PATHOGEN TMDLS FOR SELECTED REACHES

IN PLANNING SEGMENT 2B

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EXECUTIVE SUMMARY

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

The study area is part of the Arkansas Department of Environmental Quality (ADEQ) Planning Segment 2B and is located within both the Gulf Coastal Plain, and Delta ecoregions. The study area for this project is limited to eight Huc-reaches in the Arkansas Planning Segment 2B (8040205-907, 8040205-905, 8040205-904, 8040205-903, 8040205-902, 8040205-901, 8040205-013, and 8040205-005). Land use in the study area consists mostly of cropland and forest. The designated beneficial uses that have been established by ADEQ for Planning Segment 2B include fishery, primary and secondary contact recreation; domestic, agricultural and industrial water supply.

The numeric water quality criteria that apply to the impaired reaches in the Bayou Batholomew Basin and that were used to calculate the total allowable loads are the primary contact water quality criteria for fecal coliform bacteria and E. coli. The TMDLs for both fecal coliform and E. coli bacteria were developed based on mass balance principles. This TMDL information was based on load duration curve methodology. This method illustrates allowable loading at a wide range of stream-flow conditions. The seasonal fecal coliform and E. coli bacteria TMDLs were developed on the basis of analyses of the applicable water quality criteria (i.e., calculating allowable loads for both summer (May 1 – September 30) and winter (October 1 – April 30)). Table ES.1 presents TMDLs and allocations for each impaired HUC-reach in Planning Segment 2B for each pollutant.

Table ES.1 Summary of Bacteria TMDLs Planning Segment 2B

Arkansas HUC-Reach #	Pollutant	Criteria	MOS cfu/day	∑ WLA cfu/day	∑ LA cfu/day	TMDL cfu/day
	Chemin-A-Haut Creek					
8040205-907	FC	PCR-S	9.11E+10	1.47E+09	8.18E+11	9.11E+11
	FC	PCR-W/SCR	4.55E+11	7.34E+09	4.09E+12	4.55E+12
	E. coli	PCR-S	9.33E+10	1.51E+09	8.38E+11	9.33E+11
	E. coli	PCR-W/SCR	4.67E+11	7.53E+09	4.20E+12	4.67E+12
	Cross Bayou					
8040205-905	FC	PCR-S	2.24E+09	0	2.02E+10	2.24E+10
	FC	PCR-W/SCR	1.12E+10	0	1.01E+11	1.12E+11
	E. coli	PCR-S	2.29E+09	0	2.06E+10	2.29E+10
	E. coli	PCR-W/SCR	1.15E+10	0	1.04E+11	1.15E+11
	Jack's Bayou					
8040205-904	FC	PCR-S	5.61E+09	0	5.05E+10	5.61E+10
	FC	PCR-W/SCR	2.80E+10	0	2.52E+11	2.80E+11
	E. coli	PCR-S	5.75E+09	0	5.18E+10	5.75E+10
	E. coli	PCR-W/SCR	2.87E+10	0	2.58E+11	2.87E+11
	Melton's Creek					
8040205-903	FC	PCR-S	8.13E+09	0	7.32E+10	8.13E+10
	FC	PCR-W/SCR	4.06E+10	0	3.66E+11	4.06E+11
	E. coli	PCR-S	8.33E+09	0	7.50E+10	8.33E+10
	E. coli	PCR-W/SCR	4.17E+10	0	3.75E+11	4.17E+11
	Harding Creek					
8040205-902	FC	PCR-S	4.31E+09	0	3.88E+10	4.31E+10
	FC	PCR-W/SCR	2.15E+10	0	1.94E+11	2.15E+11
	E. coli	PCR-S	4.42E+09	0	3.98E+10	4.42E+10
	E. coli	PCR-W/SCR	2.21E+10	0	1.99E+11	2.21E+11
	Bearhouse Creek					
8040205-901	FC	PCR-S	1.92E+10	0	1.73E+11	1.92E+11
	FC	PCR-W/SCR	9.61E+10	0	8.65E+11	9.61E+11
	E. coli	PCR-S	1.97E+10	0	1.77E+11	1.97E+11
	E. coli	PCR-W/SCR	9.85E+10	0	8.87E+11	9.85E+11

Arkansas HUC-Reach #	Pollutant	Criteria	MOS cfu/day	∑ WLA cfu/day	∑ LA cfu/day	TMDL cfu/day
	Bayou Bartholomew					
8040205-013	FC	PCR-S	1.68E+11	0	1.51E+12	1.68E+12
	FC	PCR-W/SCR	8.42E+11	0	7.57E+12	8.42E+12
	E. coli	PCR-S	1.73E+11	0	1.55E+12	1.73E+12
	E. coli	PCR-W/SCR	8.63E+11	0	7.76E+12	8.63E+12
	Deep Bayou					
8040205-005	FC	PCR-S	3.48E+10	0	3.13E+11	3.48E+11
	FC	PCR-W/SCR	1.74E+11	0	1.57E+12	1.74E+12
	E. coli	PCR-S	3.57E+10	0	3.21E+11	3.57E+11
	E. coli	PCR-W/SCR	1.79E+11	0	1.61E+12	1.79E+12

PCR-S (primary contact recreation summer) criteria – between May 1 - Sept 30 for pathogens.
PCR-W (primary contact recreation winter) criteria - between Oct. 1 - April 30, criteria may not exceed SCR (secondary contact recreation) criteria limits
SCR - Year round criteria limits
Cfu/day = colony forming units/day

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1.0 INTRODUCTION

This report presents total maximum daily loads (TMDLs) for fecal coliform and *Escherichia coli* (E. coli) for 8 HUC-reaches in the Bayou Bartholomew Sub-Basin in south Arkansas. These stream reaches were included on the Arkansas Department of Environmental Quality (ADEQ) 2004 Section 305(b) Report (ADEQ, 2005a) as not supporting their designated use of Primary Contact Recreation and/or Secondary Contact Recreation. The sources of contamination and causes of impairment from the 303(d) listing are shown below in Table1.0. The TMDLs in this report address the impairments due to pathogens and were developed in accordance with Section 303(d) of the Federal Clean Water Act and the Environmental Protection Agency's (EPA) regulations in 40 CFR 130.7.

Table 1.0 Pathogen impaired 2B reaches included in this document

HUC-Reach Number	Waterbody Name	Impaired Use	Cause of Impairment	Suspected Source	Priority Ranking
8040205-907	Chemin-A-Haut Creek	PCR	Pathogen	Unknown	Medium
8040205-905	Cross Bayou	PCR	Pathogen	Unknown	Medium
8040205-904	Jack's Bayou	PCR	Pathogen	Unknown	Medium
8040205-903	Melton's Creek	PCR	Pathogen	Unknown	Medium
8040205-902	Harding Creek	SCR	Pathogen	Urban Runoff	Low
8040205-901	Bearhouse Creek	PCR	Pathogen	Unknown	Medium
8040205-013	Bayou Bartholomew	PCR	Pathogen	Unknown	Medium
8040205-005	Deep Bayou	PCR	Pathogen	Unknown	Medium

SCR = Secondary Contact Recreation
PCR = Primary Contact Recreation

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

2.0 STUDY AREA INFORMATION

2.1 General Description

The planning segment for this project is located in the Gulf Coastal Plain and Delta ecoregions. Bayou Bartholomew, its tributaries from USGS Hydrologic Unit 08040205, and the Arkansas portion of the basin are designated by ADEQ as Planning Segment 2B. The drainage area of Bayou Bartholomew is 1,187 square miles at the USGS flow gage located 1 mile south of the Arkansas – Louisiana state line (USGS, 2001b) and 1,665 square miles at the mouth (USGS, 1971). The Arkansas portion of the basin includes parts of Jefferson, Cleveland, Drew, Chicot, Lincoln, Desha, Morehouse, and Ashley counties. The main tributaries of Bayou Bartholomew in south Arkansas are Deep Bayou, Ables Creek, Cutoff Creek, Bearhouse Creek, Overflow Creek, and Chemin-A-Haut Creek. The waters within this segment have been designated as suitable for the propagation of fish and wildlife, primary and secondary contact recreation, and domestic, industrial and agricultural water supplies. Table 2.1 below shows designated uses on selected HUC-Reaches. The 2B segment contains a total of 359.4 stream miles, all of which are being assessed using monitoring data (Figure 2.1 in Appendix A).

Table 2.1 Designated Uses on Selected HUC-Reaches

HUC-Reaches	Waterbody Name	Designated Uses
8040205-907	Chemin-A-Haut Creek	AWS, DWS, FS, IWS, PCR, SCR
8040205-905	Cross Bayou	AWS, DWS, FS, IWS, PCR, SCR
8040205-904	Jack's Bayou	AWS, DWS, FS, IWS, PCR, SCR
8040205-903	Melton's Creek	AWS, DWS, FS, IWS, PCR, SCR
8040205-902	Harding Creek	AWS, DWS, FS, IWS, PCR, SCR
8040205-901	Bearhouse Creek	AWS, DWS, FS, IWS, PCR, SCR
8040205-013	Bayou Bartholomew	AWS, DWS, FS, IWS, PCR, SCR
8040205-005	Deep Bayou	AWS, DWS, FS, IWS, PCR, SCR

AWS Agricultural Water Supply
DWS Domestic Water Supply
FS Fishery Stream
IWS Industrial Water Supply
PCR Primary Contact Recreation
SCR Secondary Contact Recreation

2.2 Soils and Topography

Soil characteristics for the watershed are also provided by the county soil surveys (USDA, 1976; USDA, 1979; USDA, 1981). The majority of soils in the Bayou Bartholomew watershed are classified as silt loam or sandy loam. Soil series that are common in the rolling uplands areas are Amy, Sacul, and Smithdale. Amy is classified as a silt loam, and Sacul and Smithdale are sandy loams. Most common in the flatwoods uplands is the Henry series, which is classified as a silt loam. Common soil series in the flood plains areas are Perry, which classified as clay and Rilla, which is classified as silt loam. These soil series are found primarily along the main stem of Bayou Bartholomew and major tributaries.

Maps showing spatial distributions of soils information were developed using data in GIS format from the STATSGO database, which is maintained by the Natural Resources Conservation Service (NRCS). The published soil surveys for these counties provide soils mapping that is more detailed than the STATSGO data, but that information is not yet available in GIS format. The predominant soil series in the Bayou Bartholomew basin are shown on Figure 2.2 in Appendix A. The values of soil erodibility (the K factor in the Universal Soil Loss Equation) are shown on Figure 2.3 in Appendix A and the hydrologic soil groups are shown on Figure 2.4 in Appendix A. Hydrologic soil groups are classifications of soils based on runoff potential; group A has the lowest runoff potential and group D has the highest runoff potential.

2.3 Land Use

Land use data for the Arkansas portion of the Bayou Bartholomew watershed were obtained from the GEOSTOR database, which is maintained by the Center for Advanced Spatial Technology (CAST) at the University of Arkansas in Fayetteville. These data were based on satellite imagery from 1999. Because this data set included many detailed land use classifications, similar land uses were combined to reduce the number of different land uses to 13. The spatial distribution of these land uses is shown on Figure 2.5 in Appendix A. Approximate percentages of these land uses in the watershed are listed below in Table 2.3.

Forest occupies over 52% of the watershed and is located mainly in the western portion of the watershed. Cropland occupies almost 38% of the watershed and is located mainly along the east side of the watershed.

Information on confined animal feeding operations (CAFOs) in the Bayou Bartholomew watershed was provided in the Bayou Bartholomew Assessment Report (ADEQ 2001a). According to this report, there are 43 CAFOs in the watershed, most of which are broiler production facilities. Most of these CAFOs are located in Lincoln County around Star City. Most of the litter from these operations is applied to adjacent pasture land, but some is applied to cropland within the county.

Table 2.3 Land Use Percentages For The Study Area.

Land use	Percentage of Study Area
Mixed forest	23
Deciduous forest	17.7
Evergreen forest	11.5
Soybeans	19.8
Cotton	12.5
Rice	3.3
Corn	2.1
Winter Pasture	3.6
Summer Pasture	1.4
Range brush	1.6
Open water	1.1
Residential	2.3
Industrial	0.1
Total	100

2.4 Flow Characteristics

There were four USGS flow gages in the study area: Bayou Bartholomew at Garret Bridge (USGS 07364133), Bayou Bartholomew near McGehee (USGS 07364150), Bayou Bartholomew near Portland (USGS 07364185) and Bayou Bartholomew near Jones, AR (USGS 07364200). Average annual precipitation for the Bayou Bartholomew watershed is about 51.75 inches based on data from five weather stations in or near the Bayou Bartholomew watershed (Pine Bluff, Dumas, Monticello, Hamburg, and Portland). Mean monthly precipitation totals for the Portland weather station are shown on Figure 2.6 in Appendix A. The mean monthly precipitation values are highest for December and March and lowest for September. The USGS has published daily stream flow data for Bayou Bartholomew at 3 locations in Arkansas and one location in Louisiana about 1 mile downstream of the state line. The locations of the gages are shown on Figure 2.7 in Appendix A. Basic information and summary statistics for these gages are summarized below in Table 2.4. Mean monthly flows for Bayou Bartholomew at the Jones, LA gaging station are shown on Figure 2.8 in Appendix A. In some instances, the flow in Bayou Bartholomew is influenced by withdrawals of irrigation water directly from the bayou and by return flows of irrigation water draining from the fields (ADEQ, 2001a). Irrigation water is also withdrawn from groundwater. A database obtained from the Arkansas Soil and Water Conservation Commission (ASWCC) showed that there are 275 surface water withdrawal sites and 1207 groundwater withdrawal sites within the Arkansas portion of the Bayou Bartholomew watershed. Over 94% of these withdrawal permits are for irrigation or other agricultural purposes.

Table 2.4 Stream Flow Gage Stations (USGS 2001a and USGS 2001b)

	Bayou Bartholomew at Garret Bridge, AR	**Bayou Bartholomew near McGehee, AR**	**Bayou Bartholomew near Portland, AR**	**Bayou Bartholomew near Jones, LA**
USGS gage number	07364133	07364150	07364185	07364200
Descriptive location	Hwy 54, 1.9 mi upstream of Flat Cr.	Hwy 4, 2.7 mi west of McGehee	Hwy 278, 1.4 mi west of Portland	Hwy 834, 1.6 mi northwest of Jones
Drainage area (mi^2)	380	576	1109	1187
Period of record	October 1987 to current	October 1945 to current	August 1998 to current	October 1957 to Current
Mean annual flow (cfs)	535	686	--	1320
Mean annual runoff (in)	19.1	16.2	--	15.1

3.0 WATER QUALITY STANDARDS

3.1 Definitions

Total Fecal coliform Bacteria

Total coliform bacteria are a collection of relatively harmless microorganisms that live in large numbers in the intestines of man and warm- and cold-blooded animals. They aid in the digestion of food.

Fecal coliform Bacteria

These organisms may be separated from the total coliform group by their ability to grow at elevated temperatures and are associated only with the fecal material of warm-blooded animals.

Escherichia coli (E. coli)

E. coli is a subset of fecal coliform bacteria.

The presence of fecal coliform bacteria in aquatic environments indicates that the water has been contaminated with the fecal material of man or other animals. At the time this occurred, the source water might have been contaminated by pathogens or disease producing bacteria or viruses that can also exist in fecal material. Some waterborne pathogenic diseases include typhoid fever, viral and bacterial gastroenteritis and hepatitis

A. The presence of fecal contamination is an indicator that a potential health risk exists for individuals exposed to this water. Fecal coliform bacteria may occur in ambient water as a result of the overflow of domestic sewage or non-point sources of human and animal waste (USEPA, 2001).

3.2 Water Quality Standards for Surface Waters of the State of Arkansas

There is no narrative criterion. The water use classification for the impaired water-bodies primary and secondary contact recreation. The fishing classification, as stated in #014.00-002 of Arkansas's Pollution Control and Ecology Commission Regulations Establishing Water Quality Standard for Surface Waters of the State of Arkansas (Adopted on April 23, 2004 Amended April 28, 2006).

The following is an except for Arkansas Reg. 2.507 (APCEC, 2006) for the numeric criteria

"The Arkansas Department of Health has the responsibility of approving or disapproving surface waters for public water supply and of approving or disapproving the suitability of specifically delineated outdoor bathing places for body contact recreation, and it has issued rules and regulations pertaining to such uses.

For the purposes of this regulation, all streams with watersheds less than 10 mi^2 shall not be designated for primary contact unless and until site verification indicates that such use is attainable. No mixing zones are allowed for discharges of bacteria.

> (A) Primary Contact Waters - Between May 1 and September 30, the fecal coliform content shall not exceed a geometric mean of 200 col/100 ml nor a monthly maximum of 400 col/100 ml. Alternatively, in these waters, *Escherichia coli (E. coli)* colony counts shall not exceed a geometric mean of more than 126 col/100 ml, or a monthly maximum value of not more than 298 col/100ml in lakes, reservoirs and Extraordinary Resource Waters or 410 col/100 ml in other rivers and streams. During the remainder of the calendar year, these criteria may be exceeded, but at no time shall these counts exceed the level necessary to support secondary contact recreation (below).
>
> "(B) Secondary Contact Waters - The fecal coliform content shall not exceed a geometric mean of 1000 col/100 ml, nor a monthly maximum of 2000 col/100 ml. E. coli values shall not exceed the geometric mean of 630 col/100 ml. or a monthly maximum of 1490 col/100 ml for lakes, reservoirs and Extraordinary Resource Waters and 2050 col/100 me for other rivers and streams."

As specified in EPA's regulations at 40 CFR 130.7(b)(2), applicable water quality standards include antidegradation requirements. Arkansas' antidegradation policy is summarized below.

> Existing instream water uses and the level of water quality necessary to protect the existing uses shall be maintained and protected.
>
> Water quality that exceeds standards shall be maintained and protected unless allowing lower water quality is necessary to accommodate important economic or

social development, although water quality must still be adequate to fully protect existing uses.

For outstanding state or national resource waters, those uses and water quality for which the outstanding waterbody was designated shall be protected.

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

4.0 SOURCE ANALYSIS

Under the Clean Water Act, sources are classified as either point or nonpoint sources. An important part of TMDL analysis is the identification of individual sources, or source subcategories of pollutants in the watershed that affect pathogen loading and the amount of loading contributed by each of these sources. The subcategorization is mostly in the area of the TMDL implementation plan, which is outside the scope of this document.

