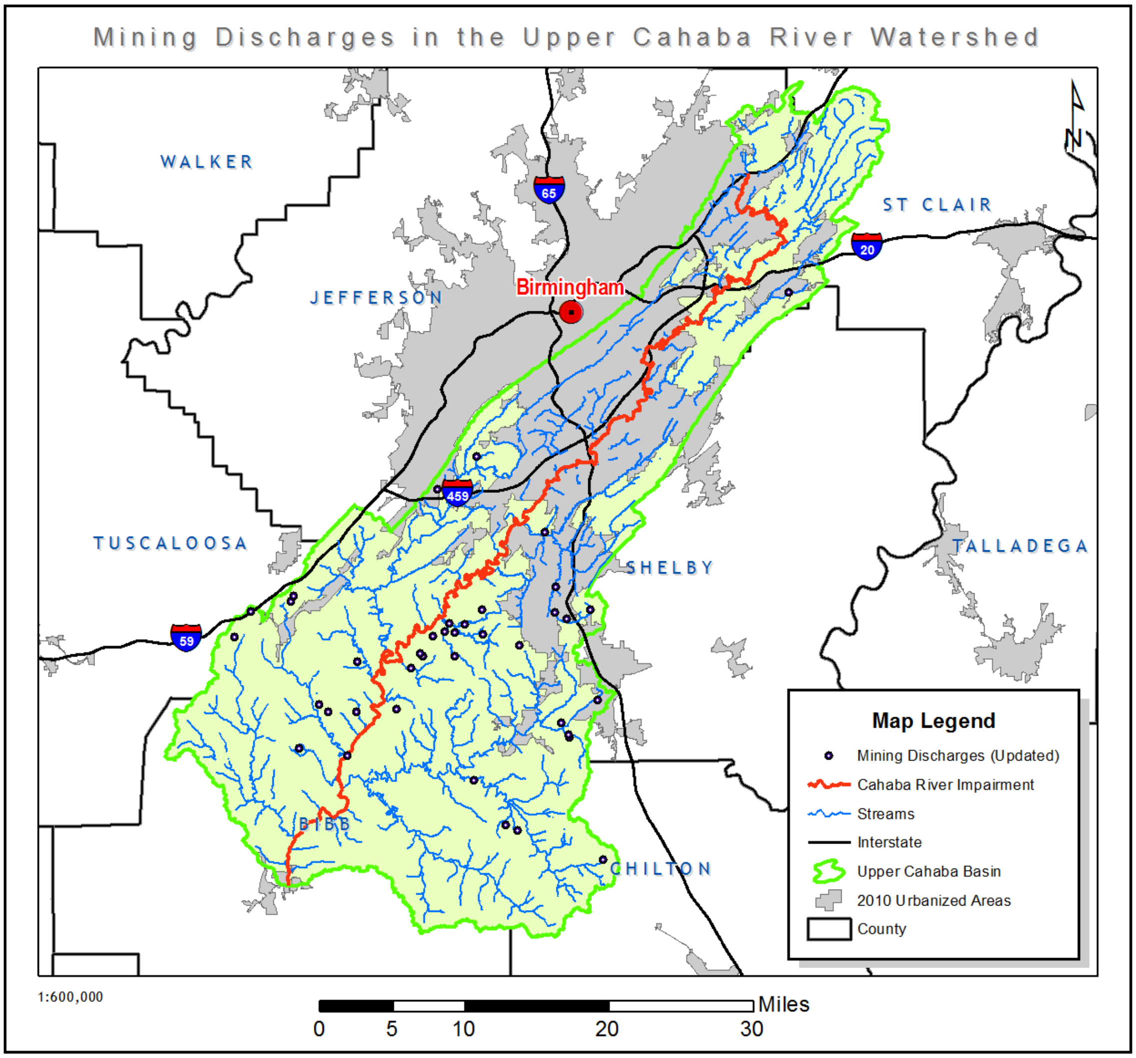
Mining facilities have both a monthly average and daily maximum TSS concentration limit. TSS limits vary by permit type and are shown in ***Table 4-2***.

Table 4-2: TSS Limits for Existing Mining Facilities

Mining Facility Type	Monthly Average	Daily Maximum	Sampling Frequency
Coal	35 mg/l	70 mg/l	2 X / Month
Sand & Gravel	35 mg/l	70 mg/l	2 X / Month
Crushed Stone (Quarries)	25 mg/l	45 mg/l	2 X / Month
Shale / Common Clay	N/A	35 mg/l	2 X / Month

Considering the large area of disturbed drainage area, special attention must be given in all mining activities to proper BMP and treatment pond design, construction, and maintenance. When executed properly, these areas can sometimes improve the water quality of runoff from certain landuse types. However, if the permit requirements are not strictly followed, there can be significant sediment loading. *Map 4-2* shows all facilities with an individual mining permit that discharge to the Upper Cahaba Watershed.

Map 4-2: Active Mining Operations in the Upper Cahaba Watershed



4.2.1.4 NPDES-Regulated Construction Stormwater General Permits

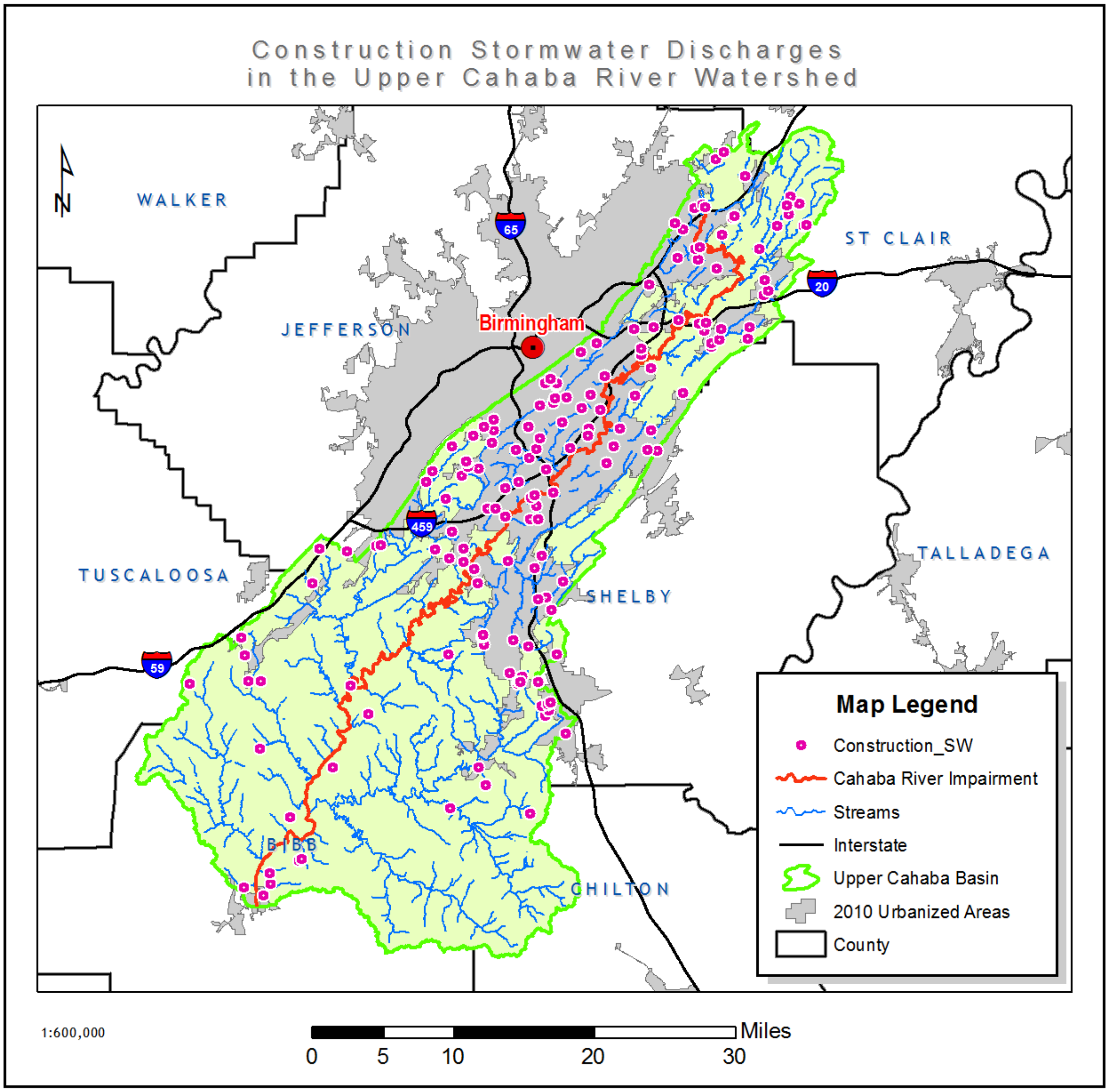
Discharges from construction activities that result in a total land disturbance of one acre or greater (including sites less than one acre but are part of a common plan of development or sale) are regulated through ADEM's Stormwater Management Branch. Permitted discharges are required to adhere to erosion and sediment controls which reduce stormwater velocity and volume, minimize amount of soil exposed, minimize stream crossings, provide and maintain buffers around surface waters, etc. Sediment and erosion control measures are site-specific and must meet or exceed the technical standards outlined in the *Alabama Handbook for Erosion Control*. A Construction Best Management Practices Plan (CBMPP) is required to be in place for all active projects or where continued land disturbance exists. This plan is to be maintained and updated for the life of the project. Where applicable, additional control measures may be required in order to achieve pollutant reductions consistent with an approved TMDL.

In addition to proper CBMPPs, discharges are also required to prepare, implement, and maintain a Spill Prevention Control and Countermeasures Plan (SPCC) where applicable. Sites are required to conduct regular monitoring and also are required to complete a full inspection no later than 72-hours after a qualifying rain event. Although not given a numeric TSS limit, some discharges are required to monitor for turbidity in the receiving stream(s) upstream of the project, just prior to discharge from the site(s), and immediately downstream of the mixing zone(s).

CBMPPs require full implementation and continued maintenance of effective structural and non-structural practices, as well as planning/management strategies, that ensure effective erosion and sediment control. By treating stormwater to the maximum extent practicable prior to discharge, the introduction of pollutants to surface waters is prevented or minimized. CBMPPs also require the treatment of construction associated non-stormwater discharges including but not limited to, pit dewatering, and the proper handling and disposal of construction wastes, and prevention of the discharge of petroleum products, solvents, and other chemicals. CBMPPs call for implementation of effective construction site nutrient management practices, temporary, annual, or perennial vegetation management, minimally disturbed natural riparian buffer area, fully vegetated filter strips, and streambank management practices. A CBMPP/BMP can be a single practice or more than one practice that combined will provide continuing effective treatment. Any management practice, structure, or procedure, that is not recognized by ADEM as a BMP based on performance, not installed/implemented correctly, not maintained, not adequately or properly located/sited, not suitable for the specific site conditions, not designed or configured to control potential or existing site conditions where the BMP is located, including but not limited to, steep slopes or grades, soils, potential precipitation and size of drainage area, which is not consistent with effective erosion and sediment control, that does not meet or exceed recognized effective industry standard practices, or not consistent with the Alabama Handbook or other ADEM recognized BMP documents, is not considered or recognized as a BMP. The Alabama Handbook mentioned previously can be found here:
http://swcc.alabama.gov/pages/erosion_handbook.aspx.

See ***Map 4-3***: NPDES Construction Stormwater Discharges in the Upper Cahaba Watershed for an illustration of all the CSW permits located within the watershed.

Map 4-3: NPDES Construction Stormwater Discharges in the Upper Cahaba Watershed



4.2.1.5 NPDES-Regulated Municipal Separate Storm Sewer Systems (MS4s)

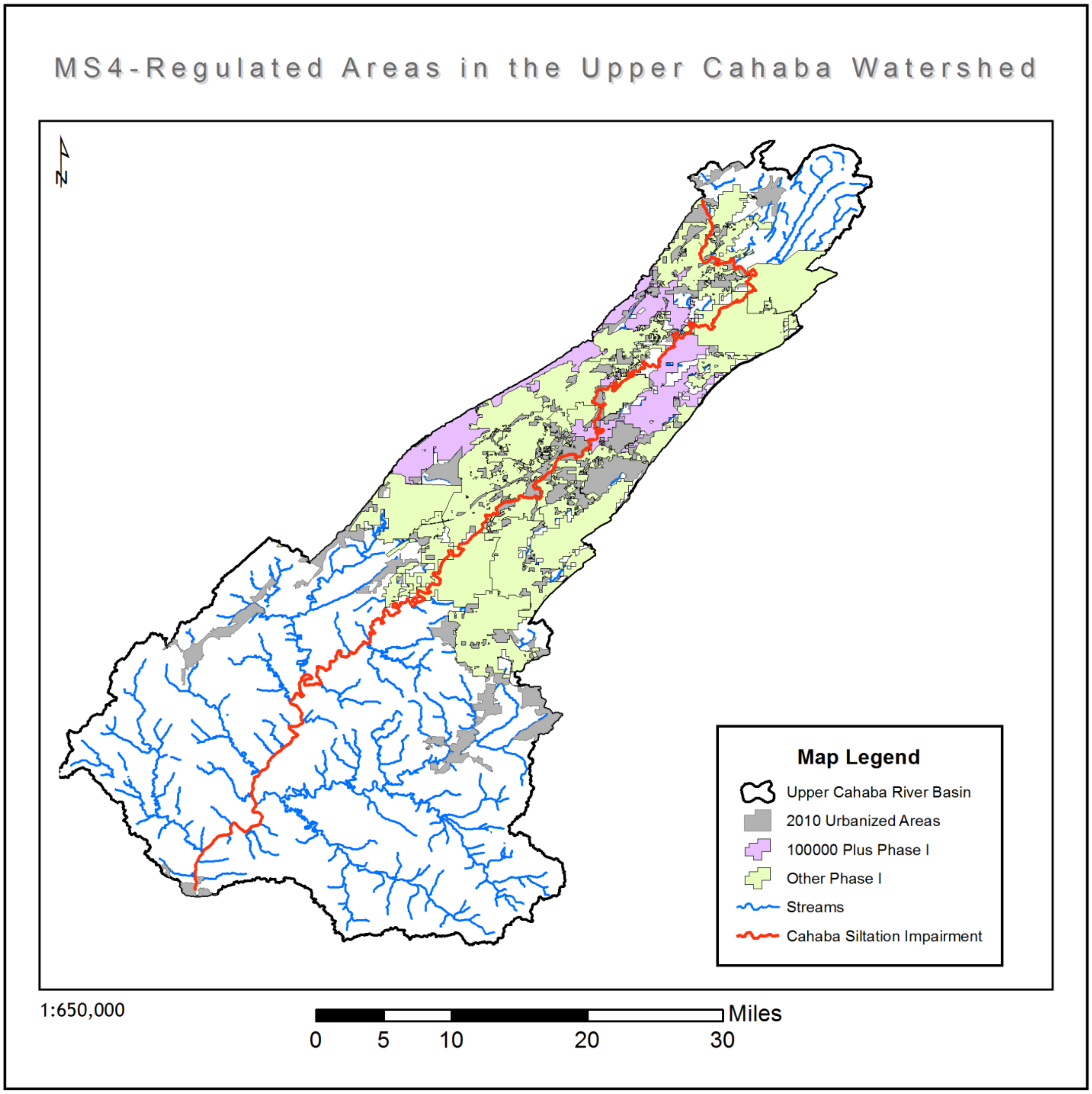
The majority of the Upper Cahaba Watershed has been defined as a phase-I MS4 area. There are currently two phase-I permits within the upper Cahaba River watershed: Jefferson County & Shelby County. Pursuant to federal regulations all discharges that are regulated under phase-I or phase-II of the NPDES stormwater program are considered point sources and must be included in the WLA portion of the TMDL. Increased urbanization of the Upper Cahaba River Watershed is widely considered one of the primary causes for habitat loss and sedimentation within portions of the Cahaba River. As development increases in a watershed, so does impervious surfaces such as paved roads, parking lots, roofs, concrete storm drains, curb and gutter, and drive ways. With the increase of impervious surfaces, the total volume and stream power increases exponentially. This process can dramatically alter the stream morphology, bed characteristics, and habitat by blowing out stream sinuosity, degrading stream banks, depositing excess sediment, and scouring sensitive habitat.