4.1 Point Sources

Under 40CFR §122.2, a point source is defined as "any discernable, confined, and discrete conveyance, including but not limited to, any pipe, ditch, channel, tunnel, conduit, well, discreet fissure, container, rolling stock, concentrated animal feeding operation, landfill leachate collection system, vessel or other floating craft from which pollutants are or may be discharged." The National Pollutant Discharge Elimination System (NPDES) program regulates point source discharges. Point source discharges can be described by broad subcategories: 1) NPDES regulated municipal and industrial wastewater treatment facilities (WWTF); 2) NPDES regulated industrial and municipal storm water discharges; 3) NPDES regulated indirect industrial and industrial non-process wastewater discharges; and 4) NPDES regulated Concentrated Animal Feeding Operations (CAFOs). A TMDL usually provides Waste Load Allocations (WLAs) for all NPDES regulated point sources.

Both treated and untreated sanitary wastewater contains fecal coliform bacteria. If they are classified with a SIC code of 4952 (Sewerage Systems), they must have pathogen requirements in the effluent monitoring data, submitted on Discharge Monitoring Reports (DMR). Information for point source discharges in the study area was obtained by searching the Permit Compliance System on the EPA web site (PCS, 2005).

4.1.1 Stormwater and MS4s – Phase I

The scope of Phase I is described as follows: In response to the 1987 Amendments to the Clean Water Act (CWA), the U.S. Environmental Protection Agency (EPA) developed Phase I of the NPDES Storm Water Program in 1990. It was mandated that cities nationwide develop programs addressing the issue of storm water pollution. The Phase I program targeted sources of storm water runoff that had the greatest potential to negatively impact water quality. Under Phase I, EPA required permit coverage for storm water discharges from "Medium" and "Large" municipal separate storm sewer systems (MS4s) located in incorporated places or counties with populations of 100,000 or more; and eleven categories of industrial activity, including construction projects that disturbs five or more acres of land. A medium MS4 is a system that services a population between 100,000 and 249,999. Meanwhile, a large MS4 is a system that services a population of 250,000 or more (USEPA, 1996).

4.1.2 Stormwater and MS4s – Phase II

The contribution of fecal material is the same as described above under Phase I. The scope of Phase II is described as follows: Smaller entities will be soon implementing the Phase II storm-water regulations. Operators of small MS4s (primarily those located in urbanized areas are required to implement programs and practices to control polluted storm water runoff from the jurisdiction serviced by the MS4. The operator must design its storm water management program to satisfy applicable CWA water quality requirements and technology standards. The program must include the development and implementation of best management practices (BMPs) and measurable goals for the following six minimum measures, and include evaluation and reporting efforts:

- Public education and outreach
- Public participation/involvement
- Illicit discharge detection and elimination
- Construction site runoff control
- Post-construction runoff control
- Pollution prevention/good housekeeping for municipal operations.

All construction operators disturbing more than 1 acre and less than 5 acres are required to apply for an NPDES storm water permit for small construction activity. EPA already regulates construction activity disturbing more than 5 acres. A construction operator is usually the developer or landowner, but can also be the contractor or another party responsible for the operational control of erosion and sediment control practices on site (EPA, 2004).

4.1.3 Concentrated Animal Feeding Operations (CAFOs)

Animal feeding operations are agricultural enterprises where animals are kept and raised in confined situations. These operations congregate animals, feed, manure and urine, dead animals, and production operations on a small land area. Feed is brought to the animals rather than the animals grazing or otherwise seeking feed in pastures, fields, or on rangeland (USEPA, 2002). Best Management Practices (BMPs) are implemented as the pollution controls at these facilities. Animal waste shall be isolated from outside surface drainage by ditches, dikes, terraces or other such structures except for a twenty-five-year, twenty-four-hour rainfall event. No waters of the state shall come into direct contact with the animals confined on the animal feeding operations.

4.2 Non-point Sources

Nonpoint sources are diffuse sources that cannot be identified as entering a waterbody through a discrete conveyance at a single location. For the purposes of this TMDL, all sources of pollutant loading not regulated by NPDES permits are considered nonpoint sources. The TMDL usually provides a Load Allocation (LA) for these sources.

These sources generally, but not always, involve accumulation of fecal coliform bacteria on land surfaces and wash off as a result of storm events. Nonpoint sources of pathogen loading are associated with any land use that has wildlife, domestic animals, or uses animal waste for any reason. The vast majority of waterbodies identified on the 303(b) Report as impaired due to pathogens could be due to nonpoint agricultural or urban sources. The predominant land uses for the listed reaches in Planning Segment 2B are forest and pasture. Therefore, the most probable source of Fecal coliform and E. coli bacteria could be from wildlife and domestic animals living in the area. Run off from the pastures can contribute Fecal coliform and E. coli to the study area. It is presently unknown to what extent these sources contribute to pathogen loads.

Nonpoint source loading of fecal bacteria from urban land use areas is attributable to multiple sources. These include: storm water runoff, illicit discharges of sanitary waste, runoff from improper disposal of waste materials, and pets. Impervious surfaces in urban areas allow runoff to be conveyed to streams quickly, without infiltration through soils and interaction with groundwater.

4.2.1 Land Application Sites

Land application of municipal sludge is common in Arkansas. In south central Arkansas, a principal cause of soil erosion is heavy rains that fall on sloping soils with thin vegetative cover. Municipal sewage sludge can be an important restorative for abused land and it can be substantially more effective than treatment of eroded areas that involves only grading and onetime fertilizing at planting. Sludge can improve soil condition, restore fertility, and maintain gentle contour while simultaneously solving the problem of disposal (Kessler, et al. 1985). One of the potential hazards associated with the application of sewage sludge to land is the possibility of human exposure to pathogens. Because of this hazard, sewage sludge must undergo additional treatment to reduce pathogens before it can be used for land application (Krogmann, et. al., 2003).

4.2.2 Agricultural Animals

Agricultural activities can be a significant source of fecal coliform bacteria loading to surface waters. The activities of greatest concern are typically those associated with livestock operations (Drapcho and Hubbs, 2002): Agricultural livestock grazing in pastures deposit manure containing fecal coliform bacteria onto land surfaces. This material accumulates during periods of dry weather and is available for washoff and transport to surface waters during storm events. The number of animals in pasture and the time spent grazing are important factors in determining the loading contribution.

Processed agricultural manure from confined feeding operations is often applied to land surfaces and can provide a significant source of fecal bacteria loading. Agricultural livestock often have direct access to water-bodies and can provide a concentrated source of fecal loading directly to a stream.

4.2.3. Septic Systems

There are rural areas still rely on septic systems. The operation of some can reasonably be assumed to be discharging fecal coliform bacteria. Discharges of untreated sewage provide a concentrated source of fecal bacteria directly to water-bodies.

4.2.4 Wildlife

Fecal coliform bacteria are produced by all warm-blooded animals, including wildlife such as mammals and birds. When developing implementation plans for bacteria TMDLs, it is useful to identify the potential for bacteria contributions from wildlife by watershed. Wildlife is naturally attracted to riparian corridors of streams and rivers. Wildlife that has direct access to the stream channel can be a concentrated source of bacteria loading to a waterbody. Fecal coliform bacteria from wildlife are also deposited onto land surfaces, where it may be washed into nearby streams by rainfall runoff. Table 4.2 below displays rough estimates of the deer population in each county within Planning Segment 2B. There are insufficient data available to estimate populations of wildlife and avian species by watershed. Consequently, it is difficult to assess the magnitude of contributions from wildlife species as a general category.

Table 4.2 Estimated Deer Population

Counties	Number of Deer
Jefferson	2130
Cleveland	4791
Drew	4382
Chicot	982
Lincoln	2274
Desha	1921
Ashley	4631

5.0 CHARACTERIZATION OF EXISTING WATER QUALITY

5.1 Comparison of Observed Data to Criteria

Fecal coliform bacteria monitoring data for each listed reach were obtained from ADEQ (Table 5.1 in Appendix A). A map of the monitoring station is provided in Appendix A (Figure 2.7). All the stations collected a number of samples from 1998 thru 1999.

As indicated in Table 5.2 in Appendix A, the samples collected at 5 out of 8 stations had exceeded the primary contact recreation criterion of 400 colonies/100 ml during the summer months for fecal coliform. The samples collected at 5 out of 8 stations had exceedances of the primary contact recreation winter/secondary contact criteria of 2000 colonies/100 ml from October through April timeframe. Station OUA0152 had the most samples above the criterion and had the largest single sample concentration of greater than 6000 colonies/100 ml.

5.2 Trends and Patterns in Observed Data

No distinct trends or patterns were found in the small data set of reported monitoring results. The highest fecal coliform bacteria concentrations were observed during the summer months and usually during low-flow conditions. Limited sample collection during high-flow periods limits the comparability of low-flow and high-flow monitoring results.

6.0 TMDL DEVELOPMENT

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

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

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

TMDLs for some pollutants are expressed as a mass loading (e.g., kilograms per day). TMDLs for bacteria can be expressed in terms of colony forming units per day, in accordance with 40 CFR 130.2(l).

The federal regulations at 40 CFR 130.7 require that TMDLs include seasonal variations and take into account critical conditions for stream-flow, loading, and water quality parameters. These TMDL fecal coliform and E. coli bacteria loadings for sub-segments with primary contact recreation as the designated use were determined for winter and summer on the basis of seasonal water quality criteria, thus accounting for seasonality. Account for critical conditions by displaying the loads at water quality load duration curves for infrequent occurrences and not only for average conditions criteria.

6.1 Load Duration Curves (LDC)

Historically, in developing WLAs for pollutants from point sources, it was customary to designate a critical low flow condition (*e.g.*, 7Q2) at which the maximum permissible loading was calculated. As water quality management efforts expanded in scope to quantitatively address non-point sources of pollution and types of pollutants, it became clear that this single critical low flow condition was inadequate to ensure adequate water quality across a range of flow conditions. Use of the LDC removes the need to determine a design storm or selected flow recurrence interval with which to characterize the appropriate flow level for the assessment of critical conditions. The “non-point source critical condition” would typically occur during high flows, when rainfall runoff would contribute the bulk of the pollutant load. The “point source critical condition” would typically occur during low flows, when treatment plant effluents would dominate the base flow of the impaired water. This makes when a segment is affect by both point sources and non-point sources. LDCs display the maximum allowable load over the complete range of flow conditions by a line using the calculation of flow multiplied by the water quality criterion. The TMDLs can be expressed as a continuous function of flow, equal to the line, or as discrete values derived from each specific flow value.

The load duration curve (LDC) was used to develop TMDLs for Segment 2B. LDCs facilitate rapid development of TMDLs and are effective at identifying whether impairments are associated with point or non-point sources. Because loading capacity varies as a function of the flow present in the stream, these TMDLs represent a continuum of desired loads over all flow conditions, rather than fixed at a single value. The technical approach for using LDCs for TMDL development includes the following steps:

i) Developing flow duration curves (FDCs) for gaged and un-gaged HUC-Reach;

ii) Convert the FDCs to load duration curves (LDCs) for each HUC-Reach within Planning Segment 2B; and,

iii) Interpreting LDCs to derive TMDL elements – WLA, LA and MOS

6.1.1 Flow Duration Curves Development

Flow duration curves are graphical representations of the flow characteristics of a stream at a given site. Flow duration curves utilize the historical hydrologic record from stream USGS gages to forecast future recurrence frequencies. There is a number of WQM stations throughout Arkansas do not have long term flow data and therefore, flow frequencies must be estimated using a standard drainage area ratio method. The most basic method to estimate flows at an un-gaged site involves 1) identifying an upstream or downstream flow gage; 2) calculating the contributing drainage areas of the un-gage sites and the flow gage; and 3) calculating daily flows at the un-gage site by using the flow at the gage site multiplied by the drainage area ratio. More complex approaches may also consider watershed differences in rainfall, land use, and the hydrologic properties of soil that govern runoff and retention. More than one upstream watershed may also be considered. Flow duration curves are a type of cumulative distribution function.

The flow duration curve represents the fraction of flow observations that exceed a given flow at the site of interest. Daily stream flow measurements were sorted in increasing order, and the percentile ranking of each flow was calculated. The observed flow values are first ranked from highest to lowest, then, for each observation, the percentage of observations exceeding that flow is calculated. The flow value is read from the ordinate (y-axis), which is typically on a logarithmic scale since the high flows would otherwise overwhelm the low flows. The flow exceedance frequency is read from the abscissa (x-axis), which is numbered from 0 to 100 percent, and is not logarithmic. The lowest measured flow occurs at an exceedance frequency of 100 percent indicating that flow has equaled or exceeded this value 100 percent of the time, while the highest measured flow is found at an exceedance frequency of 0 percent. The median flow occurs at a flow exceedance frequency of 50 percent. The flow exceedance percentiles for each HUC-Reach addressed in this report are provided in Appendix B. The number of observations required to develop a flow duration curve is not rigorously specified, a flow duration curve is usually based on more than 1 year of observations, and encompasses inter-annual and seasonal variation. The drought of record and flood of record are included in the observations. The long term flow gage stations operated by the USGS are utilized (USGS 2005a). A typical semi-log flow duration curve exhibits a sigmoid shape, bending upward near the flow duration of 0 percent and downward at a frequency near 100 percent, often with a relatively constant slope in between. The curve will intersect the abscissa at a frequency less than 100 percent for sites that on occasion exhibit no flow. The line of the LDC tends to appear smoother as the number of observations at a site increases. At extreme low and high flow values, flow duration curves may exhibit a “stair step” effect due to the USGS flow data rounding conventions near the limits of quantization. The flow rate (e.g., cubic feet per second) and the percentage of days on which the plotted flow is exceeded are typically plotted on the Y-axis and the X-axis, respectively. The flow exceedance range of flow duration curves was subdivided into five hydrologic condition classes (see Table 6.1 below). The hydrologic classes selected facilitate the diagnostic and analytical uses of flow and LDCs. Flow duration curves (Figures B.1 through B.8) generated for HUC-Reaches using the described method are displayed in Appendix B.

Table 6.1 Hydrologic Classification Scheme Flow Duration Interval

0-10%	High flows
10-40%	Moist Conditions
40-60%	Mid-Range Conditions
60-90%	Dry Conditions
90-100%	Low Flows

6.1.2 Development of Load Duration Curve

Load Duration Curves (LDCs) were developed for each season numeric criterion for each bacterium (i.e., fecal coliform and E. coli). The load duration curve presents corresponding flow information and monitoring results plotted as a load. This approach allows the monitoring data to be placed in relation to their place in the flow continuum. Assumptions of the probable source or sources of the impairment can then be made from the plotted data. The load duration curve shows the calculation of the TMDL at any flow rather than at a single critical flow. The official TMDL number is reported as a single number, but the curve is provided to demonstrate the value of the acceptable load at any flow. This will allow analysis of load cases in the future for different flow regimes.

The flows rate from the flow duration curves was multiplied by the appropriate fecal coliform and E. coli bacteria numeric criterion concentrations to compute an allowable load. For instance, the curve represents the single sample water quality criterion for fecal coliform (400 cfu/100 ml), *E. coli* (410 cfu/100 ml) expressed in terms of a load through multiplication by the continuum of flows historically observed at this site. Each load duration curve is a plot of mass per day versus the percent flow exceedance from the flow duration curves. In addition, LDCs have similar in appearance to flow duration curves; however, the ordinate is expressed in terms of a bacteria load in cfu per day (cfu/day). Each curve was assumed applicable at all sampling stations and for all stream reaches in that water-body.

The culmination of these steps is expressed in the following formula which is displayed on the LDC as the TMDL curve:

TMDL (cfu/day) = WQS * flow (cfs) * Unit Conversion Factor

Where: WQS = 400 cfu /100 ml (Fecal coliform); 410 cfu/100 ml (E. coli);
Unit Conversion Factor = 24,465,525 ml*s / ft3*day

The flow exceedance frequency (x-value of each point) is obtained by looking up the historical exceedance frequency of the measured flow, in other words, the percent of historical observations that equal or exceed the measured flow

- matching the water quality observations with the flow data from the same date;
- multiplying the flow by the water quality parameter concentration to calculate daily loads; then
- plotting the flow exceedance percentiles and daily load observations in a load duration plot.

Tables G.1 – G.16 in Appendix G provide flow rate and load data which were used to develop the flow and pathogen load duration curves for HUC-Reaches.

6.1.3 Estimation of Loading/Identifying Critical Conditions

Another key step in the use of LDCs for TMDL development is the estimation of existing bacteria loading by displaying this loading in relation to the TMDL line. WWTPs that discharge treated sanitary wastewater must meet the state WQSs for bacteria at the point of discharge. Data necessary for this calculation were extracted from each point source's DMR from 1998 through 2004.

Estimated existing loading was calculated by multiplying the concentration of bacteria grab samples by the flow matched to the specific sampling date. The period of record for the bacteria data set varies from WQM station to WQM station. Bacteria data after 1997 were used to estimate existing loading. Existing loads were estimated by plotting on the LDC. The existing instream fecal coliform/E. Coli load is compared the allowable load for that flow. Any existing loads above the allowable LDC (or the water quality criterion line) represent an exceedance of the WQS.

In some cases, inspection of the LDC will reveal a critical condition related to exceedances of WQSs. If criteria exceedances occur more frequently in wet weather, low flow conditions, or after large rainfall events, the critical conditions are such that if WQSs were met under those conditions. WQSs would likely be met overall.

6.2 Total Maximum Daily Loads (TMDLs)

The LDC approach recognizes that the assimilative capacity of a water-body depends on the flow, and that maximum allowable loading will vary with flow condition. TMDLs can be expressed in terms of maximum allowable concentrations, or as different maximum loads allowable under different flow conditions, rather than single maximum load values. This approach meets the requirements of 40 CFR, 130.2(i) for expressing TMDLs "in terms of mass per time, toxicity, or other appropriate measures" and is consistent with USEPA's Protocol for Developing Pathogen TMDLs (USEPA 2001). Each TMDL was calculated as the mass balance. The 50% flow exceedance value load was used. For tabulation, Table 6.2 below presents the TMDLs and allocations for the HUC-Reaches.

6.3 Waste Load Allocation (WLA)

The WLA portion of the TMDL equation is the total loading of a pollutant that is assigned to point sources. A point source can be either a wastewater (continuous) or storm-water (MS4) discharge.