Since MS4s are conveyance systems which discharge stormwater directly to waters of the United States and are permitted under the NPDES program, they are, by definition, a point source. Point sources are addressed in the WLA portion of a TMDL. Under section 303(d) of the Clean Water Act, states must create a list of impaired waters and subsequently develop a TMDL for these impaired waterbodies. In addition, 40 CFR Parts 122.26 and 122.30-122.37 define what constitutes a MS4 and establishes that they will be treated as a point source under the NPDES and TMDL programs. 40 CFR 122.34 goes on to state the following:

> *(e)(1) You must comply with any more stringent effluent limitations in your permit, including permit requirements that modify, or are in addition to, the minimum control measures based on an approved total maximum daily load (TMDL) or equivalent analysis. The permitting authority may include such more stringent limitations based on a TMDL or equivalent analysis that determines such limitations are needed to protect water quality.*

MS4 permits do not have TSS limits, but are managed with BMPs, stormwater management, and sampling initiatives. See ***Appendix Table 3*** for a detailed listing of all the MS4 permits discharging to the Upper Cahaba River Watershed and ***Map 4-4*** for a map of the MS4 area.

Map 4-4: MS4 Boundaries of the Upper Cahaba River Watershed



4.2.2 Nonpoint Sources

Each land use has the potential to contribute to sediment loading, however, these impacts are more likely to occur in areas with non-natural land uses (USEPA, 2003a), corresponding to acute events such as land disturbance caused by land development and construction, and chronic issues such as altered hydrology and magnified peak flows. As discussed in ***Section 2.3*** and ***3.2.4***, the Upper Cahaba Watershed has areas of intense development, which contribute to both acute and chronic issues.

4.2.3 Source Discussion

Field observations by ADEM, Tetra Tech, Inc. and researchers from Mississippi State University indicate that excessive siltation in the Cahaba River seem to derive from two general causes: acute and chronic sediment loading.

4.2.3.1 Acute Sediment Loading

Acute sediment loading—as a result of discrete land disturbances, generally of limited duration, and precipitation events that deliver "pulses" of fine sediments to the river, and Chronic sediment loading—long-term stream channel instability caused by magnified urban hydrology due to high fractions of impervious area and resulting in excessive suspended-sediment and bed load after precipitation events.

Acute sediment loading can result from any land disturbances such as road or building construction or mass grading. Highly-weathered clay soils in the central Alabama region are very erodible. Even though best management practices are implemented in the watershed, often the fine sediments can defeat or overwhelm the minimum barriers of traditional silt fences. In cases where stormwater runoff controls are not adequately considered, the loading from a single rain event can effectively "smother" the riverbed in certain areas until natural stream processes transport the material downstream. In this way a "pulse" of fine material may progress down river.

4.2.3.2 Chronic Sediment Loading

Chronic sediment loading results from stream instability. This happens when banks are failing due to high peak flows and dissipating excessive stream power causing channel evolution. Chronic sediment loading can be measured as an annual average suspended-sediment load that is high compared to reference streams.

In the case of the Cahaba watershed, major streambank instabilities were observed at the Bain's Bridge site on the Cahaba River, and at sites on Little Shades Creek and Patton Creek, based on geomorphic assessments described in the following section. All of the unstable sites are in the vicinity of highly urbanized areas with high percentages of impervious land cover in the form of roads, parking lots, and roofs. Magnified peak runoff from these urban areas has caused irreversible changes in stream channel structure that will continue to evolve and discharge sediment. The natural process of channel evolution (Simon, 1992) may result in a re-stabilized channel over geologic time, but due to the extreme alteration of hydrologic conditions experienced in the middle Cahaba watershed, such a natural re-stabilization seems highly unlikely, unless the hydrologic conditions can be remediated to near pre-development conditions.

In addition to the impairment of the Cahaba mainstem, there are also problem areas in tributaries that feed the Cahaba. For instance, even in segments where the Cahaba River itself is considered "stable," there may be tributaries that are unstable and/or contributing to the siltation impairment. This is yet another reason why the TMDL looks at the watershed as a whole.

4.2.3.3 Instream versus External Sediment Contributions

While there is room for debate on the sources and allocation of suspended-sediment within the Cahaba River, the sediment target was established based on stable reference sites within the same ecoregion. By using this target, it ensures that regulated entities are treating effluent and managing stormwater to a level that is known to be protective of water quality and aquatic life. Without these controls, suspended-sediment from man-made sources would certainly exacerbate any instream erosional processes. The target yield and concentration applies to the entire watershed, including both point sources and nonpoint sources.

4.3 Data Availability

Suspended-sediment data utilized in this TMDL report were collected by ADEM field personnel and Jefferson County Environmental Services Department (JCESD). Suspended-sediment datasets from USGS were also used for gaging locations where such data was available. This data varies by sample site, but generally ranges from 1990 – 2012. After establishing the relationship between TSS data and instantaneous flow data, daily average USGS flows were used in collaboration with the regression model to calculate annual load estimates. USGS Flows, available from http://waterdata.usgs.gov, included full years of record from 1990-2012.

For calculation of $Q_{1.5}$ values, USGS peak flow data was downloaded for the entire period of record of each gaging site from the USGS website.

All data gathered for Cahaba TMDLs are housed in a Water Resources Database (WRDB) which encompasses field parameters, samples analyzed for water chemistry, meteorological information, discharge monitoring reports (DMRs) and GIS data. An effort was made to include data from all available sources for the most comprehensive assessment possible. The data gathered for this project was obtained with the cooperation of agencies such as the US Geological Survey (USGS), the Geological Survey of Alabama (GSA), Jefferson County Environmental Services Department (JCESD), the Birmingham Water Works and Sewer Board (BWWSB), the Cahaba River Society (CRS), the US Environmental Protection Agency, and the Cahaba River Basin Project Steering Committee (now known as the Cahaba River Basin Clean Water Partnership). A preliminary summary of the sampling locations and available data was prepared by Tetra Tech, Inc. in November 2002 (Tetra Tech, 2002).

5.0 Technical Approach

Establishing the relationship between instream water quality and source loading is an important component of TMDL development. It allows the determination of the relative contribution of sources to total pollutant loading and the evaluation of potential changes to water quality resulting from implementation of various management options. This relationship can be developed using a variety of techniques ranging from quantitative and qualitative assumptions based on scientific principles to numerical computer modeling.

For evaluating siltation loading, a sediment loading curve approach, comparing suspended-sediment loads with streamflow at certain sites, was utilized to be consistent and comparable with the revised *Final Total Maximum Daily Load for Siltation, Turbidity, and Habitat Alteration in Shades Creek* (USEPA Region 4, 2004).

5.1 Sediment Loading Curve Approach

5.1.1 Flow and Suspended-Sediment Loading Curves

Based on the target reference yields derived by staff of the USDA/ARS National Sediment Laboratory, Channel and Watershed Process Research Unit and application of the target yields to the revised Shades Creek TMDL, a similar procedure was followed to derive suspended-sediment regressions based on measured TSS concentrations and USGS streamflow.

Suspended-sediment data were available for the Cahaba River from Jefferson County ESD sampling efforts, as well as ADEM and USGS data. Samples of suspended-sediment concentrations were used in conjunction with the instantaneous discharge at the time of sample collection in order to compute suspended-sediment transport rates and mean annual suspended-sediment loads/yields. These metrics can be used to evaluate chronic suspended-sediment loading.

The siltation 303(d)-listed segments of the Cahaba River are divided into eight segments:

Table 5-1: Segmentation and Drainage Areas

Segment #	Segment Location	Segment Drainage Area (mi²)	Total Drainage Area (mi²)
Segment 1	US Hwy 11 to I-59	19.7	19.7
Segment 2	Grants Mill Road to US Hwy 11	109.3	129
Segment 3	US Hwy 280 to Grants Mill Road	25	197 (154*)
Segment 4	Buck Creek to US Hwy 280	62	259
Segment 5	County Road 52 to Buck Creek	76	335
Segment 6	Shades Creek to County Road 52	86	421
Segment 7	Little Cahaba River to Shades Creek	229	650
Segment 8	AL Hwy 82 to Lower Little Cahaba River	377	1,027

*Segment 3 has an effective drainage area of 154 sq. mi. excluding the Lake Purdy drainage

Despite a wealth of data collected in the Cahaba River Watershed in recent years, there were only six sites on the Cahaba River with an adequate amount of data to perform this loading curve analysis. This is because the loading curve and annual loading assessment requires TSS samples at a wide range of flows, particularly at higher flows, in addition to a long-term flow record. TSS data collected by ADEM, USGS, and Jefferson County Environmental Services Department (JCESD) from 1991 – 2012 and long-term USGS streamflow were utilized in the loading curve analysis. The six USGS sites are shown in ***Table 5-2***. The location of these sites is shown in ***Map 5-1*** and additional data is provided in the ***Appendix***.

Table 5-2: USGS Streamflow Gaging Sites with Flow Record Used in Loading Curves

USGS Site	Name	Drainage Area (mi^2)	Latitude	Longitude
02423130	Cahaba River at Trussville	19.7	33.6306°	-86.5994°
02423425	Cahaba River near Cahaba Heights	201 (152.5*)	33.4156°	-86.7397°
02423496	Cahaba River near Hoover	226	33.3692°	-86.7842°
02423500	Cahaba River near Acton	230	33.3625°	-86.8133°
02423555	Cahaba River near Helena	335	33.2844°	-86.8825°
02424000	Cahaba River near Centreville	1027	32.9450°	-87.1392°

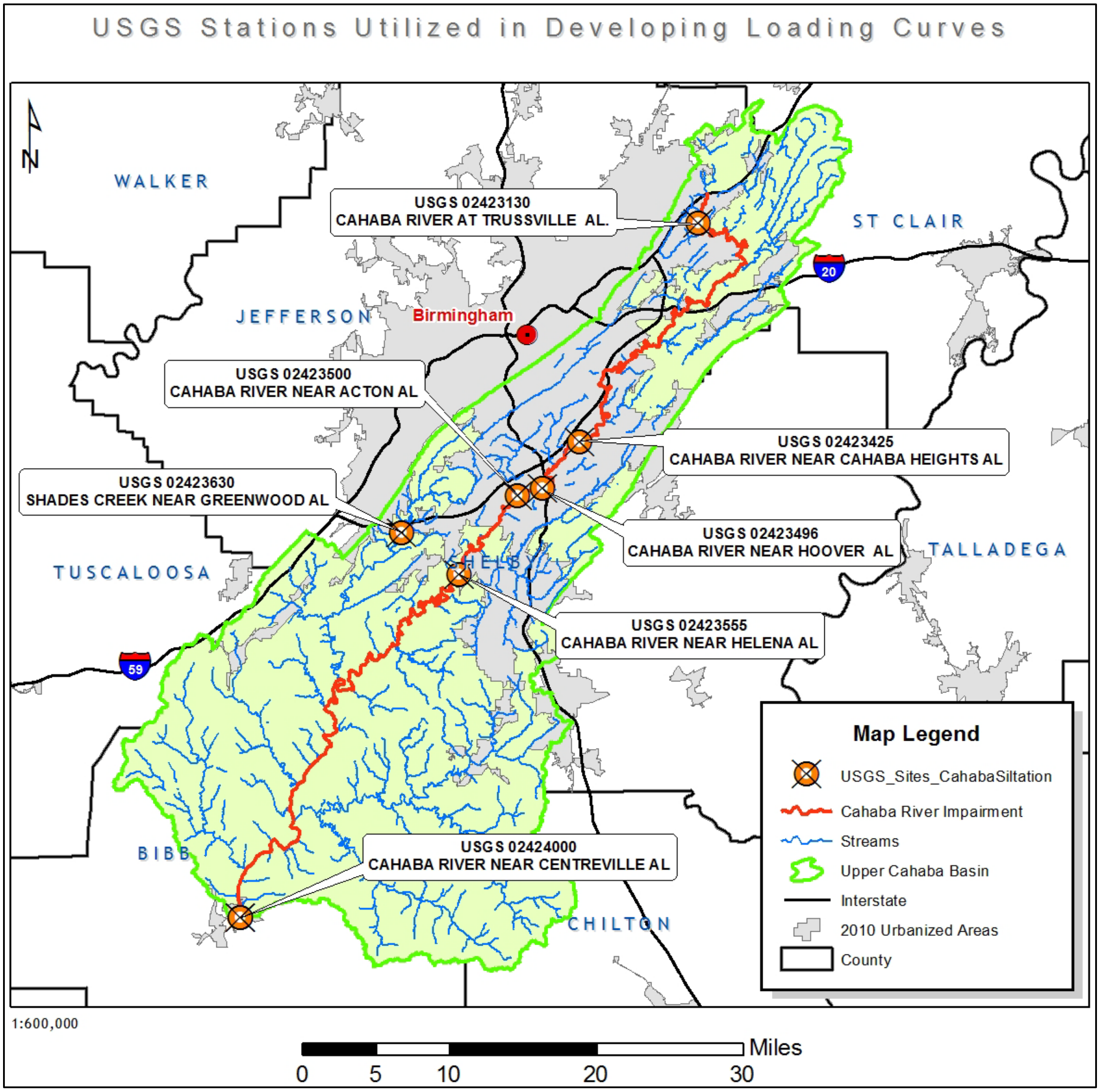
*02423425 has effective drainage area of 152.5 sq. mi. excluding the Lake Purdy drainage

In order to establish an accurate and useful transport relationship, there are a few dataset requirements that must be met. First, there must be an adequate amount of suspended-sediment and flow data. Second, this data must be distributed across the flow spectrum to capture both extremes and values in between. For example, using only data points on the low end of the spectrum may still produce a transport relationship with a strong correlation and R^2 coefficient, but it would be grossly inaccurate at predicting sediment transport during periods of higher flow.

Concerns were raised during the public participation period about using such a long data window for establishing the “existing condition.” Initially, the calculations were revised to only account for the most recent years of data. Though the correlation remained strong like the scenario mentioned above, the regression equation underestimated annual loadings due to the limited dataset and lack of measurements during peak flow events. Moreover, the presence of several drought years in such a short range of time also biased the data. As a result, the original dataset (1990 – 2012) was utilized to establish the most accurate transport rating curve for the final TMDL analysis.

The station that exhibited the highest transport relationship was USGS 02423555 (Cahaba River near Helena, AL). Data for this station consisted of over 550 instantaneous data points that were taken at various river stages (from 1.29 cfs up to 21,500 cfs) and had a R^2 coefficient of 0.88. The complete results of the transport rating curve analysis are contained in the following section (***Regression Analysis Calculations***).

Map 5-1: USGS Stations Utilized in Loading Curve Development



5.1.2 Regression Analysis Calculations

Note that both English SI units and US customary units are discussed within this report. For the data analysis, all calculations were made using SI units and subsequently converted to US customary units as needed. It is important to maintain one unit set during analysis.

Power function relationships were developed using regression analyses for each gaging site based on suspended-sediment data coupled with the instantaneous streamflow at the time of data collection. From this relationship, mean annual sediment transport and yields were calculated using daily streamflow data from USGS. The power functions have the following formula:

$$L = a * Q^{b}$$

Where ***L =*** suspended-sediment load, ***Q*** = streamflow, and ***a*** and ***b*** are regression constants

Based on these equations, it is possible to estimate the sediment loads for any day with recorded mean daily streamflow. With a long-term flow record, the estimated load may be calculated for every day of the year, thus comprising an estimate of the total annual suspended-sediment load. There is significant statistical random error associated with the calculation, but due to the high variability of sediment concentrations, this is the best possible estimate of suspended-sediment loading.