Storm-water point sources are typically associated with urban and industrialized areas, and recent USEPA guidance includes permitted storm-water discharges as point source discharges and, therefore, part of the WLA. There are two permitted facilities discharging sanitary wastewater into Segment 2B. They are City of Dermott - South Pond AR0022250 with a discharge of 1.2 MGD into Bayou Bartholomew and City of Hamburg AR0034029 with a discharge of 0.097 MGD into Chemin-A-Haut Creek. The City of Hamburg facility is not permitted to discharge during the months of May through October, and the permit does not have them list as going to an impaired area.

Some watersheds with no existing or planned continuous permitted point sources had the WLAs set to zero. A WLA may be calculated for each active NPDES wastewater discharger using a mass balance approach as shown in the equation below. The permitted average flow rate used for each point source discharge and the water quality criterion concentration are used to estimate the WLA for each wastewater facility.

WLA (cfu/day) = WQS * flow * Unit Conversion Factor

Where: WQC = 400 cfu /100 ml (Fecal coliform); 410 cfu/100 ml (E. coli)
flow (mgd) = permitted flow or design flow (if unavailable)
Unit Conversion Factor = 37,854,120 100-ml/mg

Table 6.2 Summary of Bacteria TMDLs Planning Segment 2B

Arkansas HUC-Reach #	Pollutant	Criteria	MOS cfu/day	∑ WLA cfu/day	∑ LA cfu/day	TMDL cfu/day
	Chemin-A-Haut Creek					
8040205-907	FC	PCR-S	9.11E+10	1.47E+09	8.18E+11	9.11E+11
	FC	PCR-W/SCR	4.55E+11	7.34E+09	4.09E+12	4.55E+12
	E. coli	PCR-S	9.33E+10	1.51E+09	8.38E+11	9.33E+11
	E. coli	PCR-W/SCR	4.67E+11	7.53E+09	4.20E+12	4.67E+12
	Cross Bayou					
8040205-905	FC	PCR-S	2.24E+09	0	2.02E+10	2.24E+10
	FC	PCR-W/SCR	1.12E+10	0	1.01E+11	1.12E+11
	E. coli	PCR-S	2.29E+09	0	2.06E+10	2.29E+10
	E. coli	PCR-W/SCR	1.15E+10	0	1.04E+11	1.15E+11
	Jack's Bayou					
8040205-904	FC	PCR-S	5.61E+09	0	5.05E+10	5.61E+10
	FC	PCR-W/SCR	2.80E+10	0	2.52E+11	2.80E+11
	E. coli	PCR-S	5.75E+09	0	5.18E+10	5.75E+10
	E. coli	PCR-W/SCR	2.87E+10	0	2.58E+11	2.87E+11
	Melton's Creek					
8040205-903	FC	PCR-S	8.13E+09	0	7.32E+10	8.13E+10
	FC	PCR-W/SCR	4.06E+10	0	3.66E+11	4.06E+11
	E. coli	PCR-S	8.33E+09	0	7.50E+10	8.33E+10
	E. coli	PCR-W/SCR	4.17E+10	0	3.75E+11	4.17E+11
	Harding Creek					
8040205-902	FC	PCR-S	4.31E+09	0	3.88E+10	4.31E+10
	FC	PCR-W/SCR	2.15E+10	0	1.94E+11	2.15E+11
	E. coli	PCR-S	4.42E+09	0	3.98E+10	4.42E+10
	E. coli	PCR-W/SCR	2.21E+10	0	1.99E+11	2.21E+11
	Bearhouse Creek					
8040205-901	FC	PCR-S	1.92E+10	0	1.73E+11	1.92E+11
	FC	PCR-W/SCR	9.61E+10	0	8.65E+11	9.61E+11
	E. coli	PCR-S	1.97E+10	0	1.77E+11	1.97E+11
	E. coli	PCR-W/SCR	9.85E+10	0	8.87E+11	9.85E+11

Arkansas HUC-Reach #	Pollutant	Criteria	MOS cfu/day	∑ WLA cfu/day	∑ LA cfu/day	TMDL cfu/day
	Bayou Bartholomew					
8040205-013	FC	PCR-S	1.68E+11	0	1.51E+12	1.68E+12
	FC	PCR-W/SCR	8.42E+11	0	7.57E+12	8.42E+12
	E. coli	PCR-S	1.73E+11	0	1.55E+12	1.73E+12
	E. coli	PCR-W/SCR	8.63E+11	0	7.76E+12	8.63E+12
	Deep Bayou					
8040205-005	FC	PCR-S	3.48E+10	0	3.13E+11	3.48E+11
	FC	PCR-W/SCR	1.74E+11	0	1.57E+12	1.74E+12
	E. coli	PCR-S	3.57E+10	0	3.21E+11	3.57E+11
	E. coli	PCR-W/SCR	1.79E+11	0	1.61E+12	1.79E+12

PCR-S (primary contact recreation summer) criteria – between May 1 - Sept 30 for pathogens.
PCR-W (primary contact recreation winter) criteria - between Oct. 1 - April 30, criteria may not exceed SCR (secondary contact recreation) criteria limits
SCR - Year round criteria limits
Cfu/day = colony forming units/day

6.4 Load Allocation (LA)

The load allocation is the portion of the TMDL assigned to natural background loadings as well as non-point sources such as septic tanks, wildlife, and agricultural practices. The LA was calculated by subtracting the WLA, and MOS from the total TMDL. LAs were not allocated to separate nonpoint sources; due to the lack of available source characterization data. LAs can be calculated under different flow conditions as the TMDL minus the WLA and MOS. The LA is graphically represented by the vertical distance under the LDC but above the WLA and MOS. The LA at any particular flow exceedance is calculated as shown in the equation below.

$$LA = TMDL - MOS - \sum WLA$$

6.5 Margin of Safety (MOS)

Both section 303(d) of the Clean Water Act and the regulations at 40 CFR 130.7 require that TMDLs include an MOS to account for lack of knowledge of the relationship between effluent limitation and water quality. The MOS may be expressed explicitly as unallocated assimilative capacity or implicitly using conservative assumptions in establishing the TMDL.

There are two ways to incorporate the MOS (USEPA 1991). One way is to implicitly incorporate the MOS by using conservative model assumptions to develop allocations. The other way is to explicitly specify a portion of the TMDL as the MOS and use the remainder for allocations.

A typical explicit approach would reserve some fraction of the TMDL (*e.g.,* 10%) as the MOS. In an implicit approach, conservative assumptions used in developing the TMDL are relied upon to provide an MOS to assure that WQSs are attained. For the TMDLs in this report, an explicit MOS of 10 percent of the TMDL value. Using 10 percent of the TMDL load provides an additional level of protection to the designated uses of the water-bodies of concern.

6.6 Future Growth

Compliance with these TMDLs is based on keeping the bacteria concentrations in the selected waters below the criterion limits that were set for the sites. Future growth for existing or new point sources is not limited by these TMDLs as long as they do not cause bacteria to exceed the criterion limits. The assimilative capacity of the streams will increase as the amount of flow in the stream increases. Increases in flow will allow for increased loadings. The LDC and tables will guide the determination of the assimilative capacity of the stream including the future growth.

7.0 OTHER RELEVANT INFORMATION

In accordance with Section 106 of the federal Clean Water Act and under its own authority, ADEQ has established a comprehensive program for monitoring the quality of the State's surface waters. ADEQ collects surface water samples at various locations, utilizing appropriate sampling methods and procedures for ensuring the quality of the data collected. The objectives of the surface water monitoring program are to determine the quality of the state's surface waters, to develop a long-term data base for long term trend analysis, and to monitor the effectiveness of pollution controls. The data obtained through the surface water monitoring program is used to develop the state's biennial 305(b) report (Water Quality Inventory) and the 303(d) list of impaired waters, which are issued as a single document titled Arkansas Integrated Water Quality Monitoring and Assessment Report.

8.0 PUBLIC PARTICIPATION

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

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Appendix A

Fecal Coliform Bacteria Monitoring Data, Watershed and Land Cover Maps

Table 5.1 Summary of fecal coliform bacteria data

Station number	Station name	Period of record	# of Obs.	Min. MPN/ 100 mL	Max. MPN/ 100 mL	# of Obs. Above PCR Summer criteria	# of Obs. Above PCR Winter/SCR criteria
OUA0012	Chemin A Haut Cr near Beekman, LA	11/98 - 10/99	7	88	867	0	0
OUA0145	Harding Creek In Sw Pine Bluff, AR	11/98 - 9/99	8	29	>2000	1	1
OUA0150	Jacks Bayou South of Tamo, AR	11/98 –10/99	9	4	>700	0	0
OUA0151	Deep Bayou South of Grady, AR	11/98 –10/99	9	35	>1000	1	0
OUA0152	Cross Bayou S.E. of Fresno, AR	11/98 – 8/99	7	61	6000	1	3
OUA0155	Bearhouse Creek near Snyder, AR	1/99 – 3/99	3	21	400	0	0
OUA0160	Bayou Bartholomew South of Tarry, AR	11/98 – 6/99	5	135	1399	1	0
UWBYB03	Bayou Bartholomew @Hwy 54 at Garrett Bridge	11/98 –10/99	7	108	3066	1	1

Table 5.2 Summary of Bacteria Raw Data

StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
Bayou Bartholomew					
UWBYB03	84090	WWR	09-Nov-98	>600	
UWBYB03	84610	WWR	12-Jan-99	460	
UWBYB03	84870	WWR	01-Feb-99	430	
UWBYB03	85416	WWR	09-Mar-99	867	
UWBYB03	86876	WWR	29-Jun-99	~3066	
UWBYB03	88200	WWR	27-Sep-99	210	
UWBYB03	88580	WWR	25-Oct-99	108	
Chemin-A-Haut CreeK					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0012	84066	WWR	09-Nov-98	>600	
OUA0012	84584	WWR	12-Jan-99	115	
OUA0012	84876	WWRO	01-Feb-99	235	
OUA0012	85418	WWR	09-Mar-99	88	
OUA0012	87857	WWR	30-Aug-99	425	
OUA0012	88219	WWRO	27-Sep-99	115	
OUA0012	88585	WWR	25-Oct-99	867	
Harding Creek					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0145	84081	WWR	09-Nov-98	>600	
OUA0145	84598	WWR	12-Jan-99	>1200	
OUA0145	84861	WWR	01-Feb-99	>1200	
OUA0145	85400	WWR	09-Mar-99	>2000	
OUA0145	86808	WWR	21-Jun-99	~70	
OUA0145	87587	WWR	17-Aug-99	~29	
OUA0145	87848	WWR	30-Aug-99	615	
OUA0145	88205	WWRO	27-Sep-99	~74	
Jack's Bayou					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0150	84087	WWR	09-Nov-98	>600	
OUA0150	84604	WWR	12-Jan-99	280	
OUA0150	84867	WWR	01-Feb-99	>700	
OUA0150	85407	WWR	09-Mar-99	204	
OUA0150	86879	WWR	29-Jun-99	270	
OUA0150	87583	WWR	17-Aug-99	144	
OUA0150	87867	WWR	30-Aug-99	165	
OUA0150	88196	WWR	27-Sep-99	~30	
OUA0150	88576	WWR	25-Oct-99	~4	
Deep Bayou					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0151	84088	WWR	09-Nov-98	260	
OUA0151	84608	WWR	12-Jan-99	>1000	
OUA0151	84868	WWR	01-Feb-99	>700	
OUA0151	85408	WWR	09-Mar-99	192	
OUA0151	86878	WWR	29-Jun-99	250	
OUA0151	87582	WWR	17-Aug-99	~467	
OUA0151	87868	WWR	30-Aug-99	~167	
OUA0151	88197	WWR	27-Sep-99	~35	
OUA0151	88579	WWR	25-Oct-99	156	
Cross Bayou					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0152	84089	WWR	09-Nov-98	>600	
OUA0152	84609	WWR	12-Jan-99	3400	
OUA0152	84869	WWR	01-Feb-99	>6000	
OUA0152	85409	WWR	09-Mar-99	2600	
OUA0152	86877	WWR	29-Jun-99	666	
OUA0152	87581	WWR	17-Aug-99	288	
OUA0152	87869	WWR	30-Aug-99	~61	
Bearhouse Creek					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0155	84588	WWR	12-Jan-99	165	
OUA0155	84880	WWR	01-Feb-99	400	
OUA0155	85422	WWR	09-Mar-99	~21	
Melton's Creek					
StationID	LogNumber	SampleType	DateCollected	FecalColiform	E_Coli
OUA0160	84085	WWR	09-Nov-98	>600	
OUA0160	84602	WWR	12-Jan-99	135	
OUA0160	84865	WWR	01-Feb-99	>1200	
OUA0160	85404	WWR	09-Mar-99	184	
OUA0160	86811	WWR	21-Jun-99	1399	

Figure 2.1 Bayou Batholomew Basin

Figure 2.2 Predominant Soil Types in Bayou Bartholomew Watershed

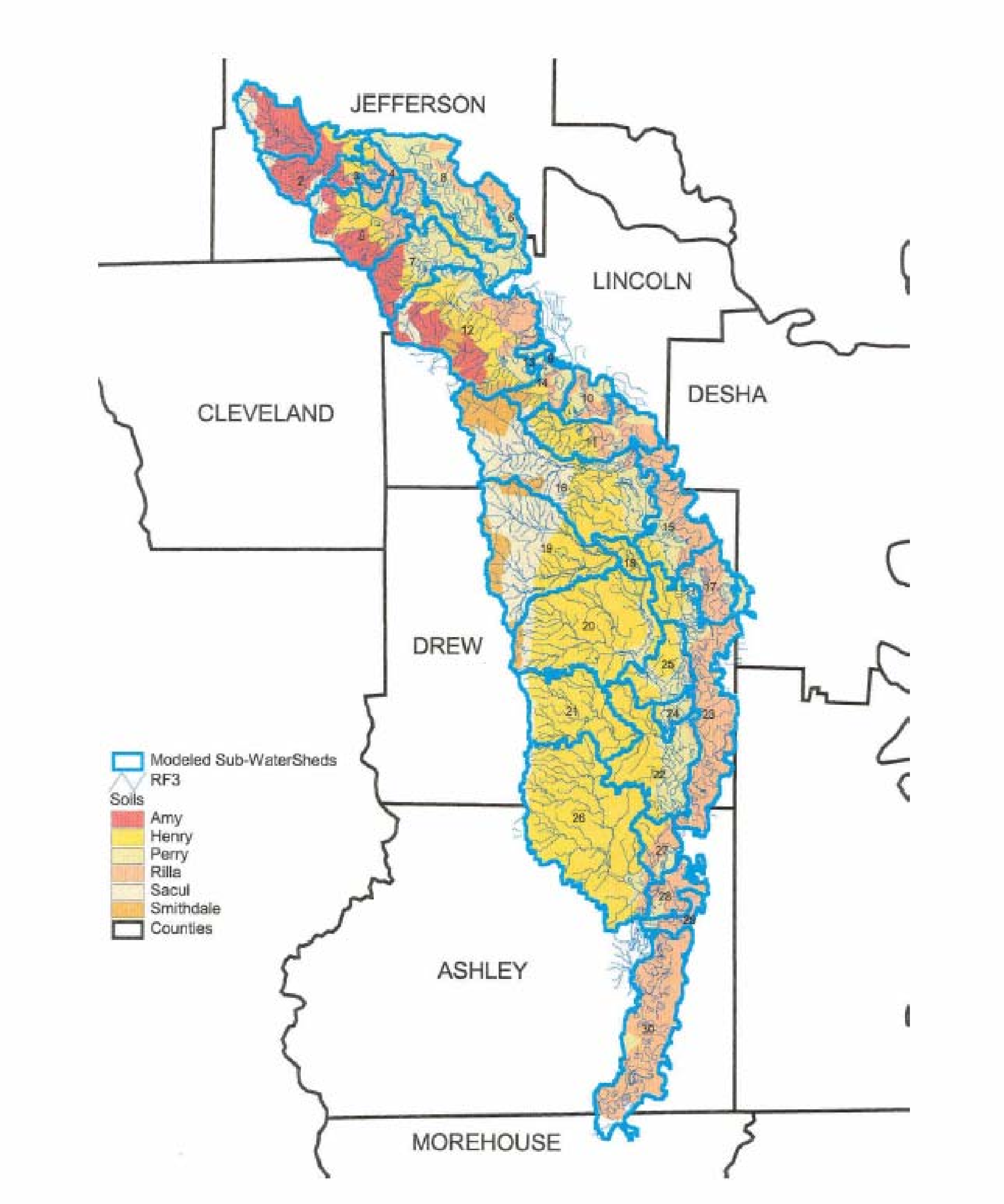


Figure 2.3 Soil Erodibility Factors in Bayou Bartholomew Watershed

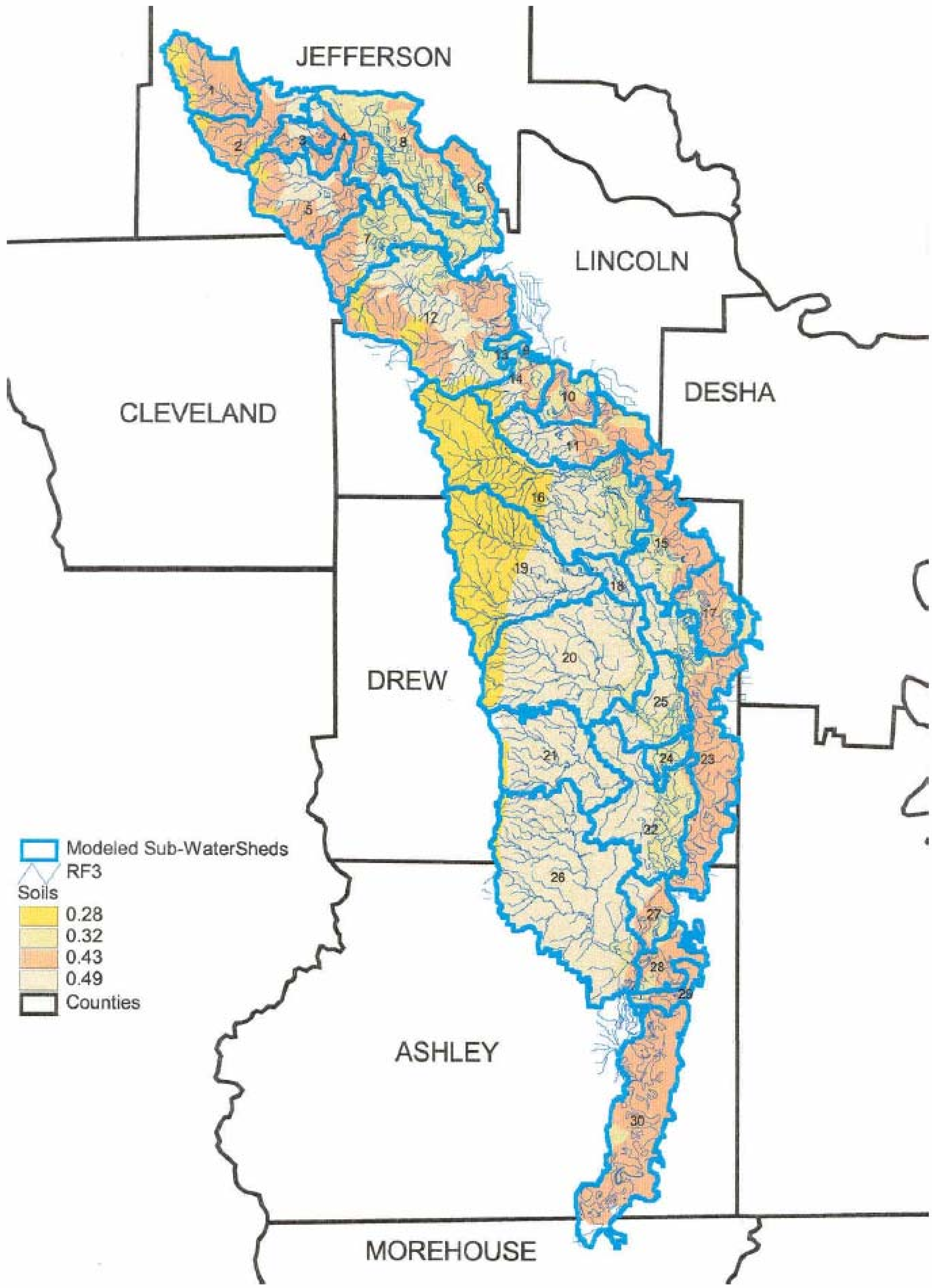


Figure 2.4 Hydrologic Soil Groups in Bayou Bartholomew Watershed

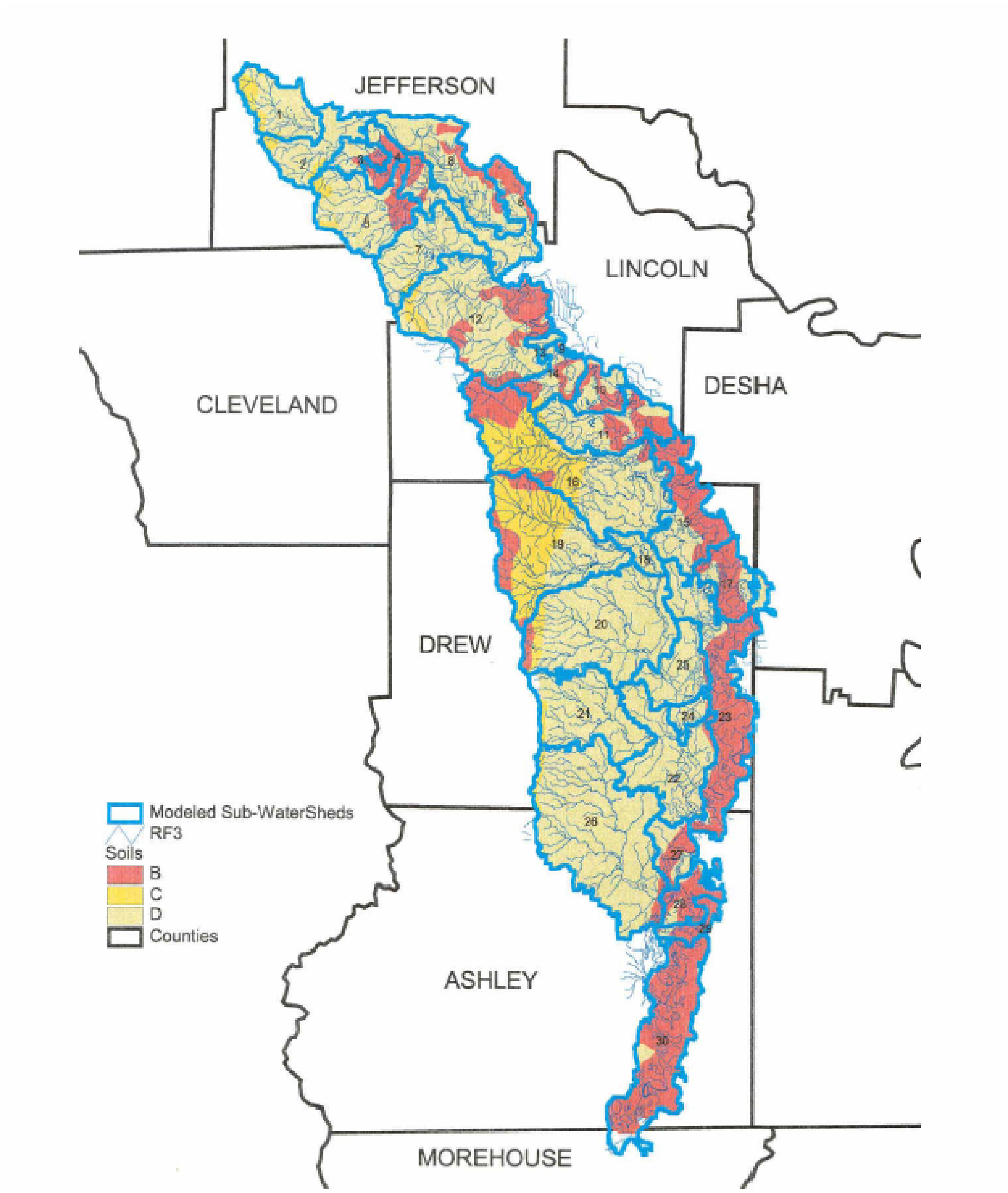


Figure 2.5 Land Uses in Bayou Bartholomew Watershed

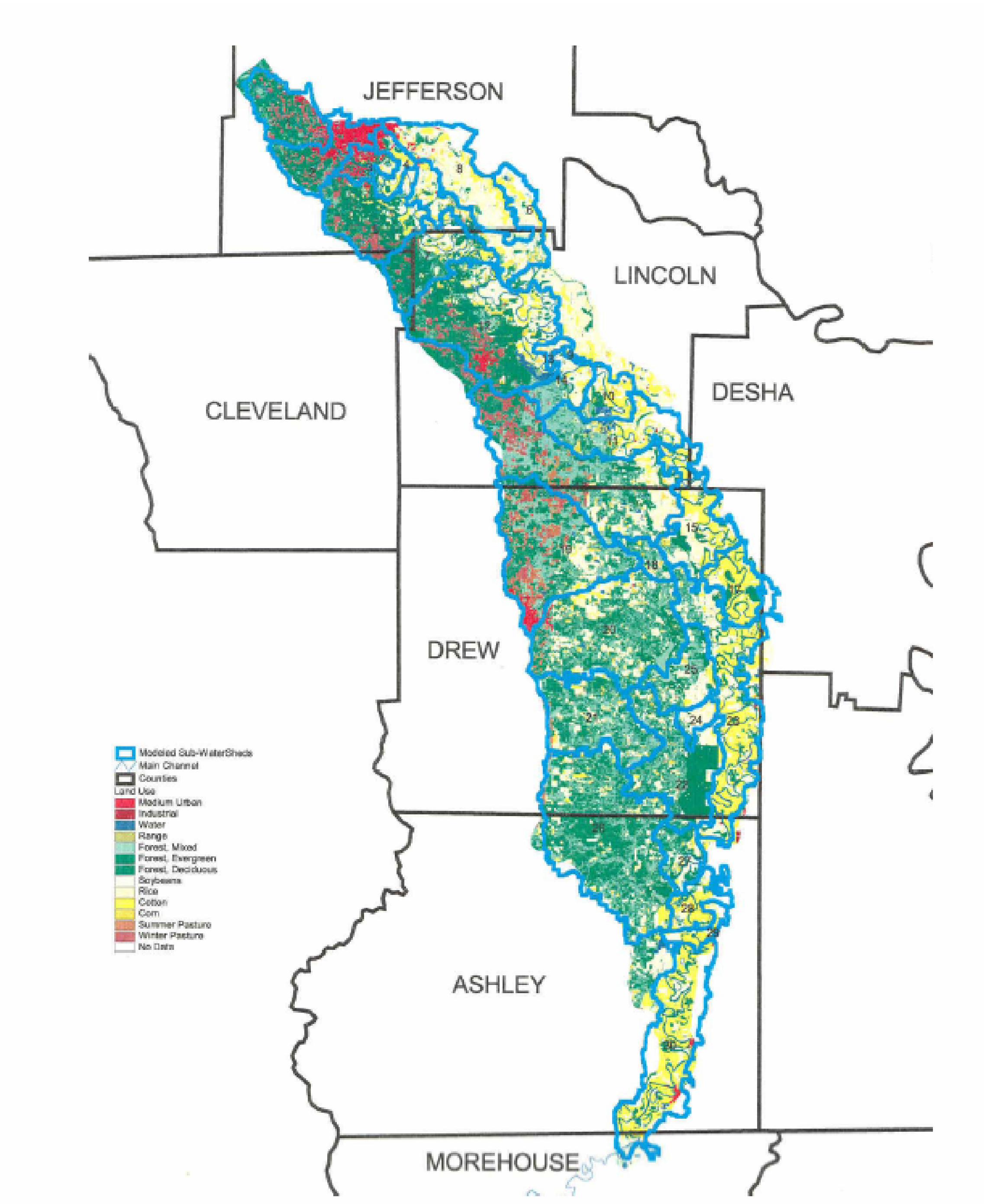


Figure 2.6 Mean Monthly Precipitation in Portland, AR

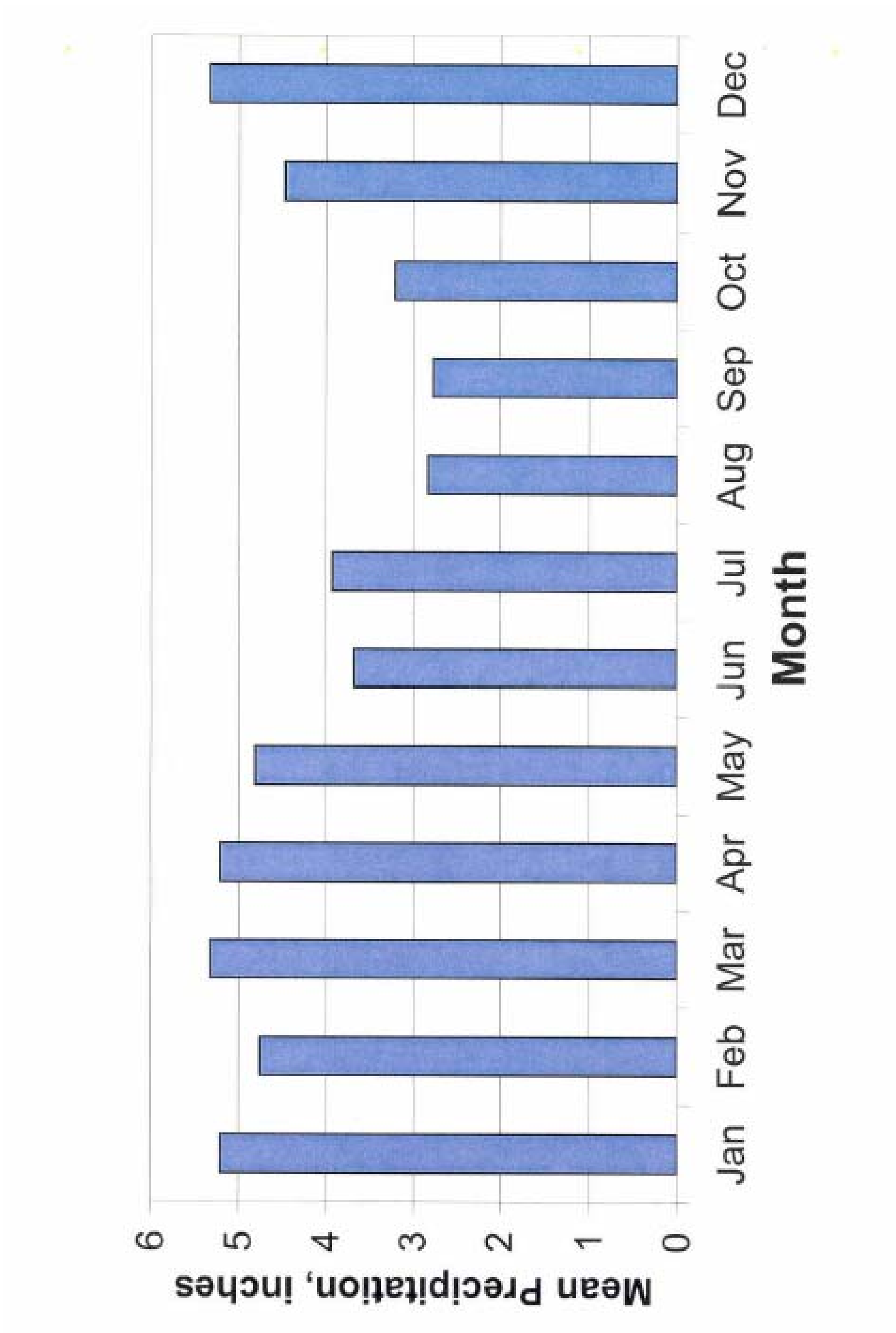


Figure 2.7 Selected Streams and Water Monitoring Stations

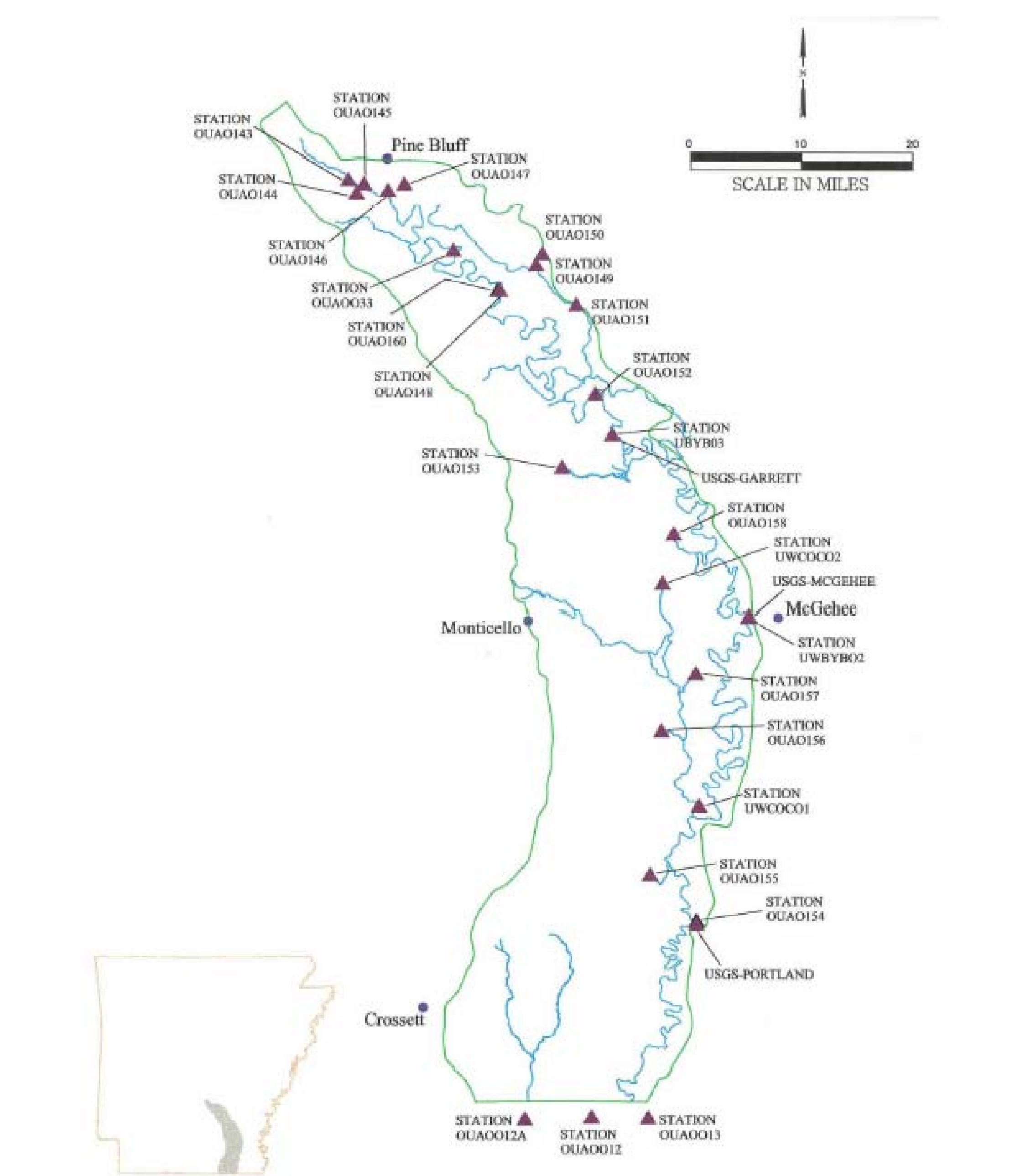
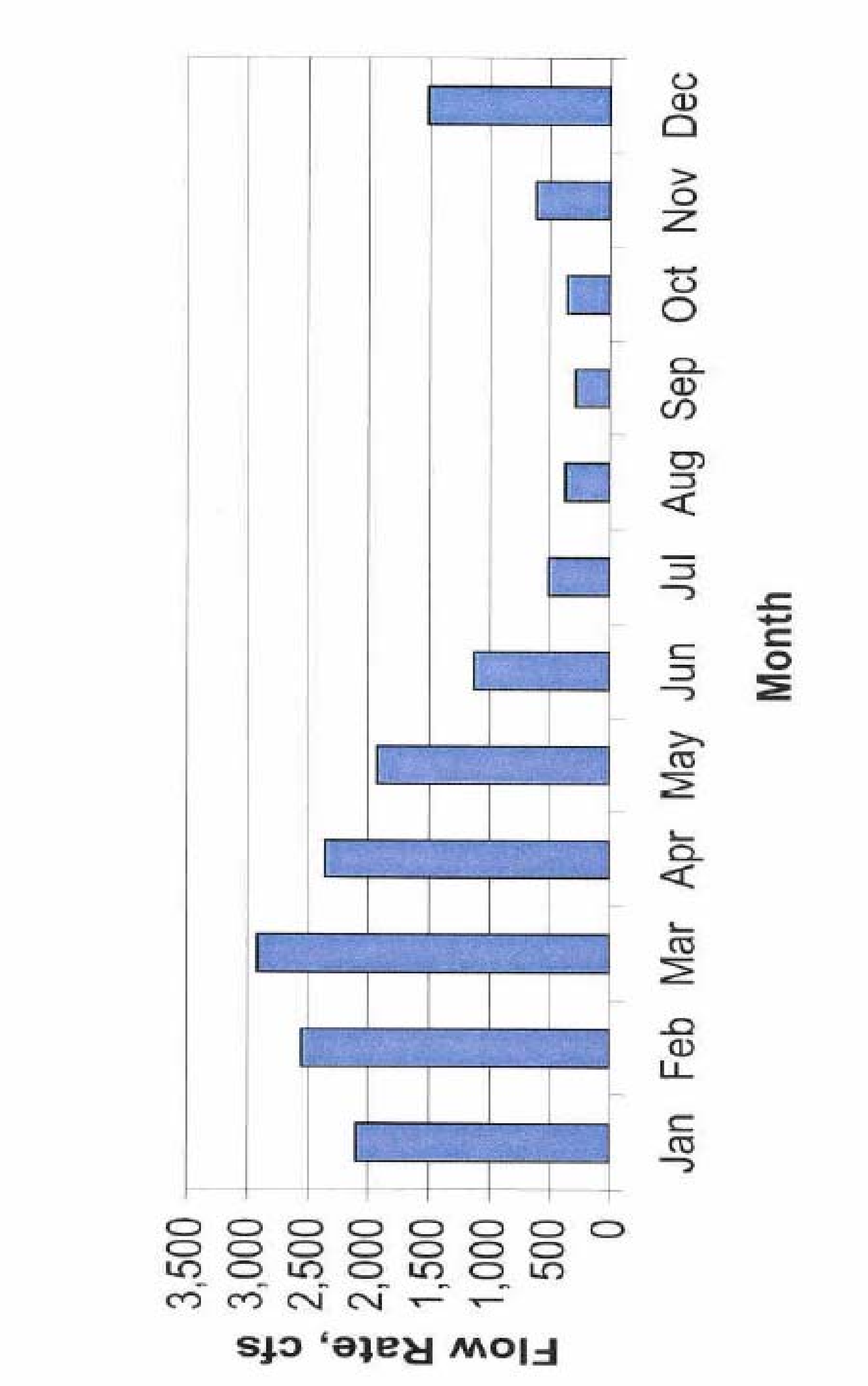