Daily suspended-sediment transport was calculated at each gage by applying the appropriate rating equation to the mean discharge for each day, giving a mean daily suspended-sediment load. Daily loads for calendar years 1990 - 2012 were used to determine mean annual suspended-sediment load, and then normalized by drainage area to obtain the annual suspended-sediment yield (tonnes/year/km^2). Following is a brief summary of how the regression relationships were established (also see :

1. Instantaneous TSS/SSC (mg/l) field measurements were plotted against corresponding real-time USGS flow (m^3/s) in log_{10}/log_{10} space.
2. A regression equation based on a power function fit was used to relate suspended-sediment to flow.
3. USGS daily average flow data was downloaded for all available years of record ranging from 1990 to 2012. Partial years were omitted as to avoid seasonal bias.
4. For each calendar year, sums for suspended-sediment load (Tonnes/yr) and volume (m^3) were calculated (Load = Concentration * Flow).
5. These yearly sums were then divided by the drainage area (km^2) of their respective gaging site to yield a normalized average loading per unit area (Tonnes/km^2/yr).
6. The individual yearly values in step 5 were then summed and divided by the number of years, resulting in a normalized mean annual suspended-sediment load for each USGS site.
7. Mean annual TSS concentrations (mg/l) were also calculated by dividing the annual load value by the corresponding total annual volume for each station.
8. These values were then compared to median reference loads (i.e. the TMDL "target") established for Ecoregion 67 and the Upper Cahaba River Basin.

Figure 5-1 shows an example of the regression analysis and ***Table 5-3*** summarizes the results for each USGS station. Finally, ***Figure 5-2*** shows annual yields for the Helena site as a function of time.

Figure 5-1: Regression Analysis Results for Cahaba River near Helena (USGS 02423555)

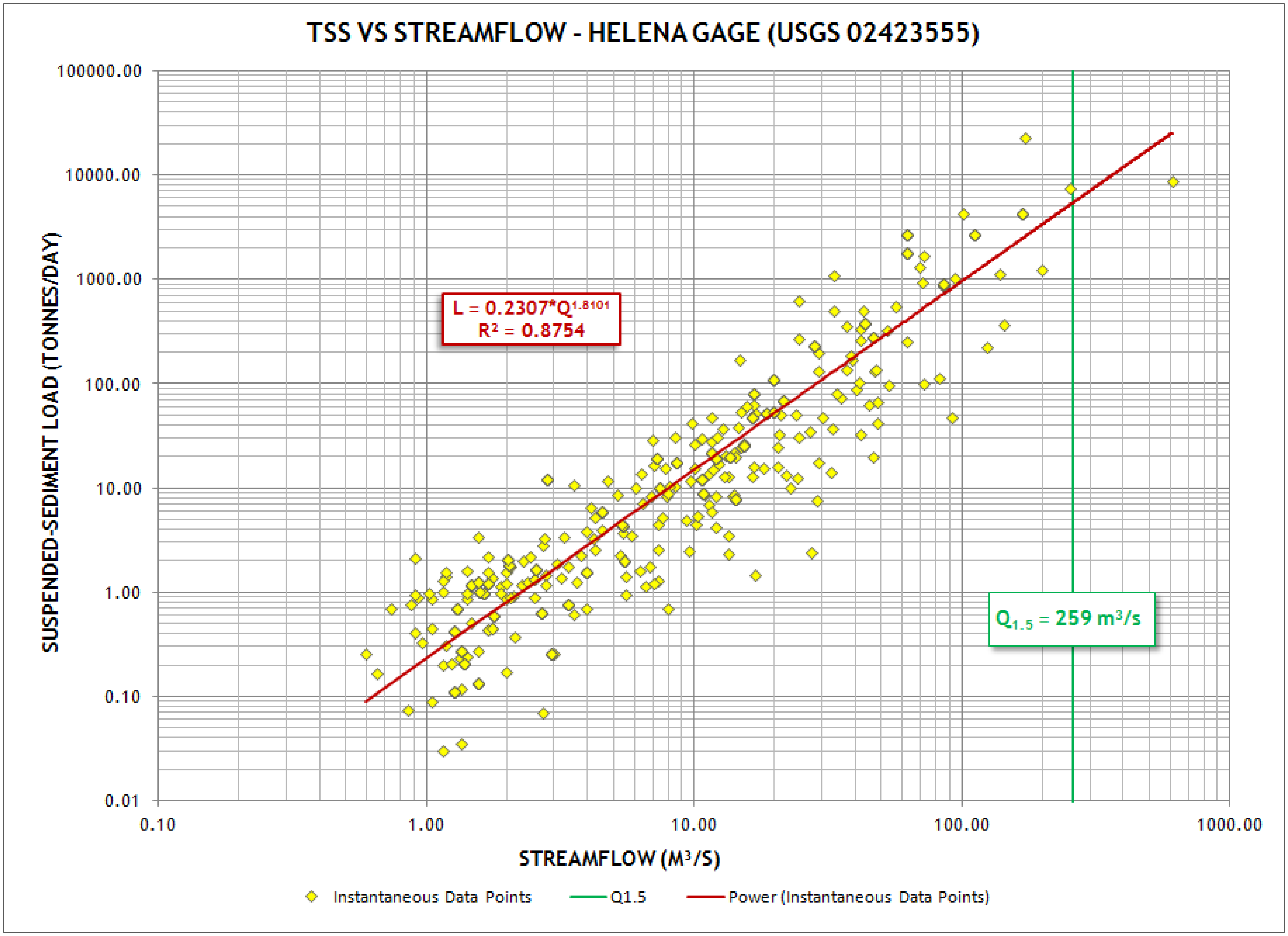


Table 5-3: Summary of Sediment-Transport Curve Results by Sampling Location

SI UNITS

USGS ID	Name	Drainage Area (km²)	Regression Equation	R^2	Mean Annual Suspended Sediment (tonnes/yr)	Mean Annual Yield (tonnes/km²/yr)	Mean Annual TSS Concentration (mg/L)	% Reduction Required	Segments Represented
02423130	Cahaba River at Trussville, AL	51	$L = 0.5733*Q^{1.2144}$	0.76	259	5.1	8.7	None	1
02423425	Cahaba River near Cahaba Heights, AL	521 (395*)	$L = 0.4760*Q^{1.4835}$	0.89	7343	18.6	29.2	None	2,3
02423496	Cahaba River near Hoover, AL	585	$L = 0.4634*Q^{1.7101}$	0.86	26823	45.8	80.8	46%	4
02423500	Cahaba River near Acton, AL	596	$L = 0.3479*Q^{1.5992}$	0.86	14713	24.7	37.6	None	4
02423555	Cahaba River near Helena, AL	868	$L = 0.2307*Q^{1.8101}$	0.88	41138	47.4	77.0	48%	5,6
02424000	Cahaba River near Centreville, AL	2660	$L = 0.0905*Q^{1.7282}$	0.81	52907	19.9	34.6	None	7,8

*USGS Gage 02423425 has an effective drainage area of 395 km² excluding Lake Purdy drainage area

US STANDARD UNITS

USGS ID	Name	Drainage Area (mi²)	Regression Equation	R^2	Mean Annual Suspended Sediment (tons/yr)	Mean Annual Yield (tons/mi²/yr)	Mean Annual TSS Concentration (mg/L)	% Reduction Required	Segments Represented
02423130	Cahaba River at Trussville, AL	19.7	$L = 0.5733*Q^{1.2144}$	0.76	285	14.4	8.7	None	1
02423425	Cahaba River near Cahaba Heights, AL	201 (152.5*)	$L = 0.4760*Q^{1.4835}$	0.89	8094	52.5	29.2	None	2,3
02423496	Cahaba River near Hoover, AL	226	$L = 0.4634*Q^{1.7101}$	0.86	29567	129.5	80.8	46%	4
02423500	Cahaba River near Acton, AL	230	$L = 0.3479*Q^{1.5992}$	0.86	16219	69.8	37.6	None	4
02423555	Cahaba River near Helena, AL	335	$L = 0.2307*Q^{1.8101}$	0.88	45347	133.9	77.0	48%	5,6
02424000	Cahaba River at Centreville, AL	1027	$L = 0.0905*Q^{1.7282}$	0.81	58319	56.2	34.6	None	7,8

*USGS Gage 02423425 has an effective drainage area of 152.5 mi² excluding Lake Purdy drainage area

Figure 5-2: Annual Sediment Yield by Year (Helena 02423555)

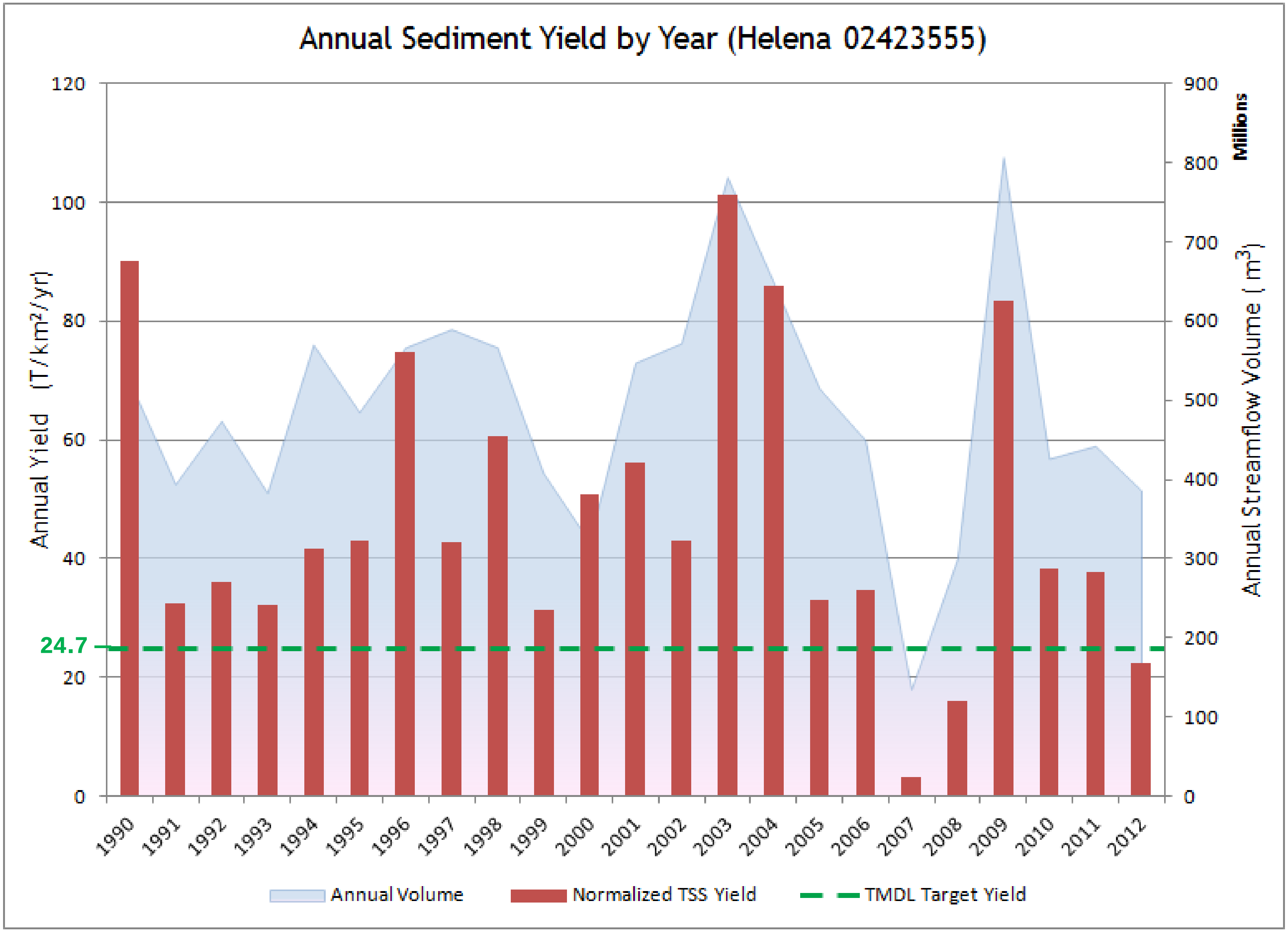


Figure 5-2 further illustrates the relationship between streamflow (and volume) and suspended-sediment transport. In drought years such as 2007, it is clearly evident that without the volume of water as the transport medium of sediment, yields drop dramatically. This also demonstrates why using a longer period of record is important when developing suspended-sediment transport relationships. Including drought years as well as years of abundant flow tends to minimize the biasing effect of anomalies within the dataset since they compensate for one another over longer periods of time.

The USGS stations used for the sediment yield calculations are not at the end points for each impaired segment, so yields for each segment cannot be precisely represented. Moreover, source assessment and determining what percentage of suspended-sediment was from upstream sources or instream erosional processes would also be virtually impossible. The USGS sites do, however, offer a good representation of this watershed as a whole. The difference between the reference values (TMDL target) and the calculated existing loadings/concentrations were analyzed. The highest yield of all the USGS stations was observed at USGS 02423555 (Cahaba River near Helena, AL). This value, 47.4 T/km^2/yr (133.9 t/mi^2/yr), was used to calculate the required percent reduction for this TMDL by comparing it to the reference yield for stable streams introduced in *Water Quality Target Identification* (*Section 4.1*).

The target reference yield of 70.5 tons/mi^2/year corresponds to 24.7 metric tonnes/km^2/yr (developed by National Sediment Laboratory for Ecoregion 67 which was also used in USEPA's development of the Shades Creek TMDL, 2004). See *Table 5-4* and *Table 5-5* for the reductions necessary to meet the TMDL target.

Table 5-4: Required Reductions in Suspended-Sediment in the Upper Cahaba River Basin

USGS Gage	Station Name	Existing Load (tons/yr)	Existing Yield (tons/mi^2/yr)	Allowable Yield (tons/mi^2/yr)	Percent Reduction
02423555	CAHABA RIVER NEAR HELENA	45,347	133.9	70.5	48%

Since many land disturbances are much smaller than a square mile, it is helpful to characterize the required reductions on a smaller scale. The following table shows the same reductions requirements in terms of pounds per acre per year.