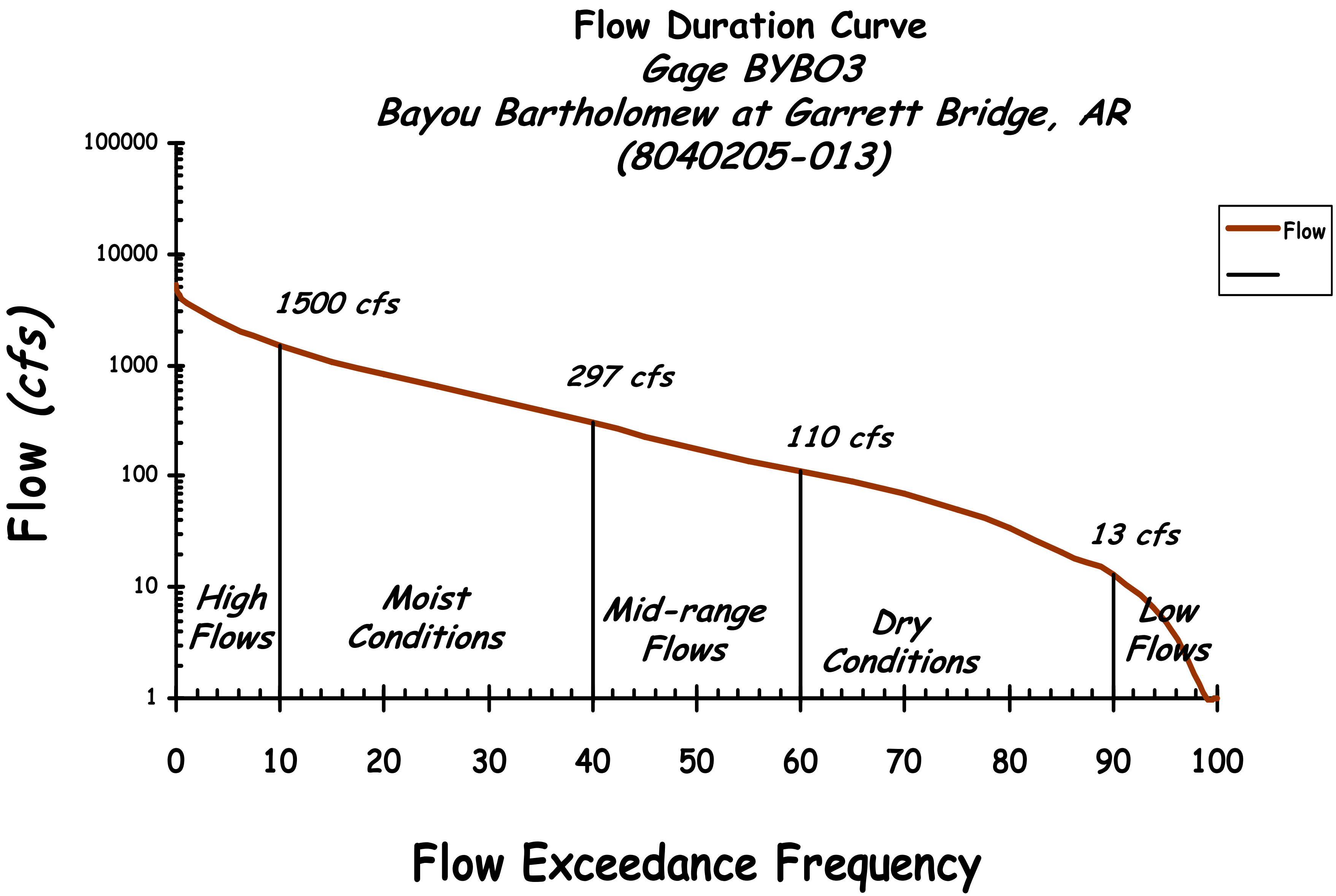
Figure 2.8 Mean Monthly Flows, Jones, LA



Appendix B

Flow Duration Curves

Figure B.1



USGS Flow Data

Figure B.2

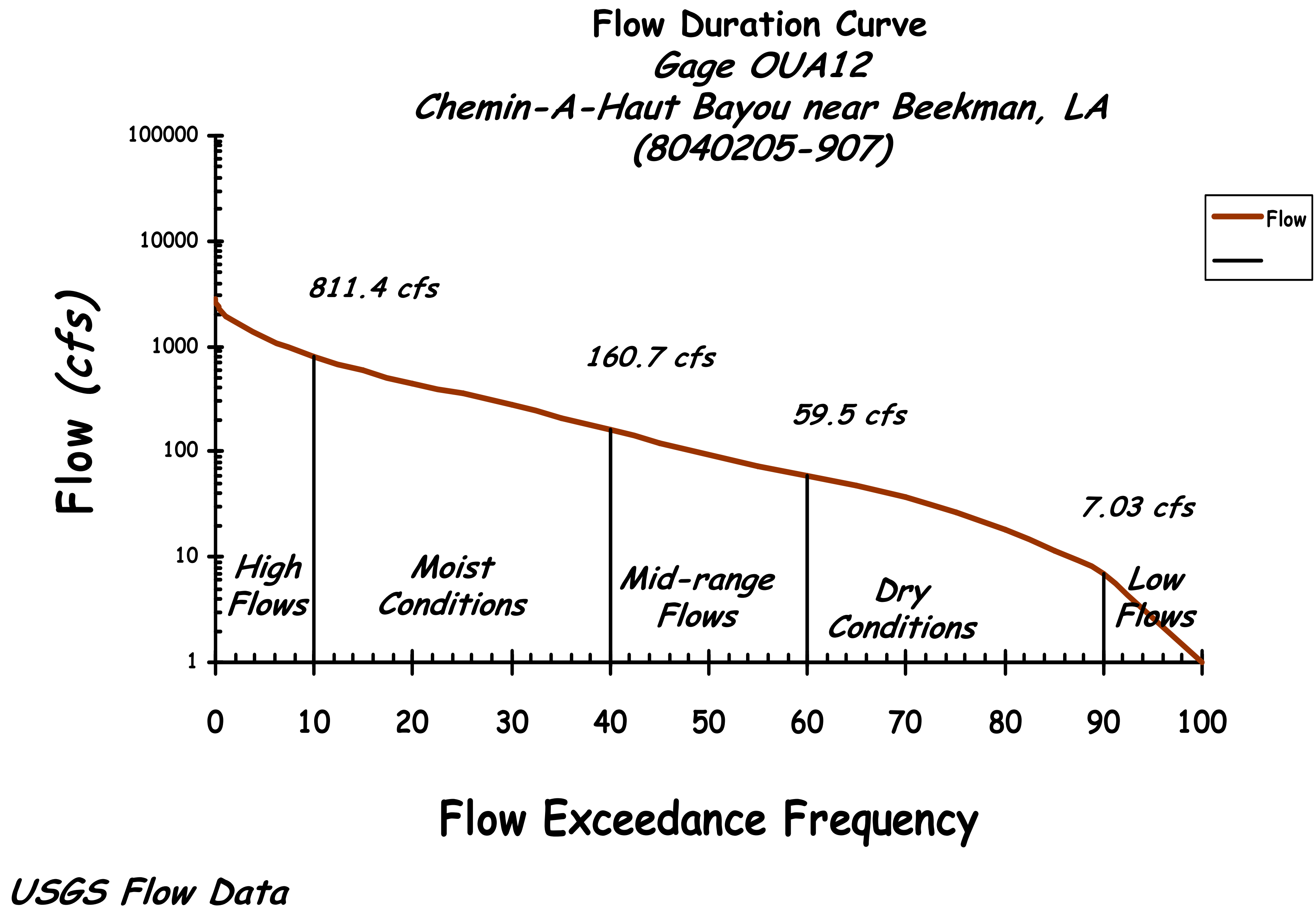
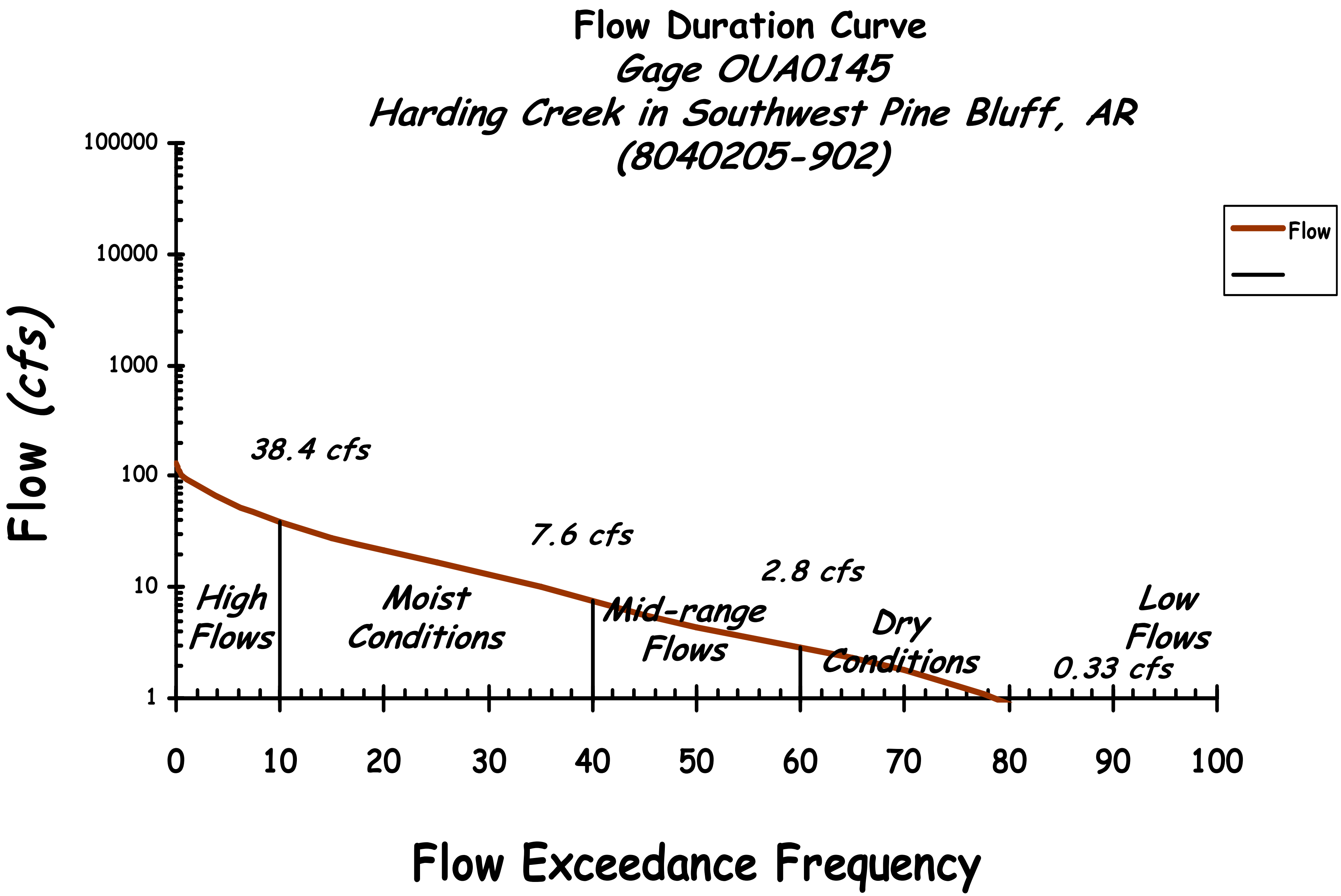
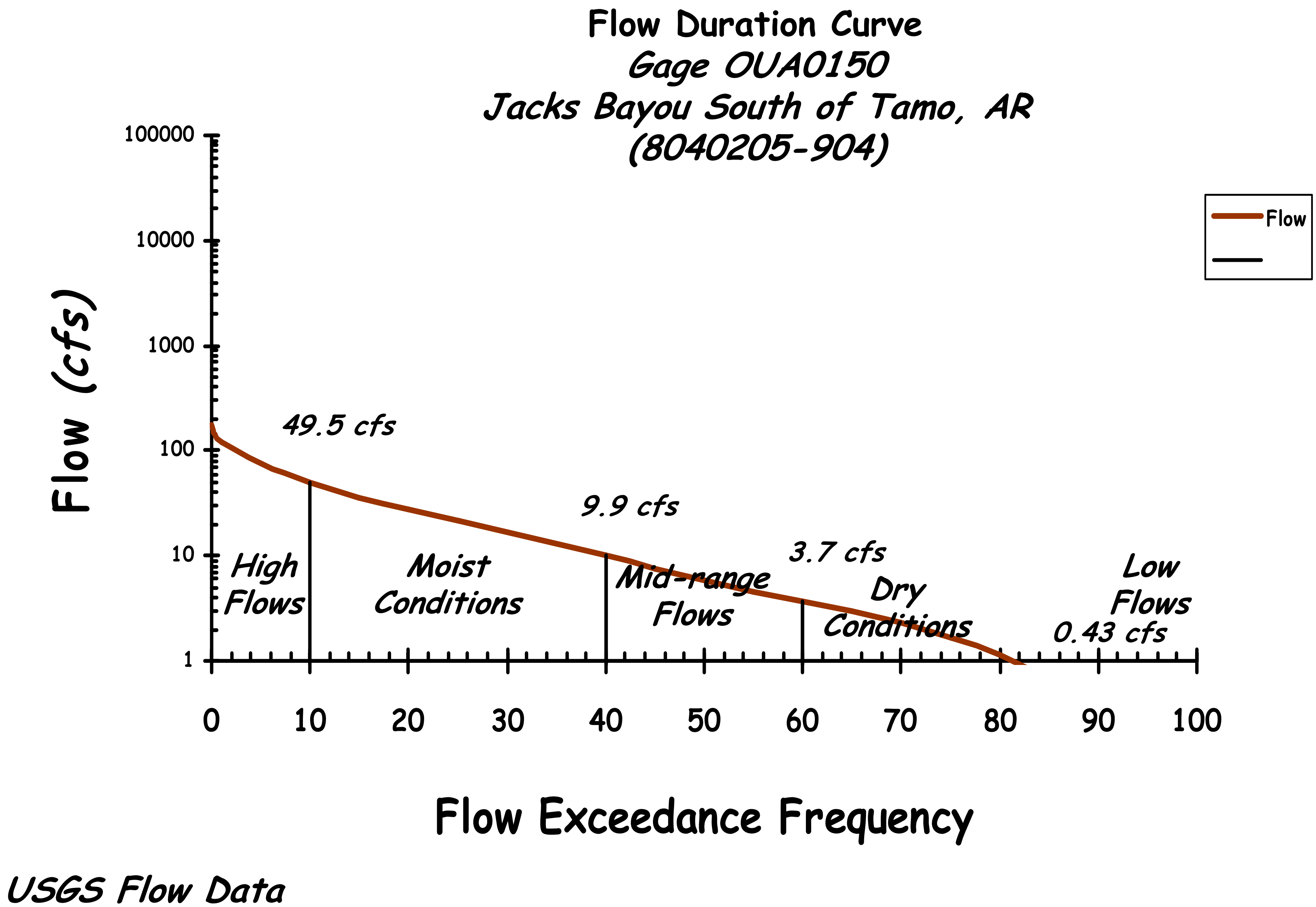

Flow Duration Curve
Gage OUA12
Chemin-A-Haut Bayou near Beekman, LA
(8040205-907)
100000
10000
1000
100
10
1
Flow (cfs)
811.4 cfs
160.7 cfs
59.5 cfs
7.03 cfs
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Exceedance Frequency
Flow
USGS Flow Data