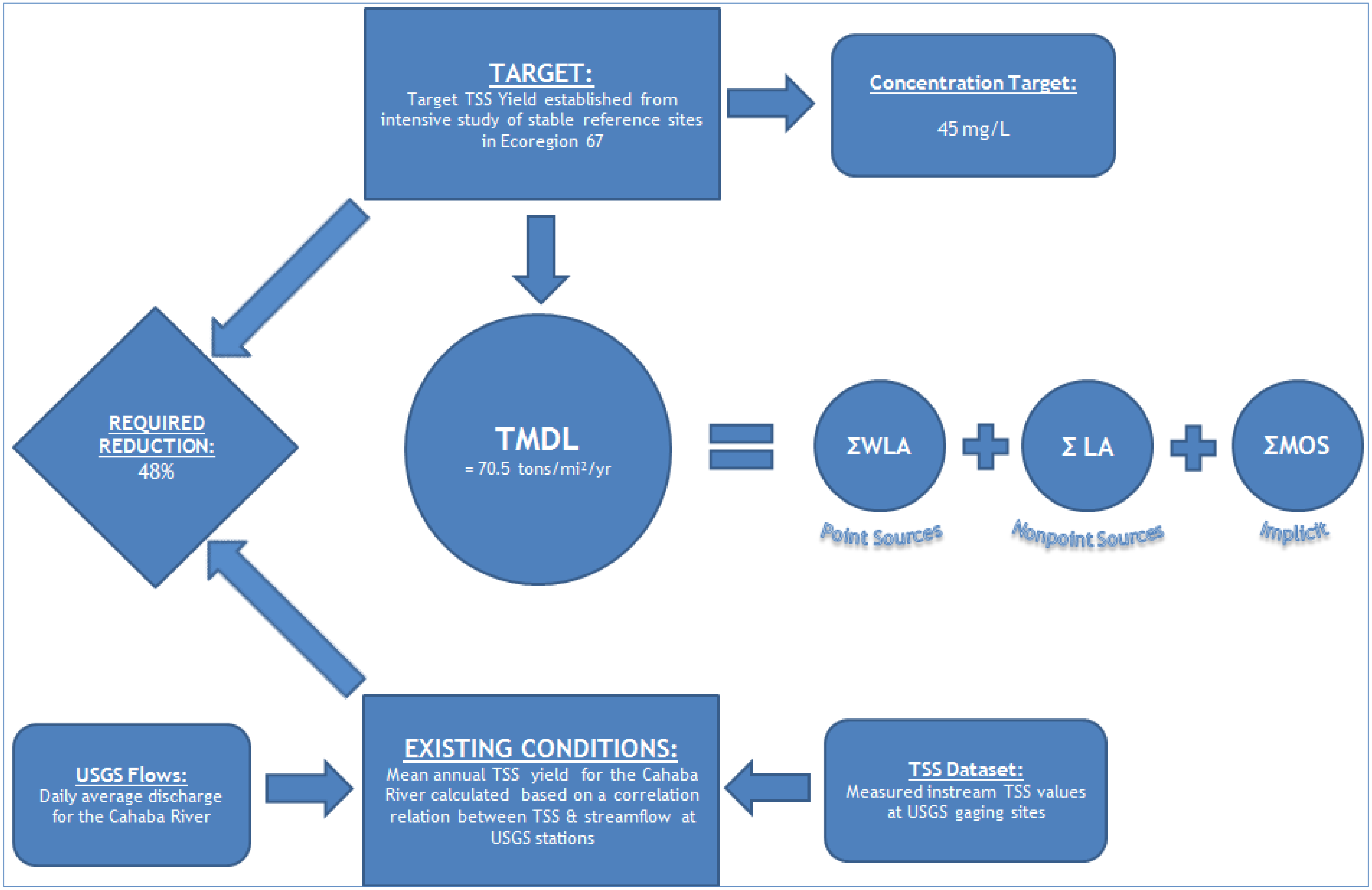
Table 5-5: Required Reductions in Suspended-Sediment in the Upper Cahaba Basin

USGS Gage	Station Name	Existing Load (tons/yr)	Existing Yield (lbs/acre/yr)	Allowable Yield[a] (lbs/acre/yr)	Percent Reduction
02423555	CAHABA RIVER NEAR HELENA	45,347	418.4	220.3	48%

a. The yield value of 220.3 lbs/acre/yr corresponds to 70.5 tons/mi^2/yr or 24.7 tonnes/km^2/yr.

6.0 TMDL DEVELOPMENT AND SUMMARY

Figure 6-1: TMDL Development Diagram



This section presents the TMDL developed for siltation for the Cahaba River watershed. A TMDL is the total amount of a pollutant load that can be assimilated by the receiving water while still achieving water quality criteria, in this case Alabama's water quality criteria for aquatic life. TMDLs can be expressed in terms of mass per time or by other appropriate measures. TMDLs are comprised of the sum of individual wasteload allocations (WLAs) for point sources, load allocations (LAs) for nonpoint sources, and natural background levels. In addition, the TMDL must include a margin of safety (MOS), either implicitly or explicitly, that accounts for the uncertainty in the relationship between pollutant loads and the quality of the receiving waterbody. Conceptually, this definition is denoted by the equation:

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

Important Note: The TMDL, WLA, and LA values are represented in normalized loadings based on drainage areas. As such, they will not have the standard additive relationship of the equation listed above.

6.1 Numeric Targets for TMDLs

The TMDL endpoints represent the instream water quality targets used in quantifying the load reduction that maintains water quality standards. The TMDL endpoints can be a combination of water quality standards, both numeric and narrative, and surrogate parameters that would ensure the standards are being met. The selected endpoint for chronic siltation loading is based on the reference yield 24.7 Tonnes/yr/km^2 introduced by USEPA Region 4 in the ***Final Total Maximum Daily Load for Siltation, Turbidity, and Habitat Alteration in Shades Creek*** (USEPA Region 4, 2004). In other words, the reference yield of 24.7 Tonnes/yr/km^2 or 70.5 tons/mi^2/yr is the TMDL target for siltation. This represents a median value, which was chosen over a mean because it was a more accurate depiction of central tendencies within the dataset. This sediment yield corresponds to a TSS concentration of 45.1 mg/l. To evaluate acute siltation loading, percent fines less than 2 mm is a measure of the typical substrate embeddedness that is a major characteristic of acute impairment. For acute siltation loading, recommendation of the range of embeddedness values of 11-16% sands, silts, & clays (<2 mm) seem to be protective of habitat and would be recommended for Cahaba sites.

6.1.1 Concentration Target Calculation

With regards to the mean annual suspended-sediment reference concentration of 45.1 mg/l, this value was established using the mean value of average daily discharge calculated for reference gages in Ecoregion 67. More specifically, this was calculated for each station-year of record by dividing the suspended-sediment load by the total volume of water during the year. A mean-annual concentration was then obtained by summing the annual concentration and dividing that figure by the number years of complete flow data (USEPA, Region 4, 2004). See also ***APPENDIX C: SUPPORTING DOCUMENTS & CALCULATIONS***.

6.2 Critical Conditions

The average annual watershed load represents the long-term processes of sediment accumulation in stream habitat areas that are associated with the potential for habitat alteration and degradation.

6.3 Margin of Safety

There are two methods for incorporating a MOS in the analysis: a) by implicitly incorporating the MOS using conservative assumptions to develop allocations; or b) by explicitly specifying a portion of the TMDL as the MOS and using the remainder for allocations. The Cahaba River Siltation TMDLs incorporate implicit margins of safety based on conservative assumptions in the development of the siltation target—that reference streams are stable and have sediment yields that should be protective of aquatic life and habitat.

6.4 Seasonal Variation

The seasonal variation is incorporated in the TMDL through the use of average annual loads. This includes high and low flow periods. The majority of sediment loads to the Cahaba River occur during high flow periods following precipitation events. A mean annual reference load is protective of chronic loading on the long-term, and a reference level of percent fines in bed sediment is protective of acute sediment loading from land disturbance.

6.5 Wasteload Allocations

The WLA portion of the TMDL is expressed as both a concentration and an annual average yield. Both of the allocations are of equal value and represented this way for permitting purposes. Some permitted facilities have more of a defined discharge point and concentration-based permitting and reporting is appropriate. Other areas have less defined discharge points and are managed most effectively with a best management practice (BMP) approach. It is more appropriate to apply TMDL allocations in terms of reductions and yields to these permits.

Any new discharges, including facility expansions and permit modifications, must also adhere to all applicable water quality standards for use classifications of their respective receiving stream. Likewise, future discharges and permits must also be consistent with load reductions stated within this TMDL document and any other approved TMDLs for those segments.

The LA portion of the TMDL applies to the nonpoint source loads that are not NPDES-regulated and are addressed through basin stakeholder efforts, ADEM's nonpoint source program, EPA §319 initiatives, and many other state and federal agencies.

6.6 TMDL Summary

Table 6-1: TMDL Summary Table[c]

WLA		LA (lbs/acre/yr)	MOS	TMDL (lbs/acre/yr)	% Reduction
TSS Concentration[a] (mg/l)	TSS Yield[b] (lbs/acre/yr)	220.3	Implicit	220.3	48%
45	220.3				

a. Existing and future NPDES permits that utilize numeric limits for TSS shall not exceed 45 mg/l applied as a monthly average.

b. The yield value of 220.3 lbs/acre/yr corresponds to 70.5 tons/mi^2/yr or 24.7 tonnes/km^2/yr.

c. Existing and future NPDES permits that utilize narrative permit requirements will comply with the TMDL through implementation and maintenance of effective BMPs on a case-by-case basis.

7.0 REQUIRED LOAD REDUCTIONS

Implementation of reductions for siltation will be sought through the NPDES permitting program and voluntary nonpoint source efforts. New growth and future permits will not be prohibited, but must be consistent with the requirements of the TMDL. Existing permits must also meet these requirements where applicable. Please reference ***APPENDIX B***: HYDROLOGIC UNITS AFFECTED BY TMDL for a geographical representation of the affected area.

All NPDES-regulated stormwater discharges will be addressed through the WLA portion of the TMDL. Stormwater discharges from sources that are not currently subject to NPDES regulation may be addressed by the LA portion of the TMDL. The WLA and LA components are expressed in this TMDL as a normalized value, evenly allocating sources of suspended-sediment. NPDES permit conditions must be consistent with the assumptions and requirements of the WLAs. For permits with numeric limits, suspended-sediment concentration is not to exceed 45 mg/l applied as a monthly limit. In lieu of numeric limits, permits with narrative permit language will demonstrate compliance through permit mechanisms such as BMPs, CBMPPs, etc. Also, NPDES discharges may also be required to perform monitoring to determine compliance with load reductions. For BMP-based permits, monitoring may be necessary to assess if the expected load reductions attributed to BMP implementation are being achieved. The permit must also provide a mechanism to make adjustments as necessary to see the BMPs are effective and performing adequately (USEPA Headquarters - Office of Water, 2002). Consideration of BMP-based permits in this TMDL is consistent with EPA guidance regarding waste load allocations for stormwater sources in TMDL development.

It is important to note that the percent reduction is merely a point of reference showing the difference between the existing condition and the target condition. The percent reduction has no bearing on the allowable yield or concentration, which are static benchmarks based on an ecoregional reference condition.

7.1 NPDES Program

7.1.1 General Industrial Permits

General industrial permits are a contributor of sediment to the system, but not believed to be a major source. The current permits and management approach is believed to be consistent with this TMDL and protective of water quality. However, for facilities with numeric TSS limits, monthly average TSS concentration limits shall not exceed 45 mg/l.

7.1.2 Individual Industrial Permits

Individual industrial permits are a contributor of sediment to the system, but not a major source. The current permits and management approach is believed to be consistent with this TMDL and protective of water quality. For facilities with numeric TSS limits, monthly average TSS concentration limits shall not exceed 45 mg/l.

7.1.3 Mining Permits

Mining activities are a contributor of sediment to the system, but not believed to be a major source. The current permits and management approach is believed to be consistent with this TMDL and protective of water quality. As mentioned earlier, proper mining practices and stormwater management conducted properly can sometimes reduce the sediment loads from certain land uses. Mining permits must continue to meet permit requirements that are consistent with the TMDL. Monthly average TSS concentration limits shall not exceed 45 mg/l.

7.1.4 Construction Stormwater Permits

New and existing construction stormwater (CSW) NPDES permits that are located in the impaired portion of the Upper Cahaba Watershed must comply with this TMDL. Compliance will be demonstrated in the Construction Best Management Practice Plan (CBMPP) and by using appropriate BMPs. The CBMPPs will be evaluated to ensure that the BMPs are effective at minimizing erosion and sediment loss to the maximum extent practicable. CSW permits are not concentration-based, so all load reductions will be addressed through BMPs. Thus, WLAs should not be construed as numeric permit limits.

7.1.5 Municipal Separate Storm Sewer System Permits

MS4 permits that are located in the Upper Cahaba Watershed must comply with this TMDL. MS4s are BMP-based and currently have no numeric TSS limits. Compliance will be demonstrated and documented through stormwater management plans (SWMP). The SWMP will accomplish reductions to siltation by using appropriate BMPs, eliminating illicit discharges, conducting sampling, and education and outreach. If reductions are not met, the municipality will be required to reevaluate and revise their SWMP accordingly. WLAs should not be construed as numeric permit limits.

7.2 Nonpoint Source Program

Voluntary, incentive-based mechanisms will be used, outside of the permitting programs, to implement NPS management measures. Cooperation and active participation by the general public and various industry, business, and environmental groups is critical to successful implementation of TMDLs. Local citizen-led initiatives often offer the most efficient and comprehensive avenue for reduction of loading rates from nonpoint sources. Therefore, TMDL implementation activities will be coordinated through interaction with state and local entities in conjunction with Clean Water Partnership efforts.

8.0 FOLLOW-UP MONITORING

ADEM has adopted a basin rotation approach to water quality management; an approach that divides Alabama's fourteen major river basins into five groups. Each year, ADEM's water quality resources are concentrated in one of the five basin groups. One goal is to continue to monitor impaired waters. Monitoring will help further characterize water quality conditions resulting from the implementation of best management practices and load reductions in the watershed. This monitoring will occur in each basin according the schedule shown in the table below.

Table 8-1: 5-Year Basin Rotation Monitoring Schedule for the State of Alabama

River Basin Group	Year
Tennessee	2013
Chattahoochee / Chipola / Choctawhatchee / Perdido-Escambia	2014
Alabama / Coosa / Tallapoosa	2015
Escatawpa / Upper Tombigbee / Lower Tombigbee / Mobile	2016
Black Warrior / Cahaba	2017

During these basin rotation sampling initiatives, ADEM samples for physical, biological, and chemical parameters at selected stations for a multitude of programs. In addition, ADEM also regularly conducts habitat assessments, macroinvertebrate assessments, fish tissue analyses, and other metrics to determine the overall health of the subject waterbody. These activities are typically planned well in advance and subject to resource constraints. Certain sampling programs, such as ambient trend monitoring, are conducted statewide each year - regardless of the basin rotation. As seen in the table above, 2017 is scheduled to be the next basin rotation sampling year for the Cahaba River Basin.

9.0 PUBLIC PARTICIPATION

As part of the public participation process, this TMDL was placed on public notice and made available for review and comment. The public notice was prepared and published in the four major daily newspapers in Montgomery, Huntsville, Birmingham, and Mobile, as well as submitted to persons who have requested to be on ADEM's postal and electronic mailing distributions. In addition, the public notice and subject TMDL was made available on ADEM's Website: www.adem.state.al.us. The public can also request paper or electronic copies of the TMDL by contacting Mr. Chris Johnson at 334-271-7827 or cljohnson@adem.state.al.us. The public was given an opportunity to review the TMDL and submit comments to the Department in writing. At the end of the public review period, all written comments received during the public notice period became part of the administrative record. ADEM considered all comments received by the public prior to finalization of this TMDL and subsequent submission to EPA Region 4 for final review and approval.

10.0 REFERENCES

ADEM, 1996. "1996 305(b) Water Quality Report to Congress." Alabama Department of Environmental Management Water Division - Water Quality Section. Montgomery, Alabama.

ADEM, 1998. 1998 Section §303(d) List for Alabama. Alabama Department of Environmental Management Water Division - Water Quality Section. Montgomery, Alabama.

ADEM, 2000. Chapter 335-6-10 Water Quality Criteria. Alabama Department of Environmental Management Water Division - Water Quality Section. Montgomery, Alabama

ADEM, 2004. Draft Nutrient Total Maximum Daily Loads for the Cahaba River Watershed. Alabama Department of Environmental Management Water Division - Water Quality Section. Montgomery, Alabama.

ADEM, 2012. 2005 Cahaba River Report: Results of Macroinvertebrate Community Assessments." Alabama Department of Environmental Management Field Operations Division – Environmental Indicators Section. Montgomery, Alabama.

Erman, D.C. and N.A. Erman, 1984. "The response of stream macroinvertebrates to substrate size and heterogeneity." *Hydrobiologia* 108:75-82.

Gray, John R., G.G. Glysson, L.M. Turcios, and G.E. Schwartz. "Compariability of Suspended Sediment Concentrations and Total Suspended Solids Data." USGS Water-Resources Investigations Report 00-4191. USGS, Washington DC.

Hartfield, Paul, 2002. "Mussels of the Cahaba River: Species Assessment and Sources of Information." Presented to USEPA, ADEM and JCESD May 23, 2002. U.S. Fish and Wildlife Service, Jackson MS.

Howell, W.M. and Davenport, L.J., 2001. Report on Fishes and Macroinvertebrates of the Upper Cahaba River and Three Additional Sites. Report Submitted to Jefferson County Environmental Services Division, Birmingham, Alabama.

Howell, W.M. and Davenport, L.J., 2002. Report on Fishes and Macroinvertebrates of the Upper Cahaba River and Three Additional Sites. Report Submitted to Jefferson County Environmental Services Division, Birmingham, Alabama.