Figure B.3



USGS Flow Data

Figure B.4



Flow Duration Curve
Gage OUA0150
Jacks Bayou South of Tamo, AR
(8040205-904)
Flow (cfs)
100000
10000
1000
100
10
1
49.5 cfs
9.9 cfs
3.7 cfs
0.43 cfs
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
Flow
0
10
20
30
40
50
60
70
80
90
100
Flow Exceedance Frequency
USGS Flow Data

Figure B.5

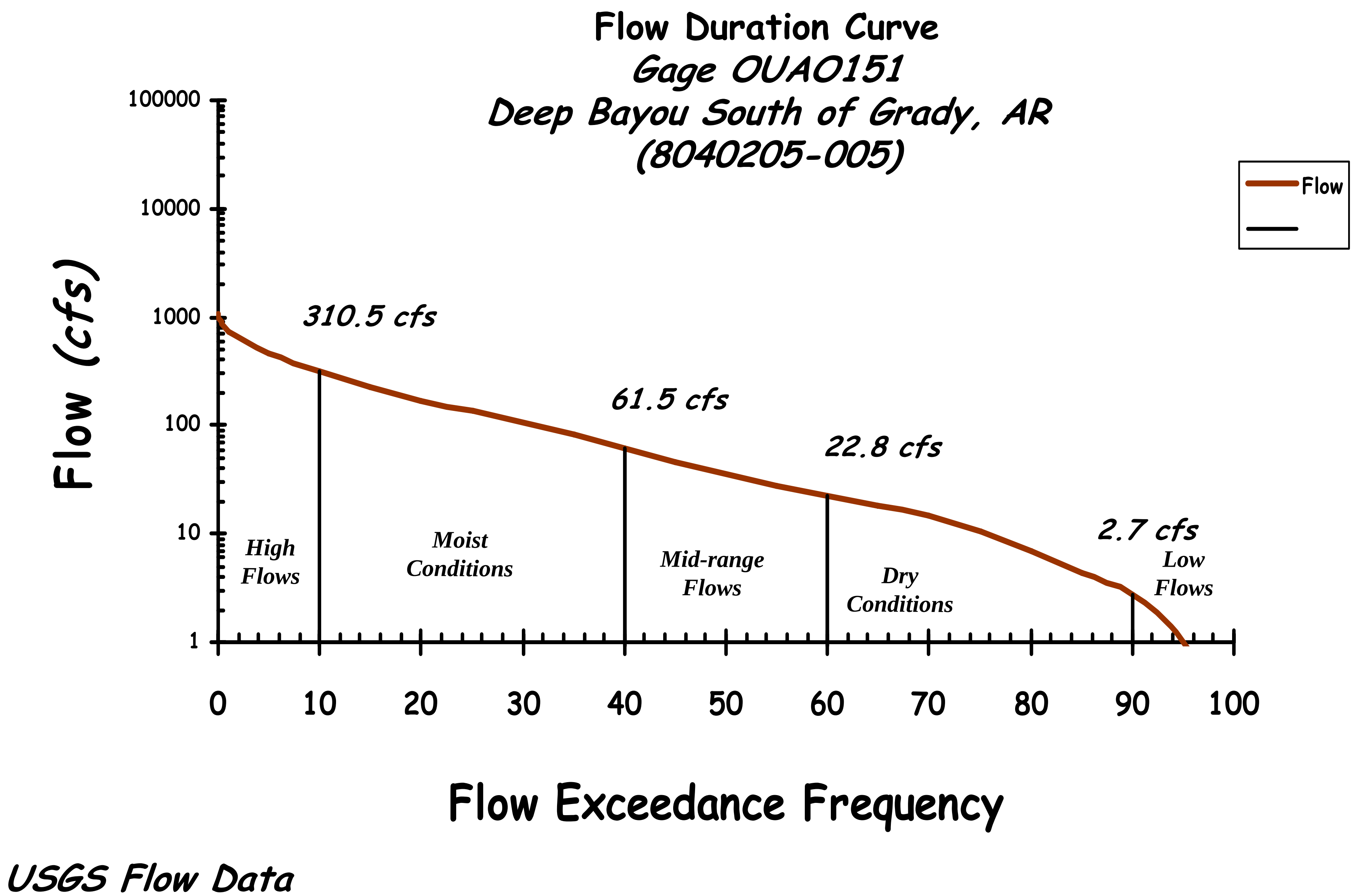
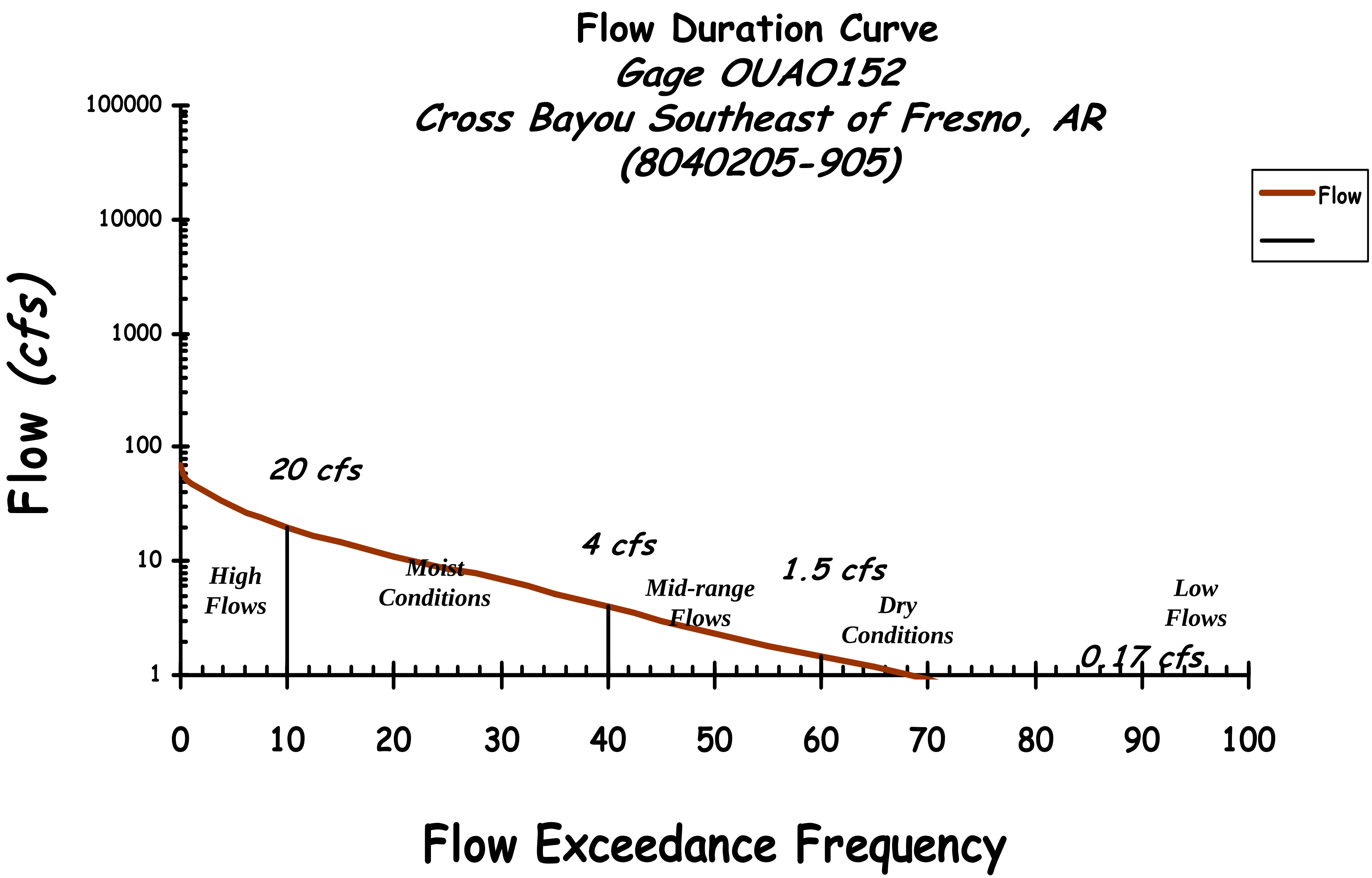
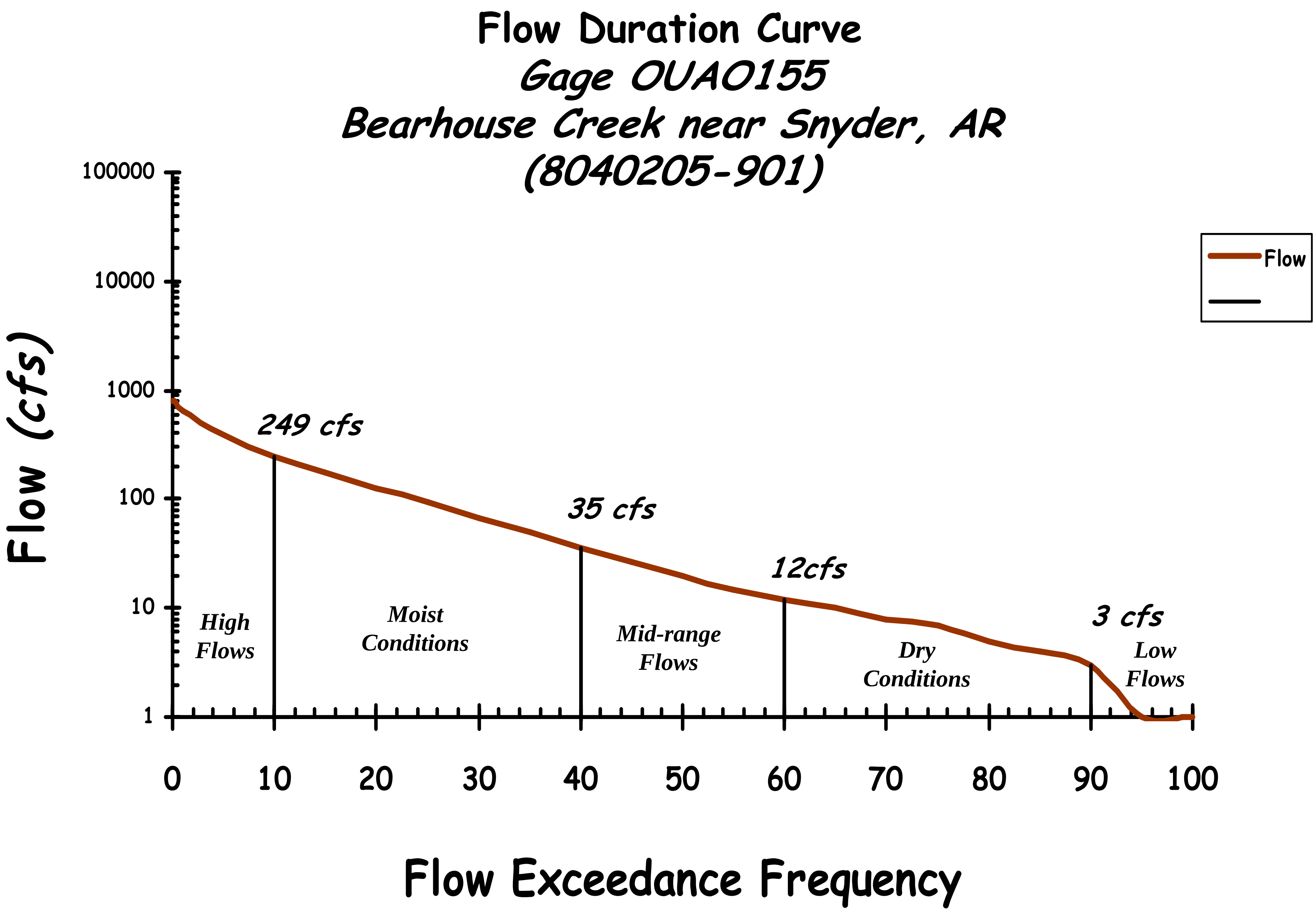

Flow Duration Curve
Gage OUA0151
Deep Bayou South of Grady, AR
(8040205-005)
Flow
Flow (cfs)
100000
10000
1000
100
10
1
310.5 cfs
61.5 cfs
22.8 cfs
2.7 cfs
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Exceedance Frequency
USGS Flow Data

Figure B.6



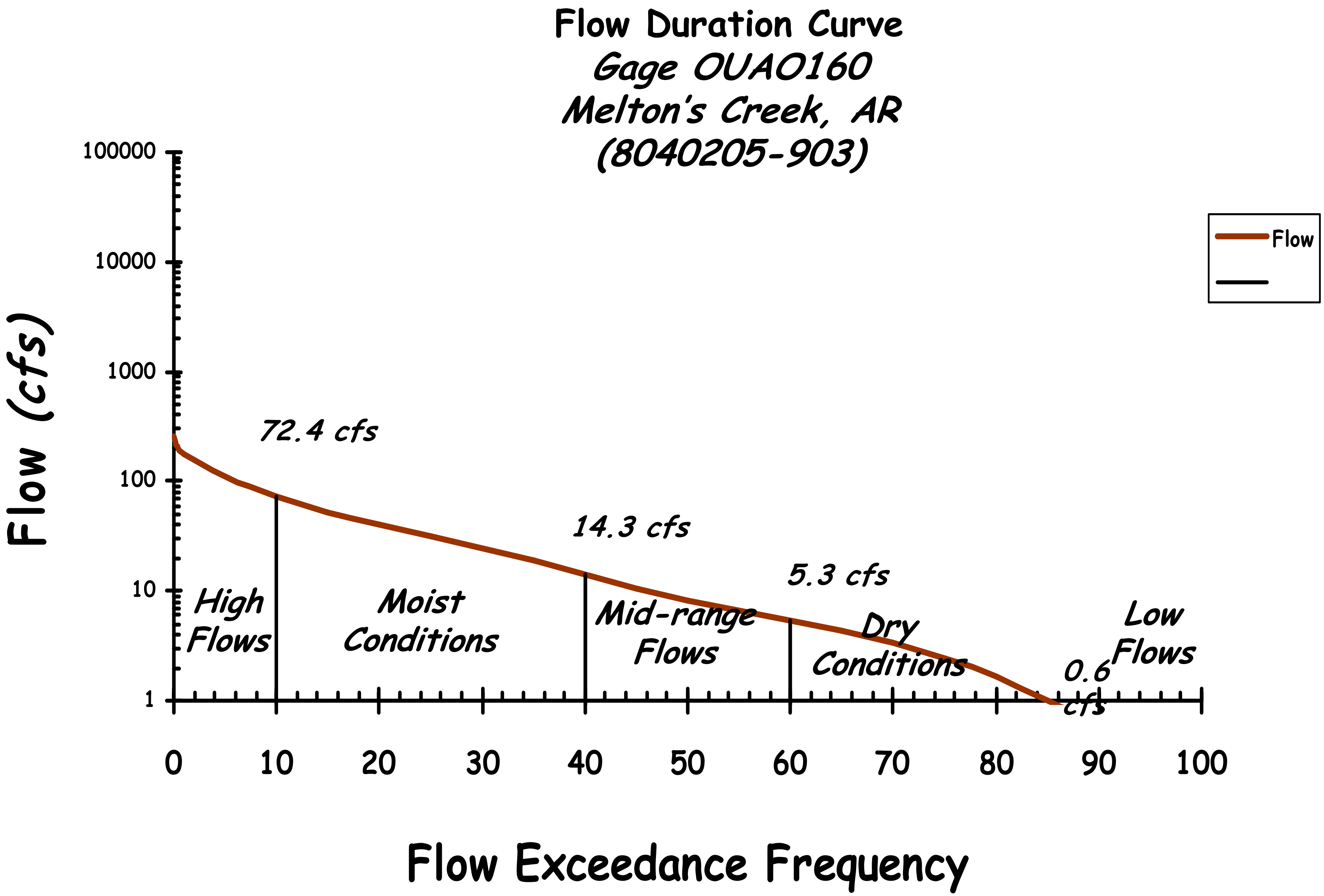
USGS Flow Data

Figure B.7



USGS Flow Data

Figure B.8



USGS Flow Data

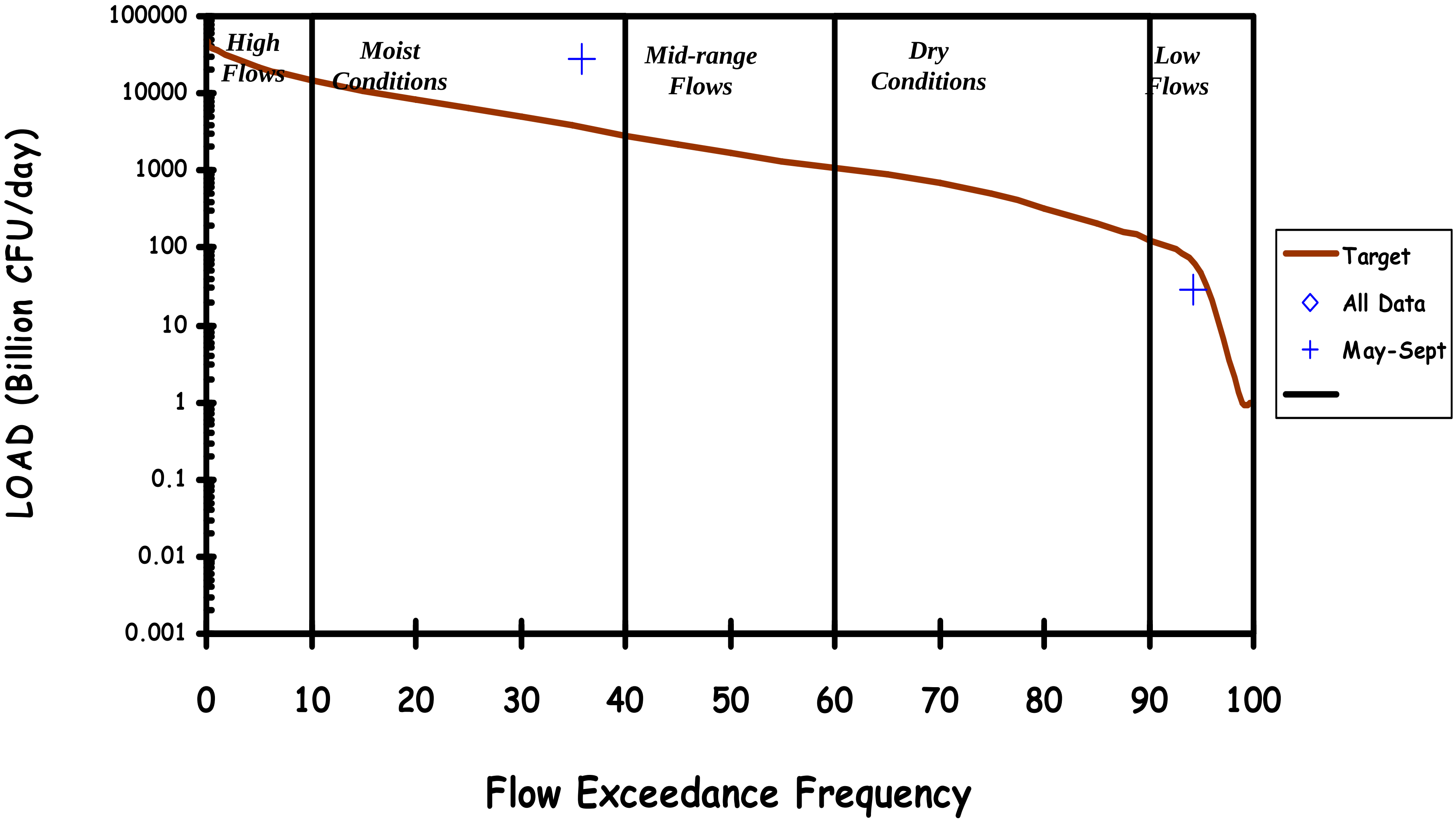
Appendix C

Primary Contact Recreation Summer Season Load Duration Curves for Fecal Coliform Bacteria

Figure C.1

Primary Contact Recreation Summer Season Load Duration Curve

Gage BYB03 - Fecal Coliform
Bayou Bartholomew at Garrett Bridge, AR
(8040205-013)

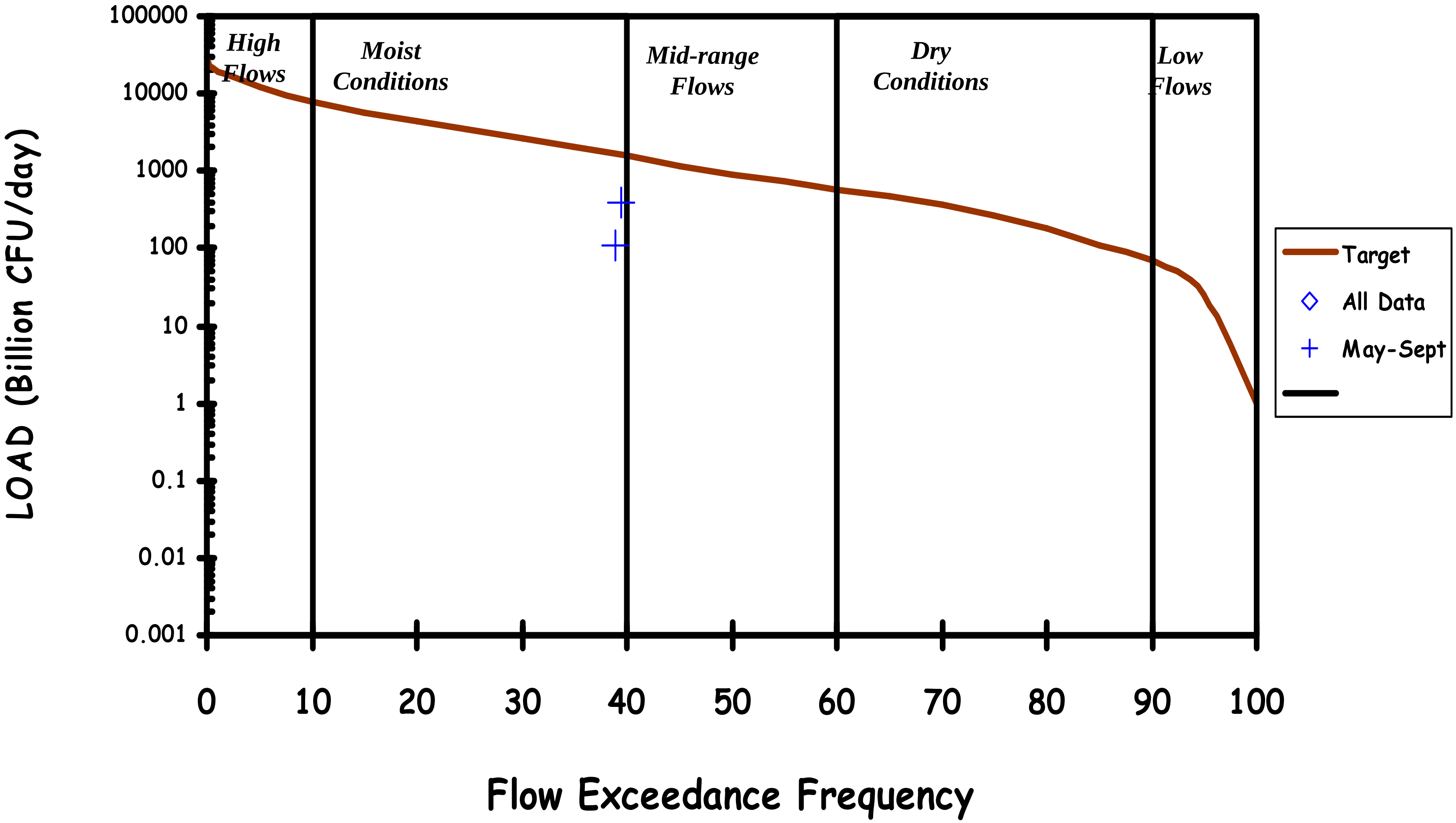


USGS Data

Figure C.2

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0012 - Fecal Coliform
Chemin-A-Haut Bayou near Beekman, LA
(8040205-907)

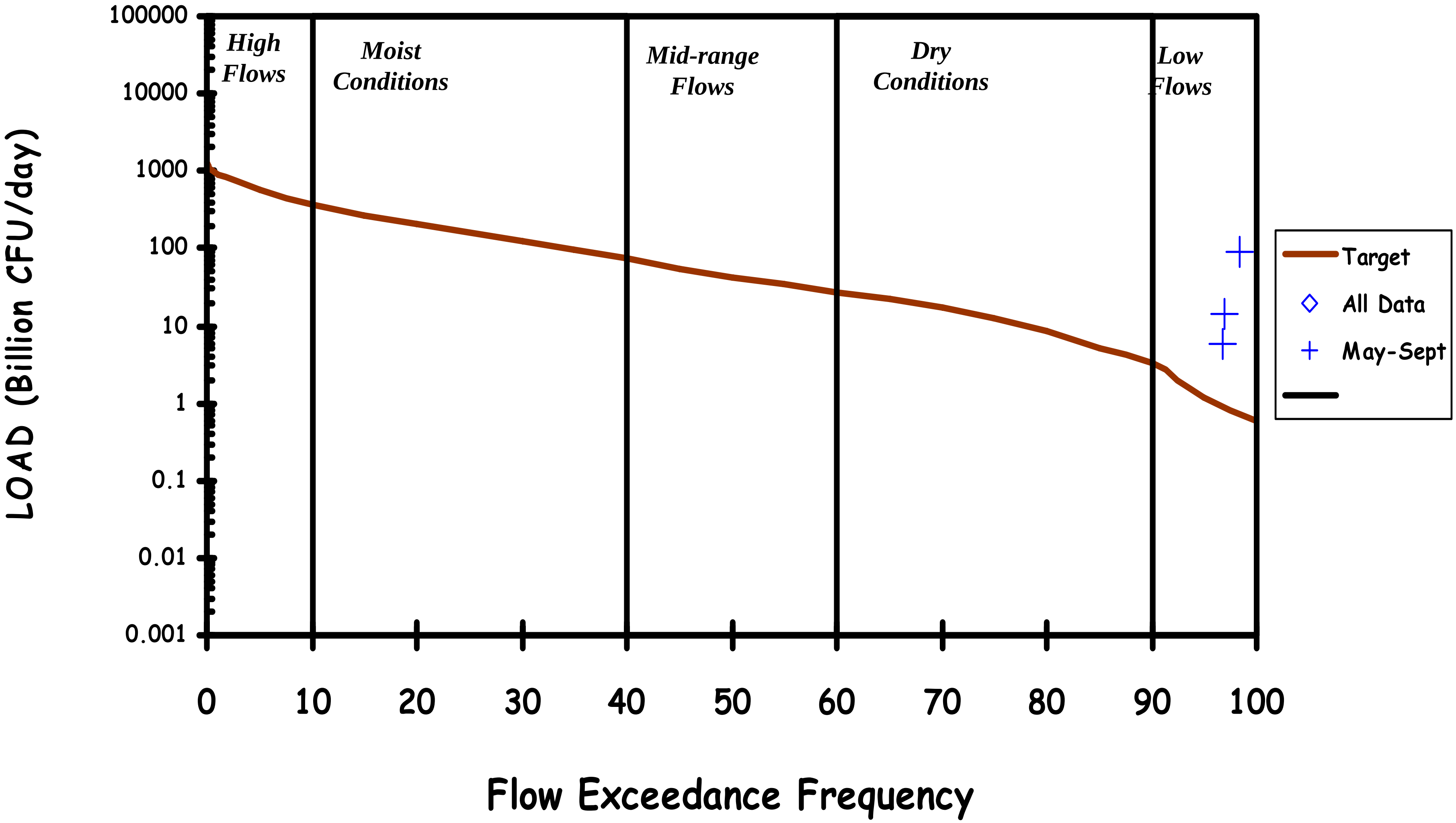


USGS Data

Figure C.3

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0145 - Fecal Coliform
Harding Creek in Southwest Pinebluff, LA
(8040205-902)

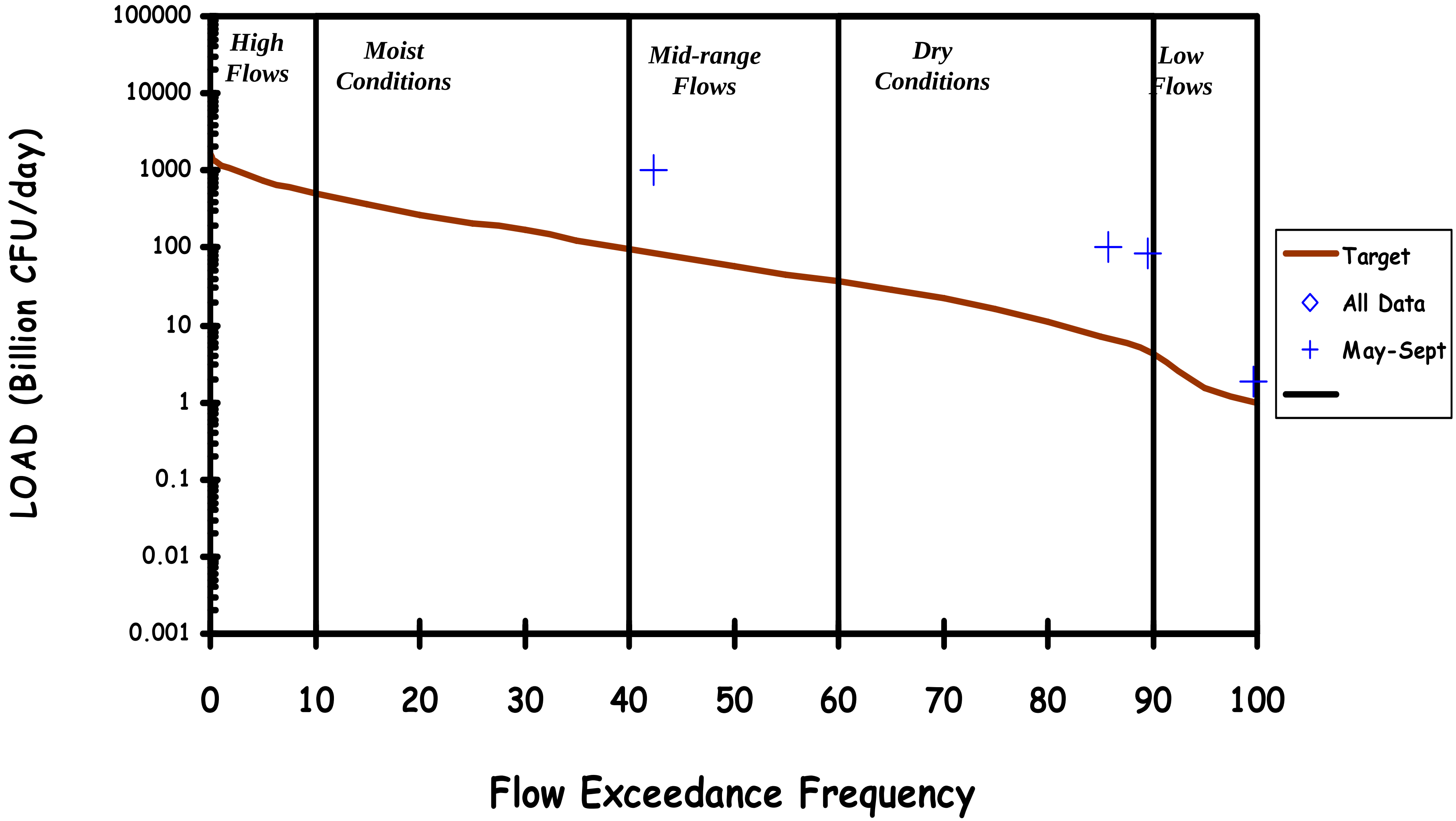


USGS Data

Figure C.4

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0150 - Fecal Coliform
Jack's Bayou South of Tamo, LA
(8040205-904)

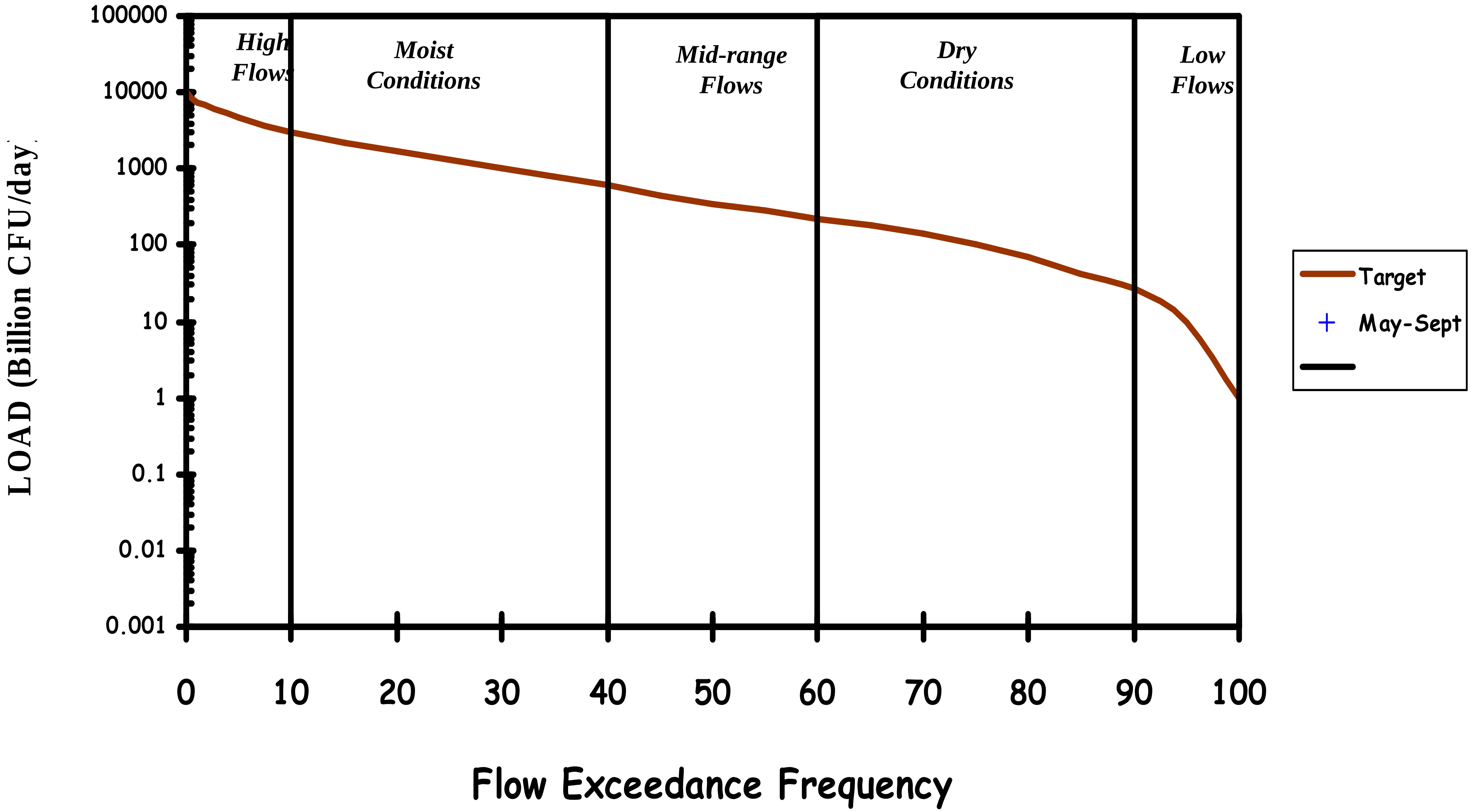


USGS Data

Figure C.5

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0151 - Fecal Coliform
Deep Bayou South of Grady, AR
(8040205-005)