Lenat, D.R., D.L. Penrose and K.w. Eagleson, 1979. Biological Evaluation of Non-Point Sources Pollutants in North Carolina Streams and Rivers. North Carolina Department of Natural Resources and Community Development, Biological Series 102, Raleigh, NC.

O'Neil, Patrick E., 2002. A Biological Assessment of Selected Sites in the Cahaba River System, Alabama. Geological Survey of Alabama. Montgomery, Alabama.

O'neil, Patrick E., Shepard, Thomas E. et al. "Hatchet Creek Regional Reference Watershed Study." Geological Survey of Alabama. Open-file Report 0509.Tuscaloosa, Alabama.

Shepard, Thomas E., Patrick E. O'Neil, Stuart W. McGregor, Maurice F. Mettee, and Steven C. Harris, 1994a. "Biomonitoring and Water Quality Studies in the Upper Cahaba River Drainage of Alabama, 1989-1994." Geological Survey of Alabama. Bulletin 165. Montgomery, Alabama.

Shepard, Thomas E., Patrick, E. O'Neil, Stuart W. McGregor, and Steven C. Harris, 1994b, "Water-Quality and Biomonitoring Studies in the Upper Cahaba River Drainage of Alabama." Geological Survey of Alabama. Bulletin 160. Montgomery, Alabama.

Simon, A., 1992. Energy, time, and channel evolution in catastrophically-disturbed fluvial systems. In: Phillips, J.D., Renwick, W.H. (Eds.), *Geomorphic Systems: Geomorphology* vol. 5 pp. 345-372.

Simon, A., 2004. "Suspended-Sediment Transport and Bed-Material Characteristics of Shades Creek, Alabama and Ecoregion 67: Developing Water-Quality Criteria for Sediment", U.S Department of Agriculture-Agricultural Research Service, National Sedimentation Laboratory, Channel and Watershed Processes Research Unit, January 2004.

Tetra Tech, 2002. "Data Summary Report for the Cahaba River Watershed," Prepared for ADEM, November 2002. Atlanta, GA.

U.S. Census Bureau, 1990-2010. Census 1990 Summary File. http://factfinder.census.gov

USDA Agricultural Research Service National Sedimentation Laboratory, 2006. "Suspended-sediment Transport Rates for Level III Ecoregions of EPA Region 4: The Southeast". USDA. Oxford, Mississippi.

USEPA Headquarters - Office of Water, 2002. Memorandum: "Establishing Total Maximum Daily Load (TMDL Wasteload Allocations (WLAs) for Storm Water Sources and NPDES Permit Requirements Based on Those WLAs." USEPA, Washington D.C.

USEPA Region 4, 2003a, "Cahaba River: Biological and Water Quality Studies, Birmingham, Alabama, March/April, July and September, 2002," USEPA Region 4, Science and Ecological Support Division, Athens, GA.

USEPA Region 4, 2004, "Total Maximum Daily Load for Siltation, Turbidity, and Habitat Alteration in Shades Creek, Jefferson County, Alabama." USEPA Region 4, Atlanta, GA.

USFWS, 2000. "Recovery Plan for the Mobile River Basin." U.S. Fish and Wildlife Service, Jackson MS.

USFWS, 2004. Endangered and Threatened Wildlife and Plants; Designation of Critical Habitat for Three Threatened Mussels and Eight Endangered Mussels in the Mobile River Basin; Final Rule. 50 CFR Part 17, RIN 1018-AI73, Federal Register Vol. 69, No. 126, Thursday July 1, 2004, Rules and Regulations.

USGS, 1992. Multi-Resolution Land Use Classification. Available for download at http://landcover.usgs.gov.

USFR, 1998. Endangered and Threatened Wildlife and Plants; Endangered Status for Three Aquatic Snails, and Threatened Status for Three Aquatic Snails in the Mobile River Basin of Alabama. U. S. Federal Register Vol. 63, No. 208: 57610-57620.

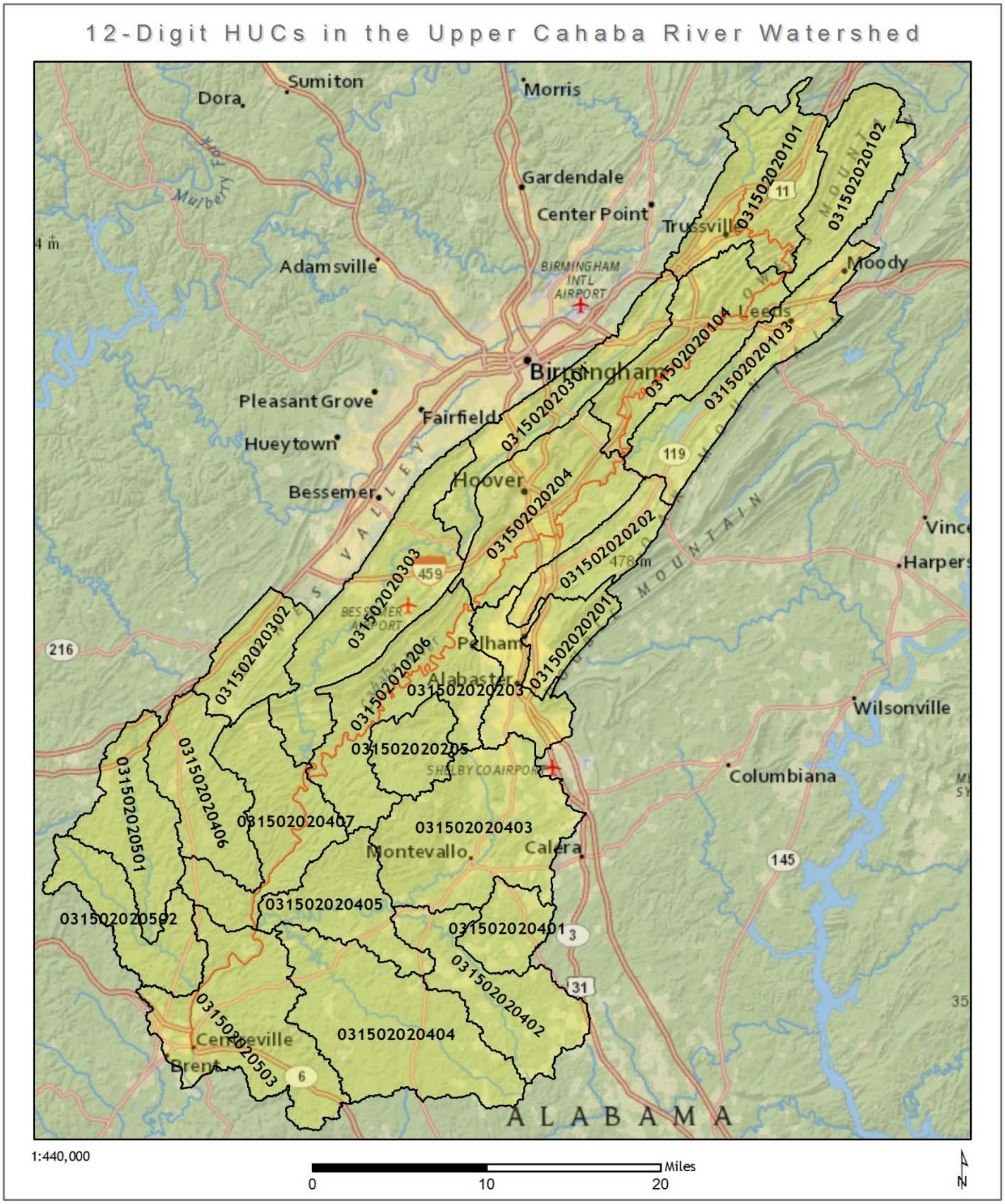
11.0 APPENDIX A: TSS/FLOW DATA SUMMARY

Appendix Table 1: TSS/FLOW Data Summary Statistics

USGS ID	Site Name		Data Points (N)	Mean	Median	Minimum	Maximum	Range	Date Range
02423130	Cahaba River at Trussville, AL	FLOW (m^3/s) →	288	3.16	0.74	0.00	190.86	190.86	(1991 - 2012)
		TSS (mg/L) →		16.79	6.00	0.30	808.00	807.70	
02423425	Cahaba River near Cahaba Heights, AL	FLOW (m^3/s) →	166	11.28	2.80	0.07	237.30	237.23	(1999 - 2012)
		TSS (mg/L) →		22.07	7.95	0.20	496.00	495.80	
02423496	Cahaba River near Hoover, AL	FLOW (m^3/s) →	108	12.36	5.80	0.59	138.47	137.88	(1999 - 2004)
		TSS (mg/L) →		47.76	12.75	0.40	701.00	700.60	
02423500	Cahaba River near Acton, AL	FLOW (m^3/s) →	178	10.41	3.50	0.05	173.30	173.25	(1999 - 2012)
		TSS (mg/L) →		22.29	8.30	0.10	469.00	468.90	
02423555	Cahaba River near Helena, AL	FLOW (m^3/s) →	557	20.99	7.42	0.04	608.81	608.77	(1991 - 2012)
		TSS (mg/L) →		45.85	11.80	0.30	1540.00	1539.70	
02424000	Cahaba River near Centreville, AL	FLOW (m^3/s) →	161	53.05	22.00	3.00	1022.24	1019.24	(1990 - 2012)
		TSS (mg/L) →		29.27	9.00	0.30	604.00	603.70	

12.0 APPENDIX B: HYDROLOGIC UNITS AFFECTED BY TMDL

Map 12-1: 12-digit HUCs in Upper Cahaba



Appendix Table 2: 12-digit HUCs in the Upper Cahaba Watershed

<table>
<tr><th>HUC 12 Name</th><th>12-digit HUC</th><th>10-digit HUC</th><th>8-digit HUC</th></tr>
<tr><td>Upper Cahaba River</td><td>031502020101</td><td rowspan="4">0315020201</td><td rowspan="24">03150202</td></tr>
<tr><td>Big Black Creek</td><td>031502020102</td></tr>
<tr><td>Little Cahaba River</td><td>031502020103</td></tr>
<tr><td>Lower Cahaba River</td><td>031502020104</td></tr>
<tr><td>Peavine Creek</td><td>031502020201</td><td rowspan="6">0315020202</td></tr>
<tr><td>Cahaba Valley Creek</td><td>031502020202</td></tr>
<tr><td>Prairie Brook-Buck Creek</td><td>031502020203</td></tr>
<tr><td>Patton Creek-Cahaba River</td><td>031502020204</td></tr>
<tr><td>Murry Creek-Piney Woods Creek</td><td>031502020205</td></tr>
<tr><td>Beaverdam Creek-Cahaba River</td><td>031502020206</td></tr>
<tr><td>Upper Shades Creek</td><td>031502020301</td><td rowspan="3">0315020203</td></tr>
<tr><td>Cooley Creek-Mud Creek</td><td>031502020302</td></tr>
<tr><td>Lower Shades Creek</td><td>031502020303</td></tr>
<tr><td>Walker Branch</td><td>031502020401</td><td rowspan="7">0315020204</td></tr>
<tr><td>Mahan Creek</td><td>031502020402</td></tr>
<tr><td>Mayberry Creek-Shoal Creek</td><td>031502020403</td></tr>
<tr><td>Sixmile Creek-Little Cahaba River</td><td>031502020404</td></tr>
<tr><td>Alligator Creek-Little Cahaba River</td><td>031502020405</td></tr>
<tr><td>Caffee Creek</td><td>031502020406</td></tr>
<tr><td>Cahaba River</td><td>031502020407</td></tr>
<tr><td>Hill Creek</td><td>031502020501</td><td rowspan="3">0315020205</td></tr>
<tr><td>Shultz Creek</td><td>031502020502</td></tr>
<tr><td>Sandy Creek-Cahaba River</td><td>031502020503</td></tr>
</table>

12.1 MS4 Permit Information

Appendix Table 3: Municipal Separate Stormwater Sewer Systems (MS4) Phase I Permits in the Upper Cahaba Watershed

Permit ID	Facility	Receiving	County
ALS000001	Storm Water Management Authority (SWMA)	Upper Cahaba Watershed	Jefferson
ALS000003	Shelby County Commission	Upper Cahaba Watershed	Shelby

13.0 APPENDIX C: SUPPORTING DOCUMENTS & CALCULATIONS

Figure 13-1: Standard Rapid Geomorphic Assessment Scoring Form (Simon et al. 2002)

RAPID GEOMORPHIC ASSESSMENT (RGA) FORM
CHANNEL STABILITY RANKING SCHEME

Station Name____

Station Description____

Date__________ Crew________________________ Pebble count taken: Y / N

Pics (circle): u/s, d/s, x-sec, LB, RB Slope________ Pattern: meander/ straight/ braided

1. Primary bed material

Bedrock	Boulder/Cobble	Gravel	Sand	Silt/Clay
0	1	2	3	4

2. Bed/bank protection

Yes	No	(with) 1 bank protected	2 banks protected
0	1	2	3

3. Degree of incision (relative elev. of "normal" low water if floodplain/terrace is 100%)

0-10%	11-25%	26-50%	51-75%	76-100%
4	3	2	1	0

4. Degree of constriction (relative decrease in top-bank width from up to down stream)

0-10%	11-25%	26-50%	51-75%	76-100%
0	1	2	3	4

5. Streambank erosion (dominant process each bank)

	None	fluvial	mass wasting (failures)
Inside or left	0	1	2
Outside or right	0	1	2

6. Streambank instability (percent of each bank failing)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	0	0.5	1	1.5	2
Outside or right	0	0.5	1	1.5	2

7. Established riparian vegetative cover (woody or stabilizing perennial grasses each bank)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

8. Occurrence of bank accretion (percent of each bank with fluvial deposition)

	0-10%	11-25%	26-50%	51-75%	76-100%
Inside or left	2	1.5	1	0.5	0
Outside or right	2	1.5	1	0.5	0

9. Stage of channel evolution (I and VI generally < 11 total score)

I	II	III	IV	V	VI
0	1	2	4	3	1.5

10. SUM OF ALL VALUES →

13.1 Target Calculations

Figure 13-2: Normalized Loading Unit Conversion Calculation

Normalized Loading Conversion Calculation:

$$24.7 \frac{\cancel{\text{Tonnes}}}{\cancel{\text{km}^2}} \text{X} \frac{1 \quad \cancel{\text{km}^2}}{0.386102 \quad \text{mi}^2} \text{X} \frac{1.102311 \text{ tons (US Short Ton)}}{1 \quad \cancel{\text{Tonne (metric)}}} = \mathbf{70.5178} \frac{\textbf{tons}}{\textbf{mi}^2} \text{(per year)}$$

Figure 13-3: Percent Reduction Calculation

$$PERCENT\ REDUCTION = \left\{\frac{(EXISTING\ CONDITION - TARGET\ CONDITION)}{(EXISTING\ CONDITION)}\right\} \times 100\%$$

$$= \left\{\frac{(47.4 - 24.7)}{24.7}\right\} \times 100\% \ = \mathbf{48}\%$$

13.2 $Q_{1.5}$ Approximation & Results

In order to approximate the effective discharge for each of the USGS sites, peak flow data was obtained from the USGS website. This data was then imported into the US Army Corps of Engineers' (ASACE) Hydrologic Engineering Center (HEC) computer program where the analysis was performed. ***Appendix Table 4*** summarizes the $Q_{1.5}$ flow estimations by USGS site:

Appendix Table 4: $Q_{1.5}$ Estimates for Selected USGS Stations

USGS Site ID	Site Description	Drainage Area (mi^2)	$Q_{1.5}$ (cfs)
02423130	Cahaba River @ Trussville, AL	19.7	2577
02423425	Cahaba River Near Cahaba Heights, AL	201	7475
02423496	Cahaba River Near Hoover, AL	226	7129
02423500	Cahaba River Near Acton, AL	230	9194
02423555	Cahaba River Near Helena, AL	335	9142
02424000	Cahaba River Near Centreville, AL	1027	22965

See the following pages for the resulting flow-probability curves for each site.

Figure 13-4: $Q_{1.5}$ Effective Discharge for USGS 02423130 (Cahaba River @ Trussville, AL)

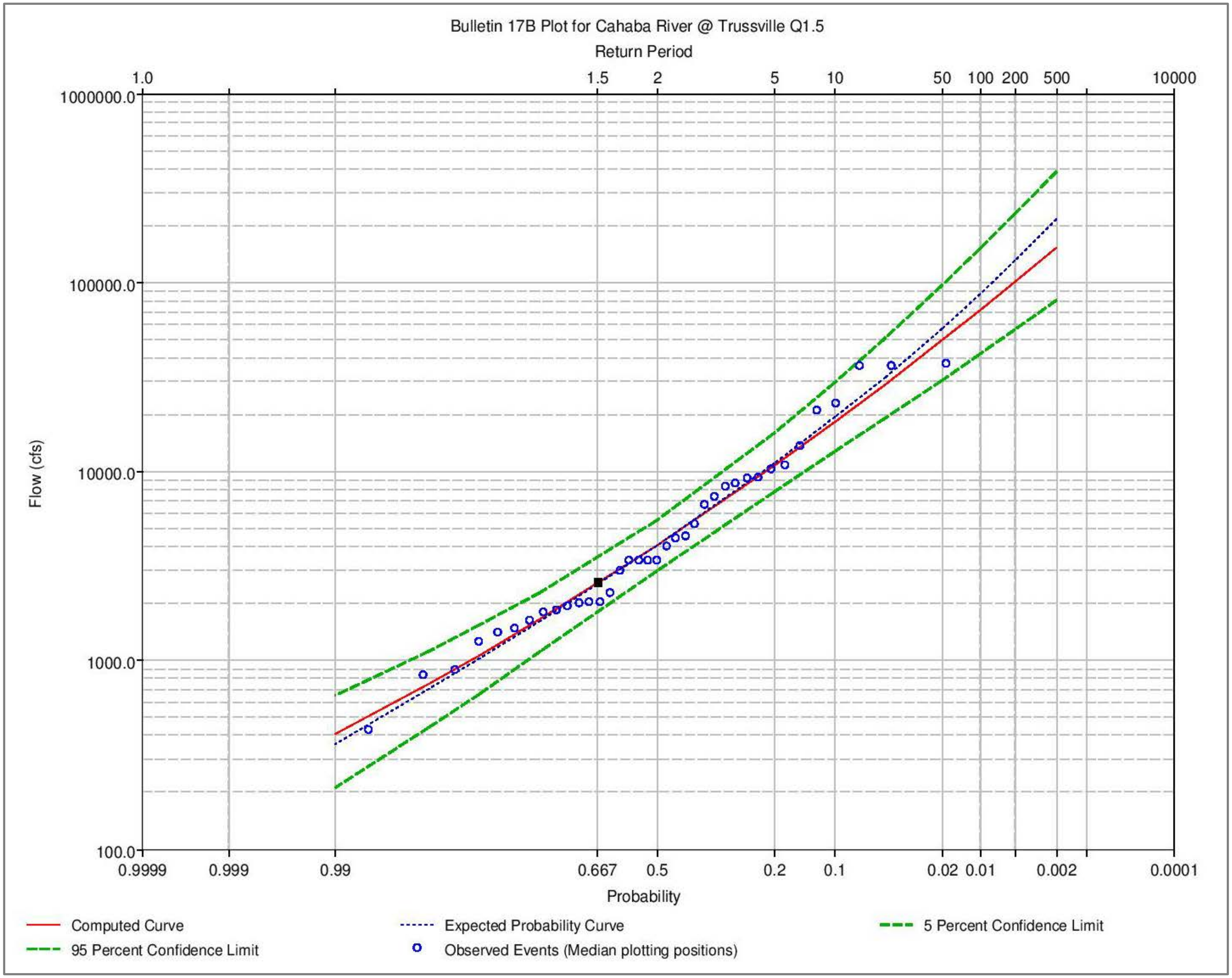


Figure 13-5: $Q_{1.5}$ Effective Discharge for USGS 02423425 (Cahaba River near Cahaba Heights, AL)

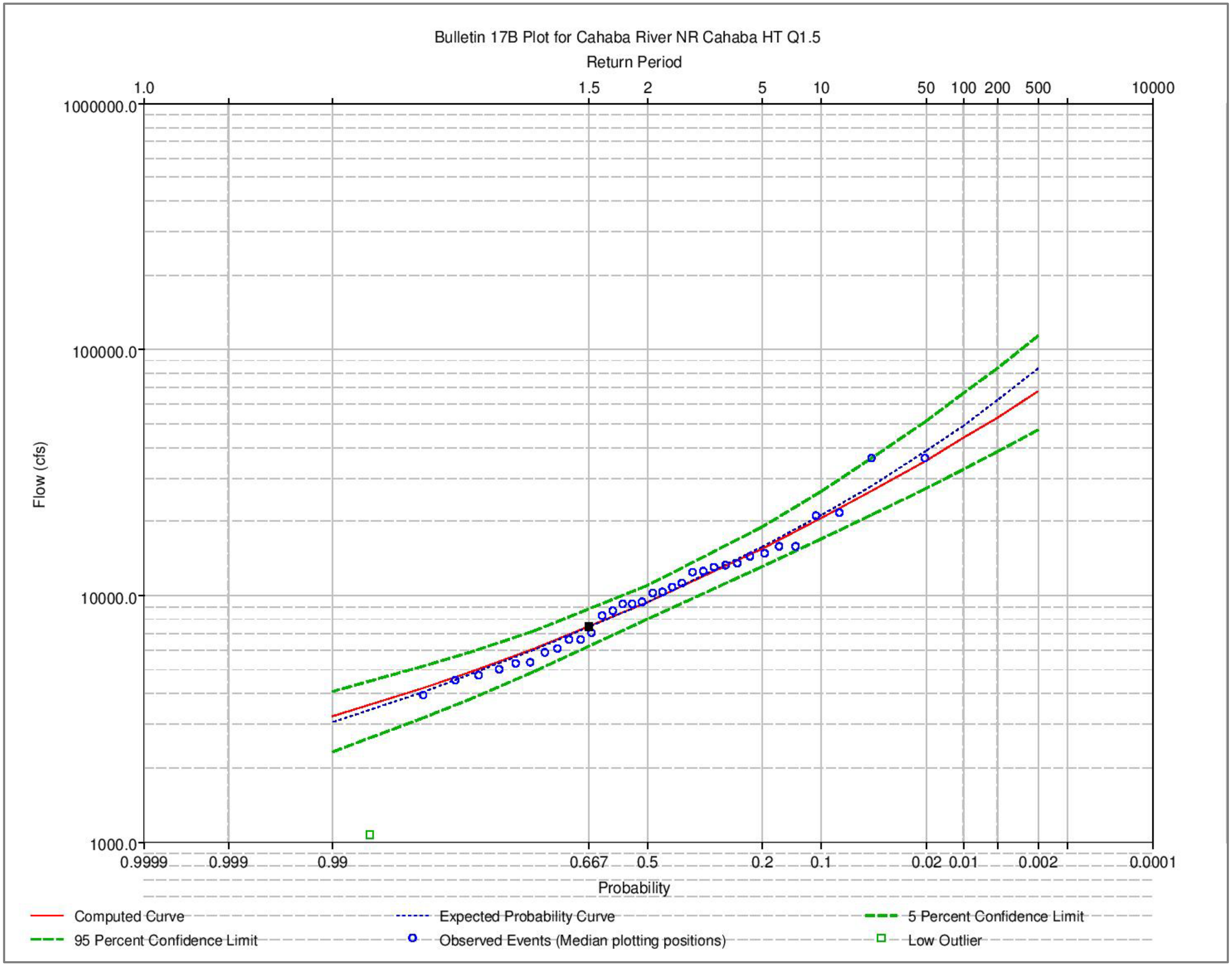


Figure 13-6: $Q_{1.5}$ Effective Discharge for USGS 02423496 (Cahaba River near Hoover, AL)

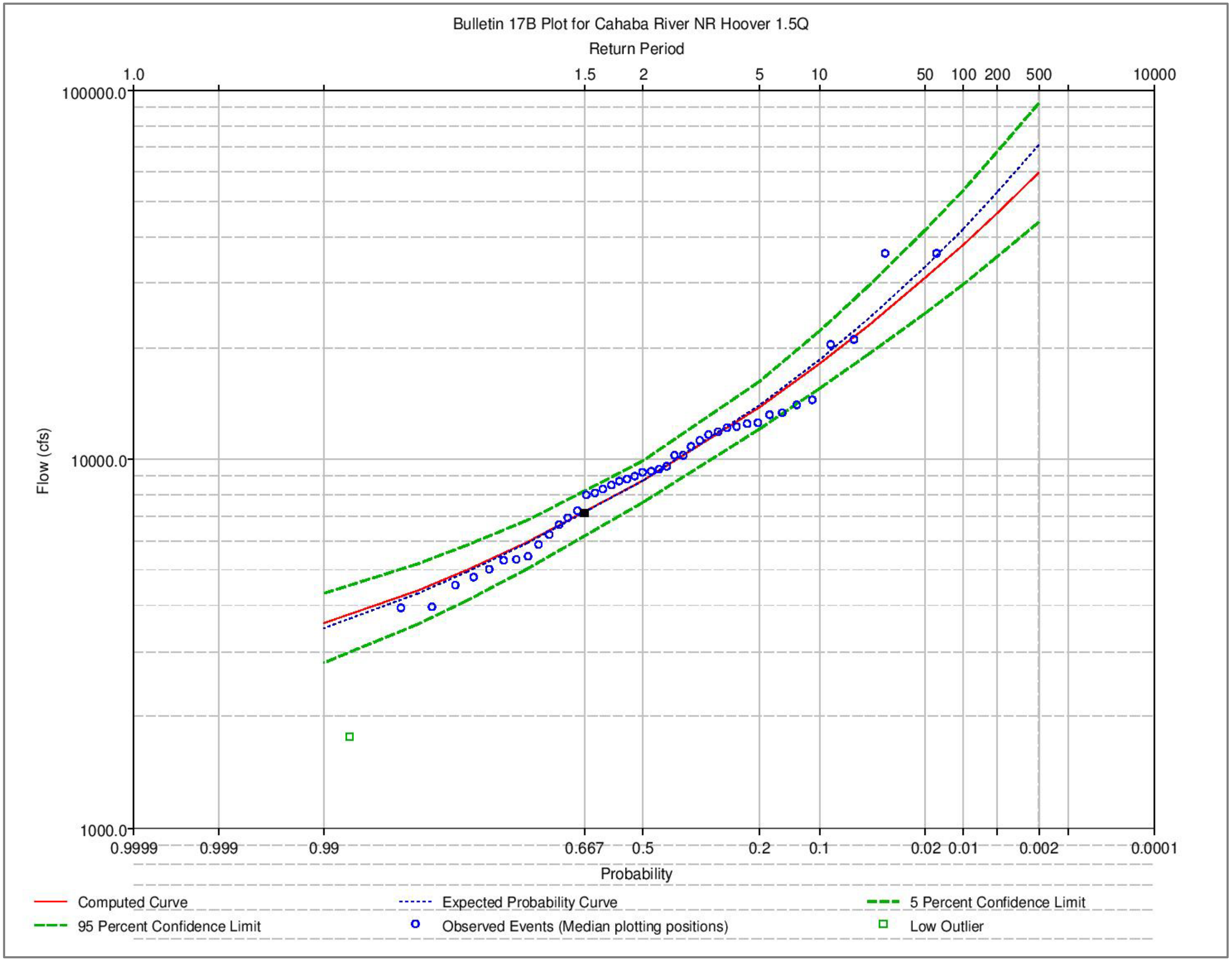


Figure 13-7: $Q_{1.5}$ Effective Discharge for USGS 02423500 (Cahaba River near Acton, AL)

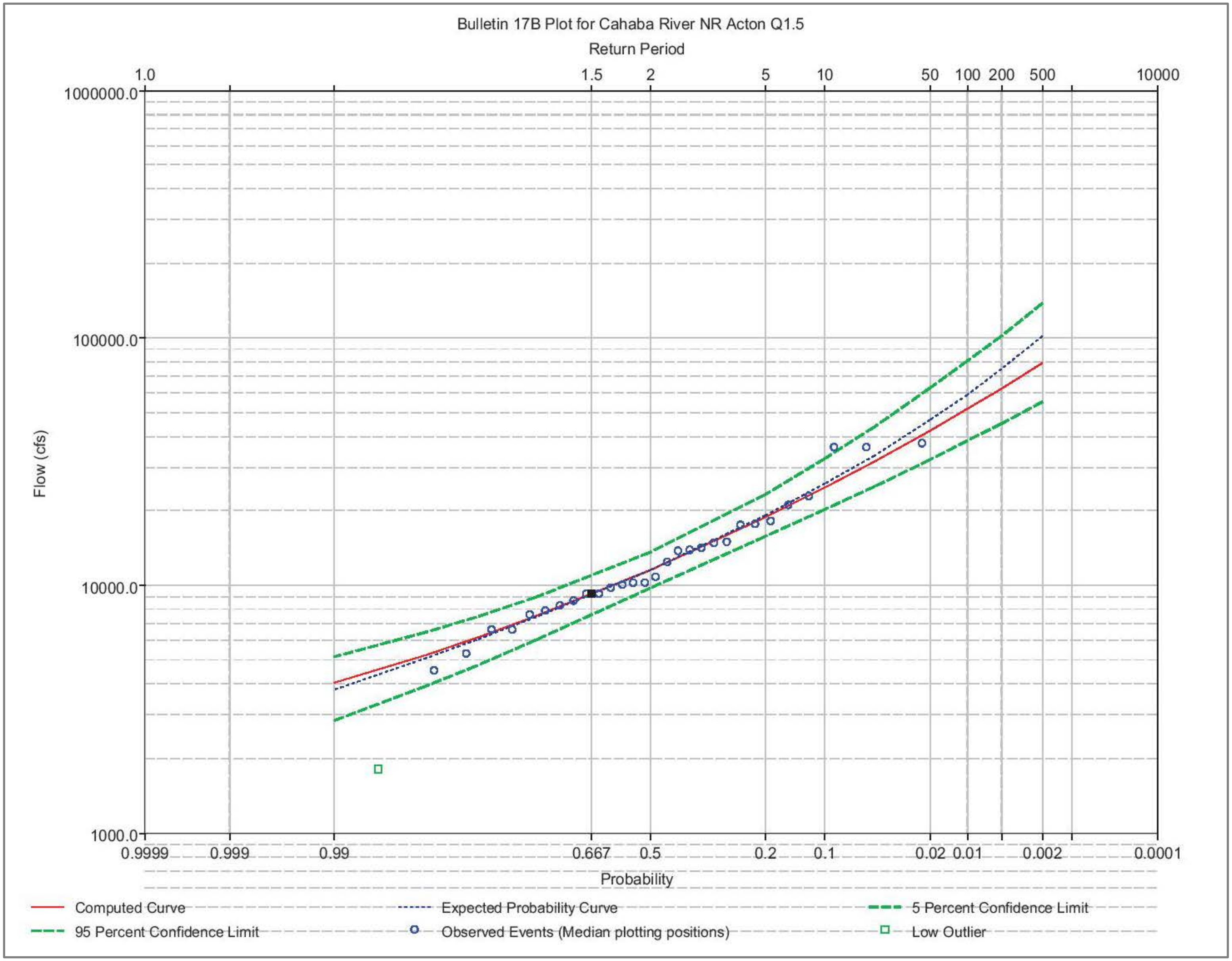


Figure 13-8: $Q_{1.5}$ Effective Discharge for USGS 02423555 (Cahaba River near Helena, AL)

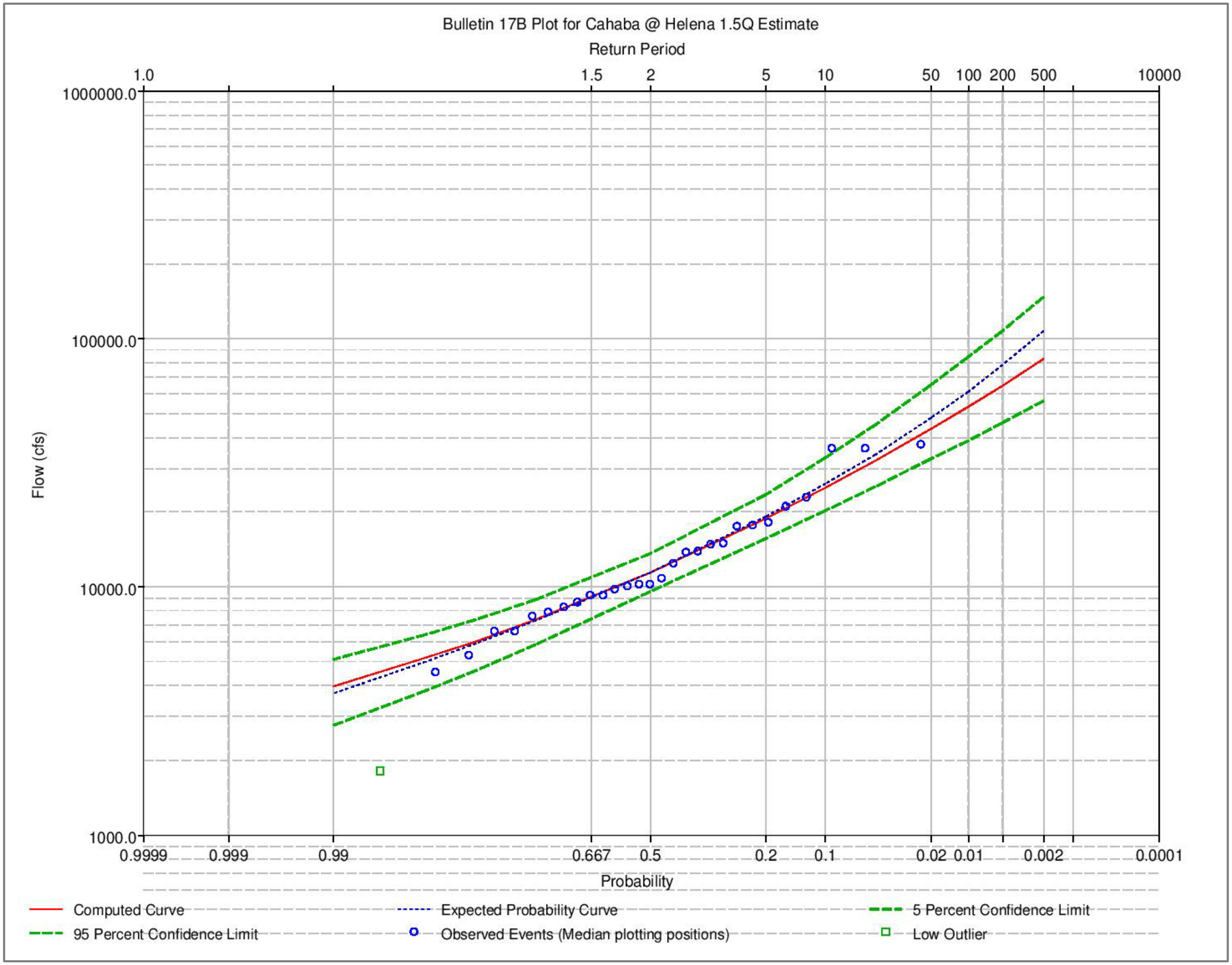
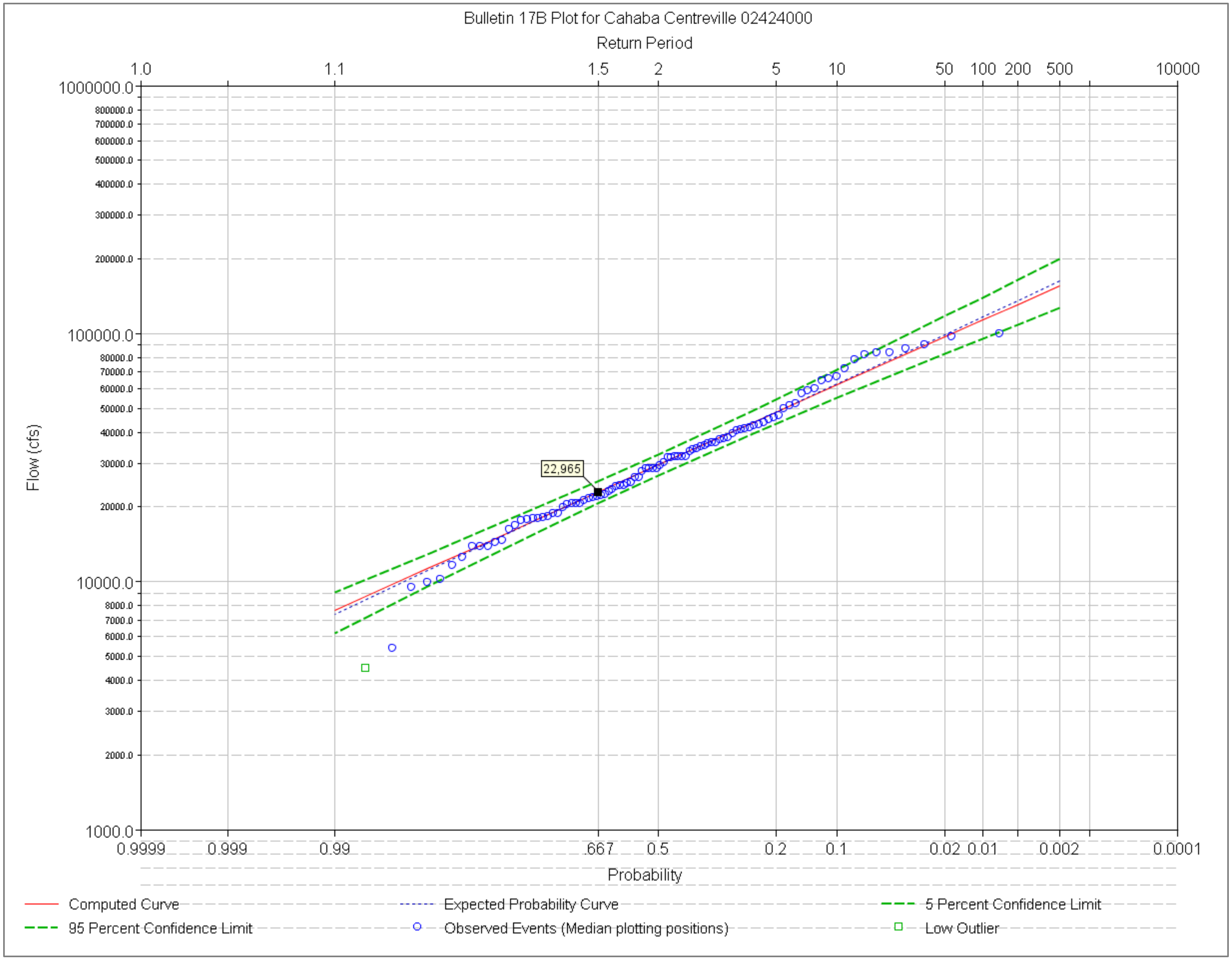


Figure 13-9: $Q_{1.5}$ Effective Discharge for USGS 02424000 (Cahaba River near Centreville, AL)



13.3 Sediment Transport Curves & Calculations

Figure 13-10: Sediment-transport Curve for USGS 02423130 (Trussville)

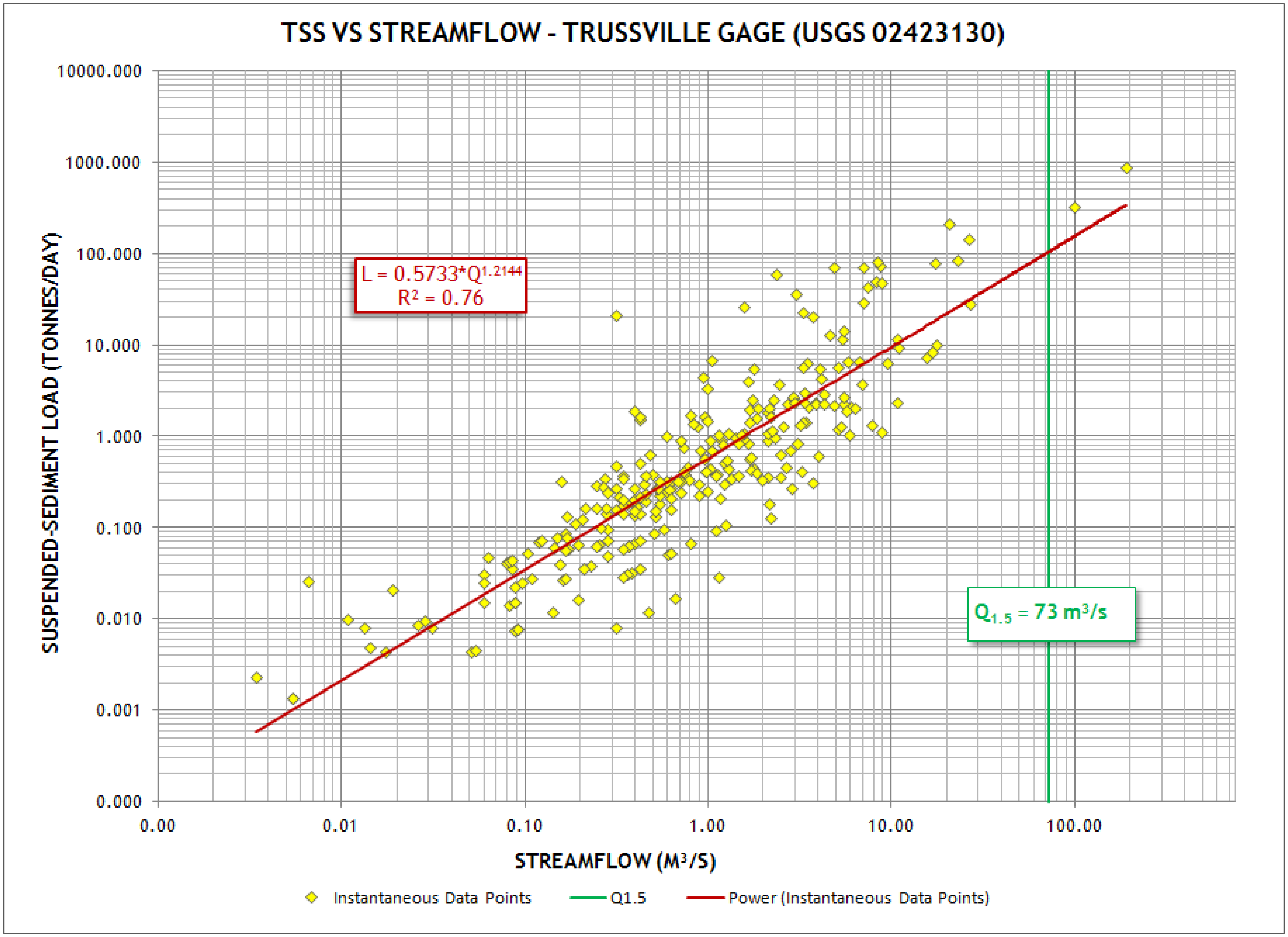


Figure 13-11: Sediment-transport Curve for USGS 02423425 (Cahaba Heights)

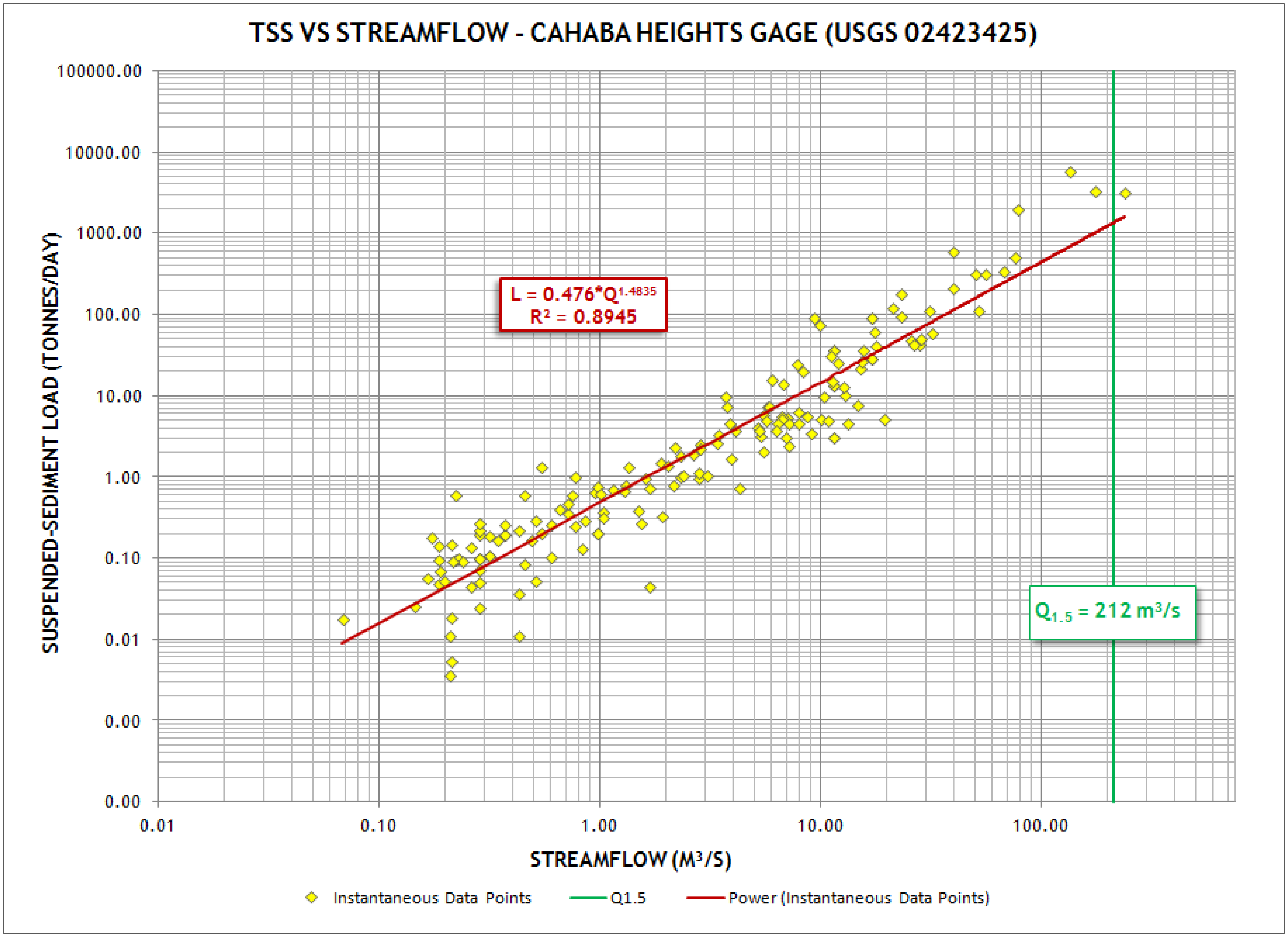


Figure 13-12: Sediment-transport Curve for USGS 02423496 (Hoover)

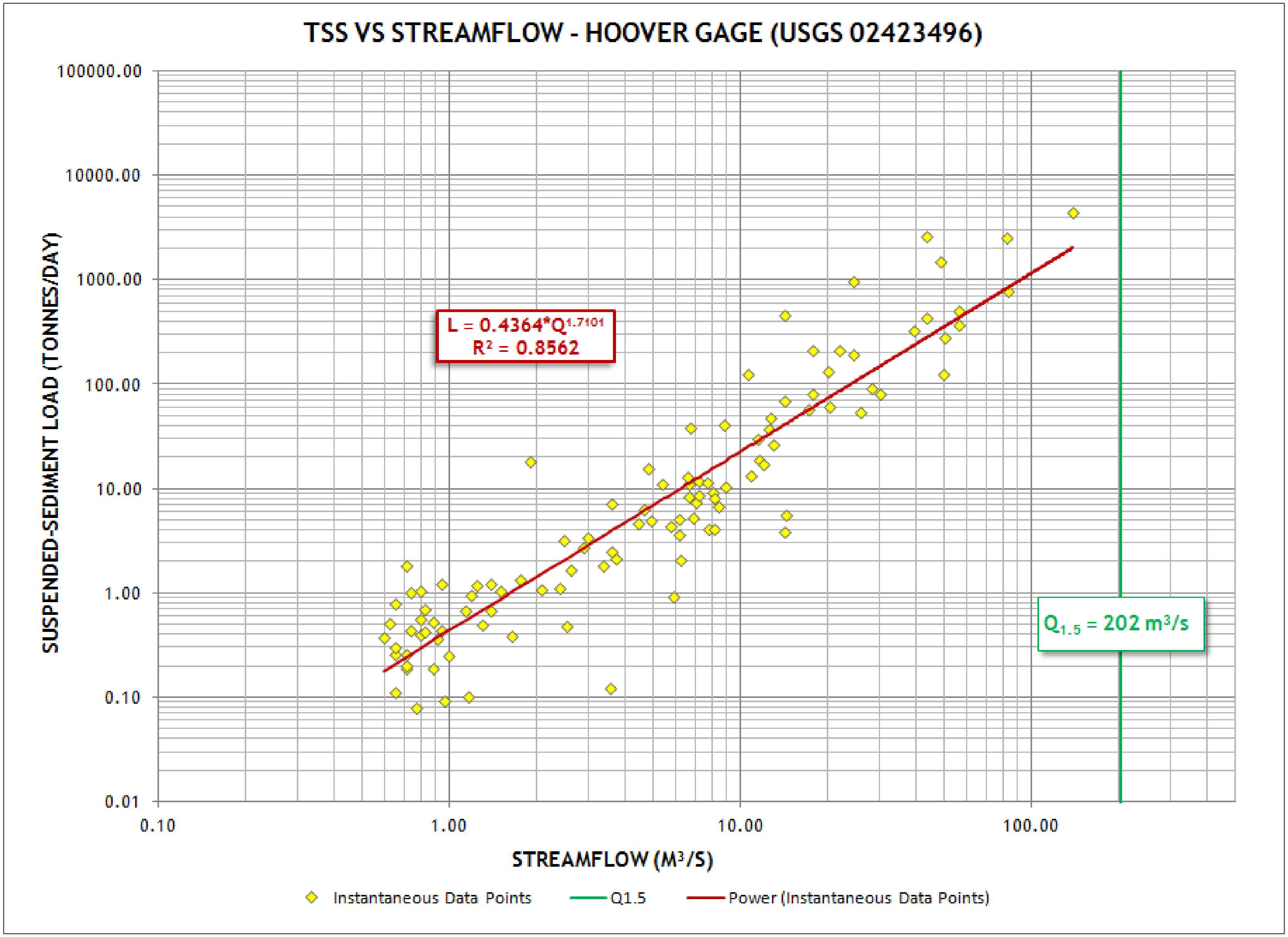


Figure 13-13: Sediment-transport Curve for USGS 02423500 (Acton)

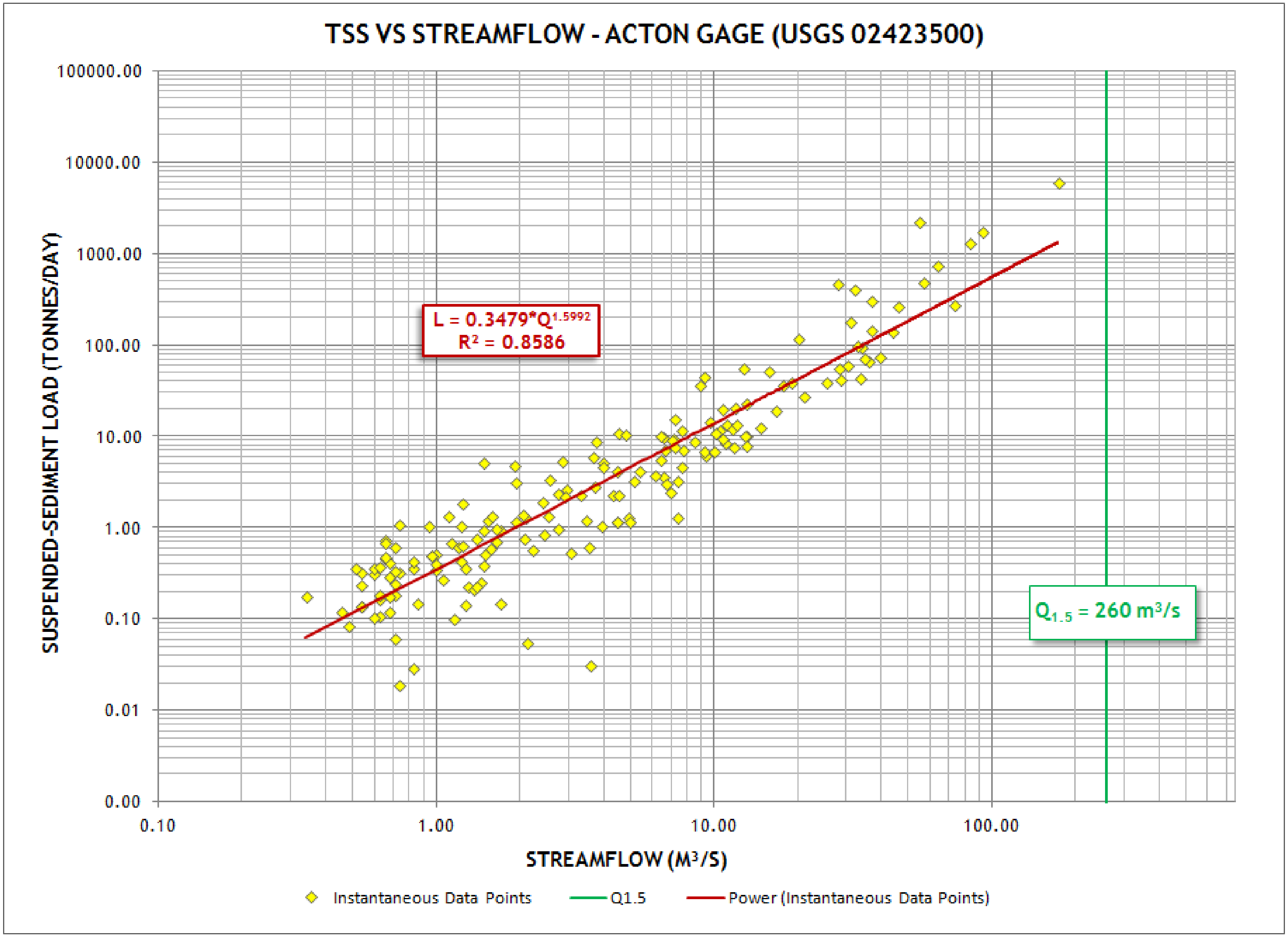


Figure 13-14: Sediment-transport Curve for USGS 02423555 (Helena)

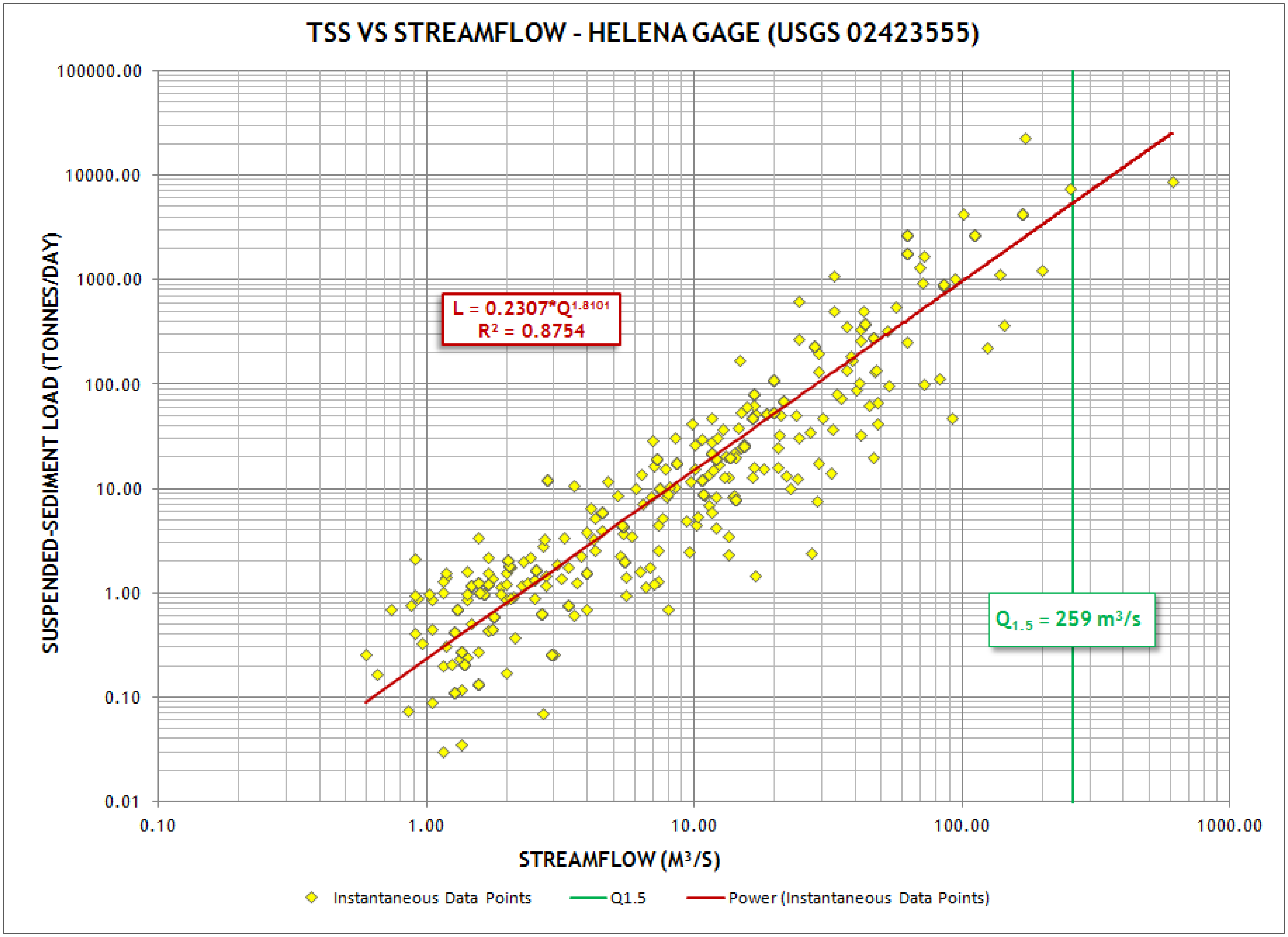
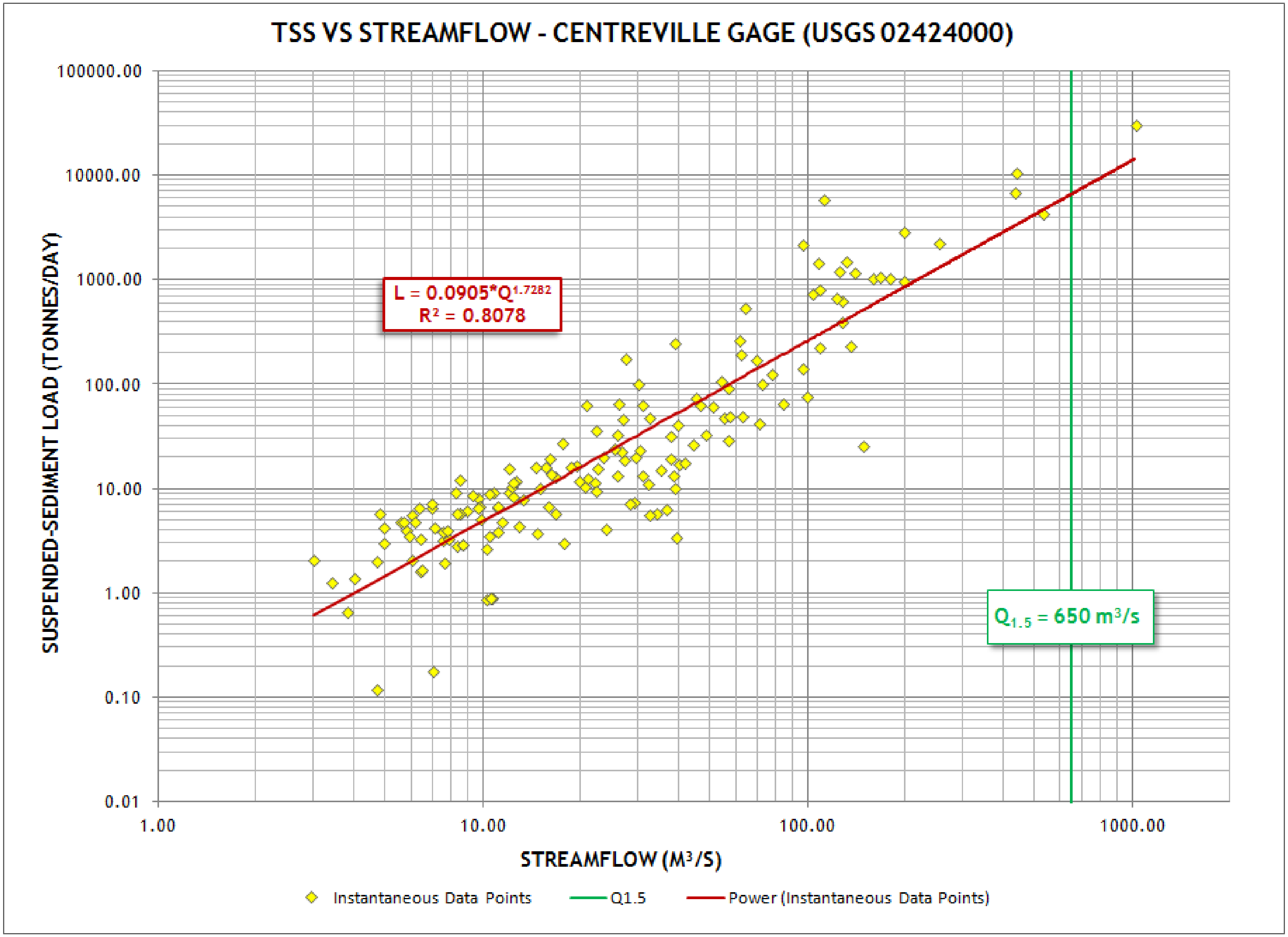


Figure 13-15: Sediment-transport Curve for USGS 02424000 (Centreville)



14.0 APPENDIX D: SUPPORTING PICTURES

Picture 14-1: Cahaba River @ USGS 02423130 Upstream (8/25/2010)

Picture 14-2: Cahaba River @ USGS 02423130 Downstream (8/252010)

Picture 14-3: Cahaba River near USGS 02423425 Upstream (7/8/2010)

Picture 14-4: Cahaba River near USGS 02423425 Downstream (7/8/2010)

Picture 14-5: Cahaba River @ USGS 02423555 Upstream (4/06/2010)

Picture 14-6: Cahaba River @ USGS 02423555 Downstream (4/06/2010)

Picture 14-7: Cahaba River @ USGS 02423500 Upstream (4/13/2010)

Picture 14-8: Cahaba River @ USGS 02423500 Downstream (4/13/2010)

Picture 14-9: Cahaba River @ USGS 02424000 Upstream (07/18/2012)

Picture 14-10: Cahaba River @ USGS 02424000 Downstream (07/18/2012)

Picture 14-11: Sediment Deposits in the Cahaba River

Picture 14-12: Debris Collected on Streambank after Storm Event