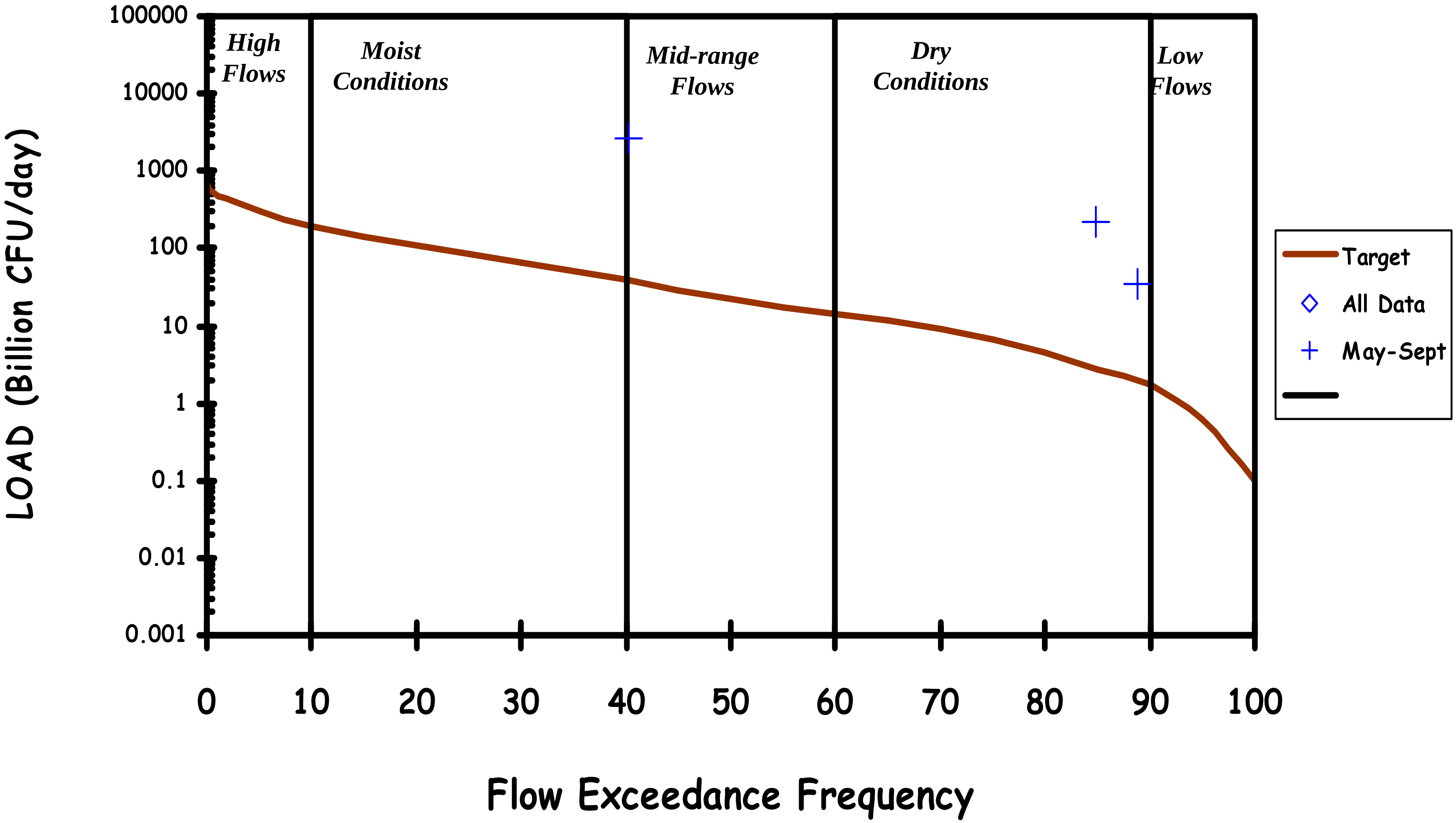


USGS Data

Figure C.6

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0152 - Fecal Coliform
Cross Bayou Southeast of Fresno, AR
(8040205-905)

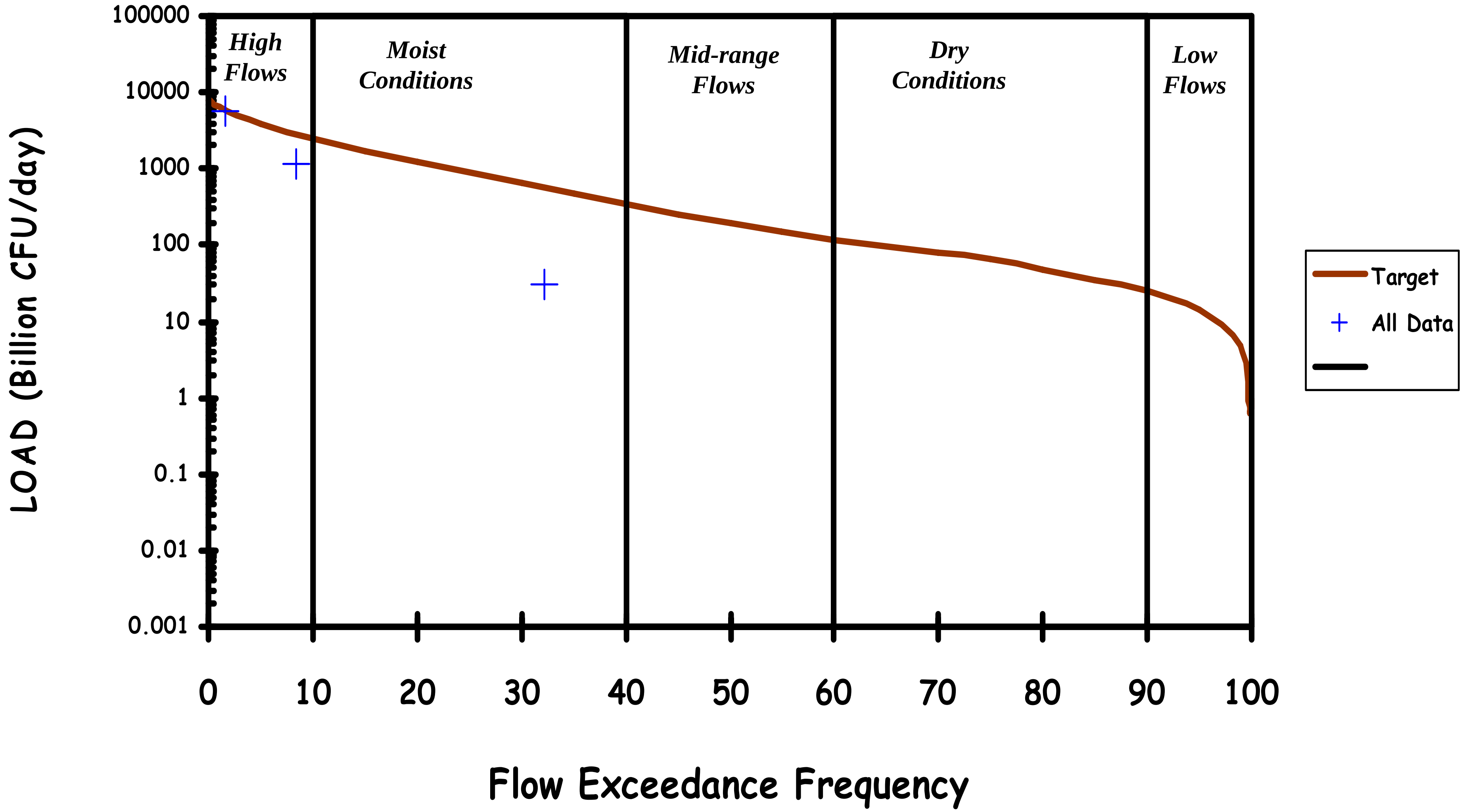


USGS Data

Figure C.7

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0155 - Fecal Coliform
Bearhouse Creek near Snyder, AR
(8040205-901)

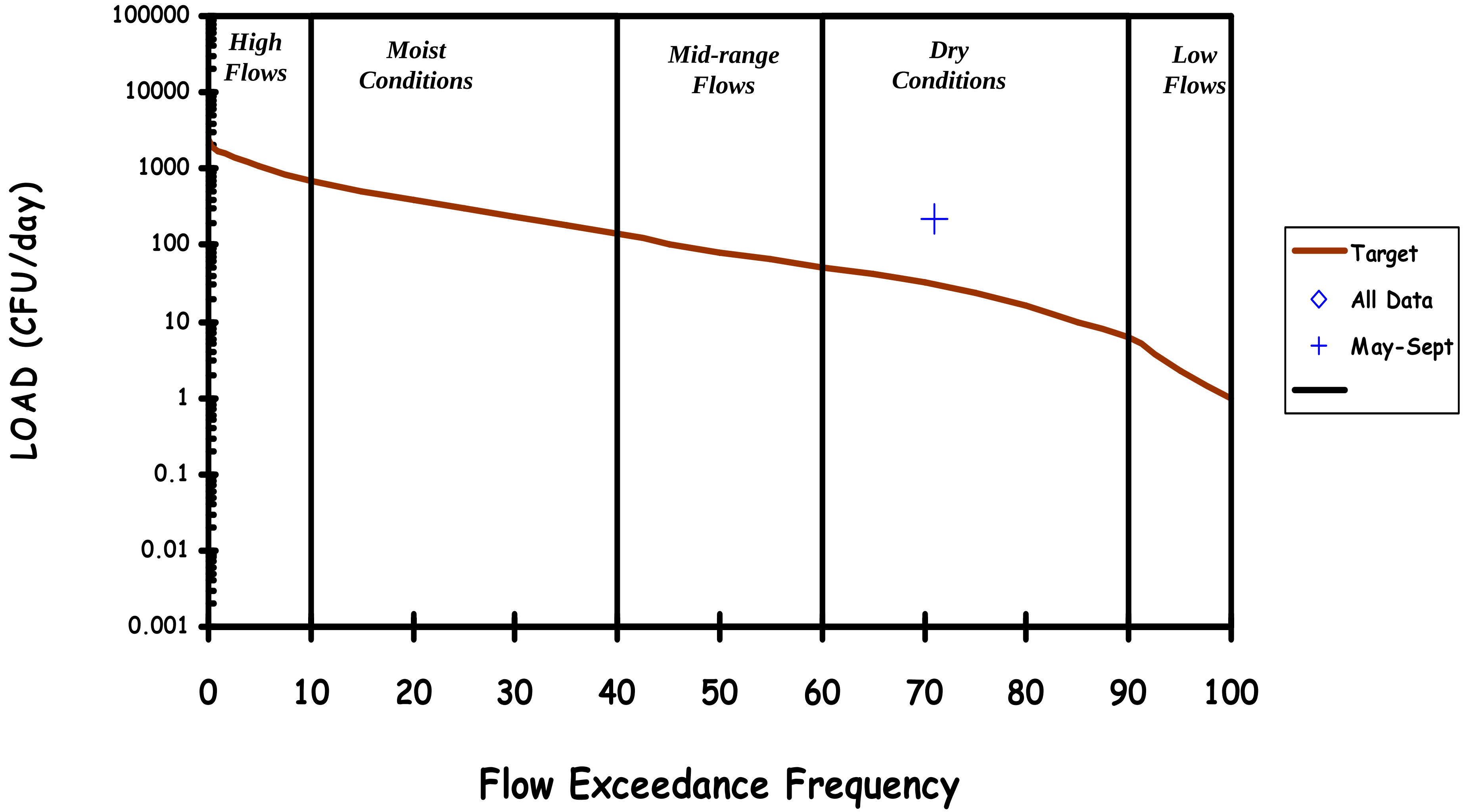


USGS Data

Figure C.8

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0160 - Fecal Coliform
Melton's Creek, AR
(8040205-903)

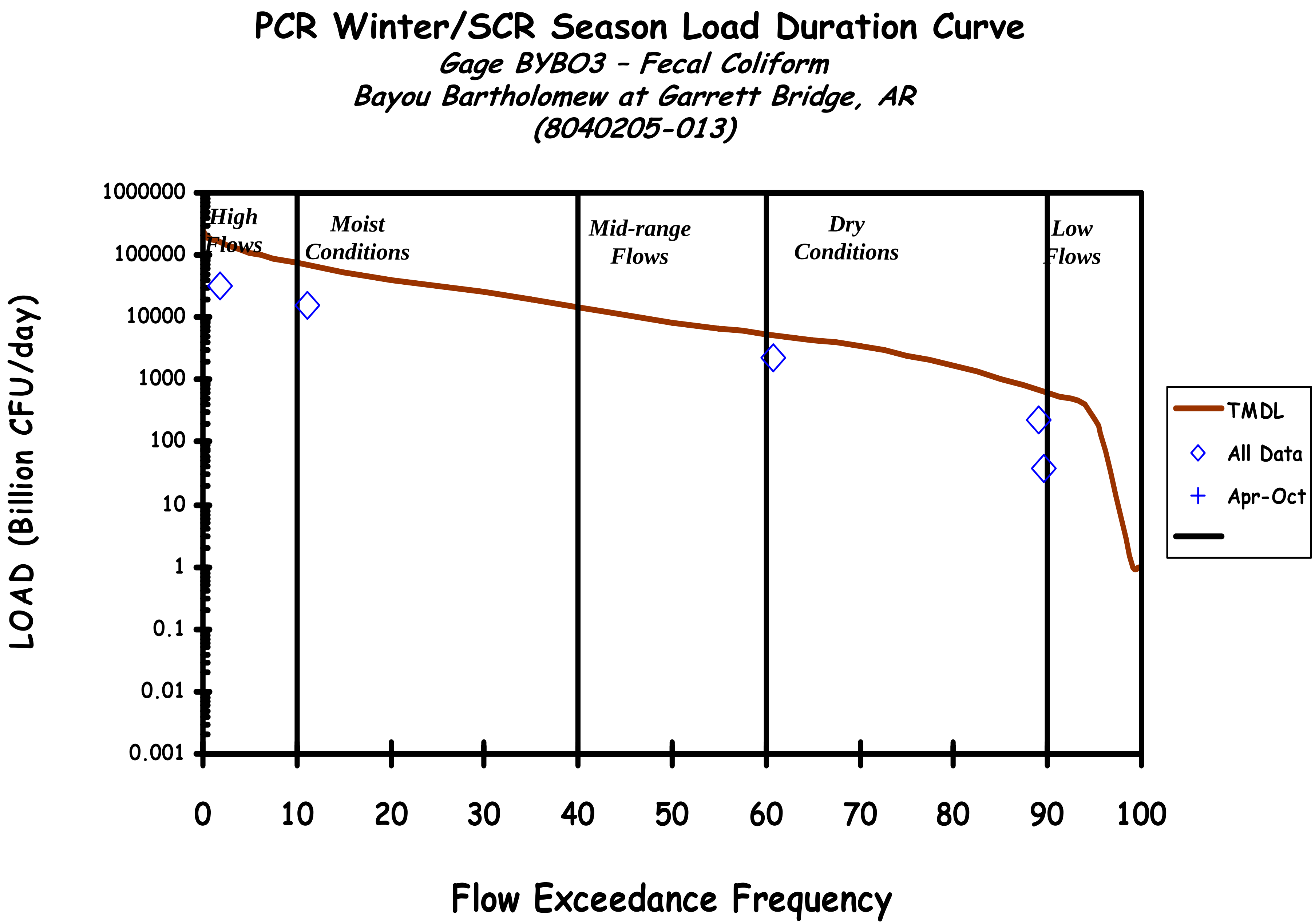


USGS Data

Appendix D

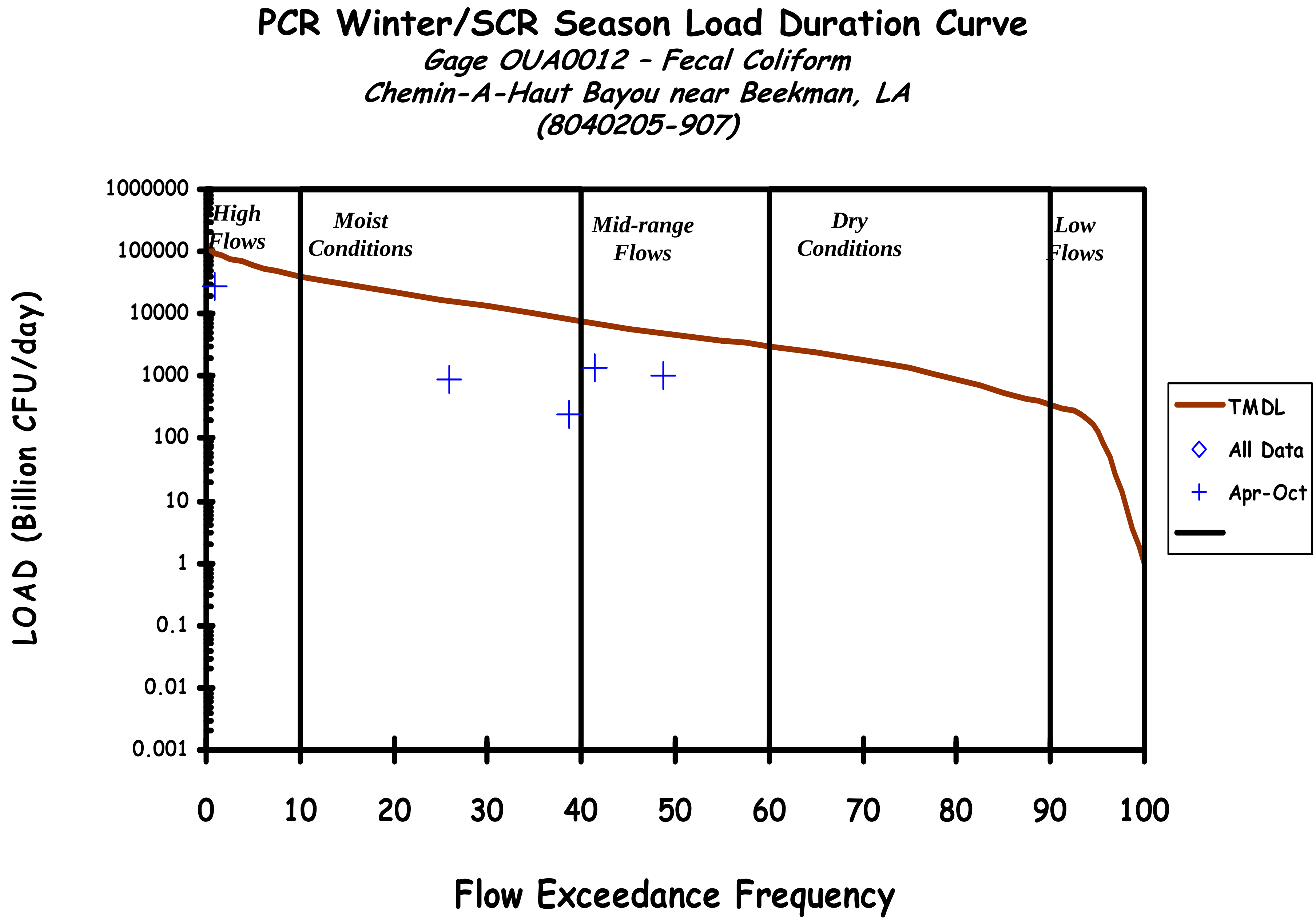
PCR Winter/SCR Season Load Duration Curves for Fecal Coliform Bacteria

Figure D.1



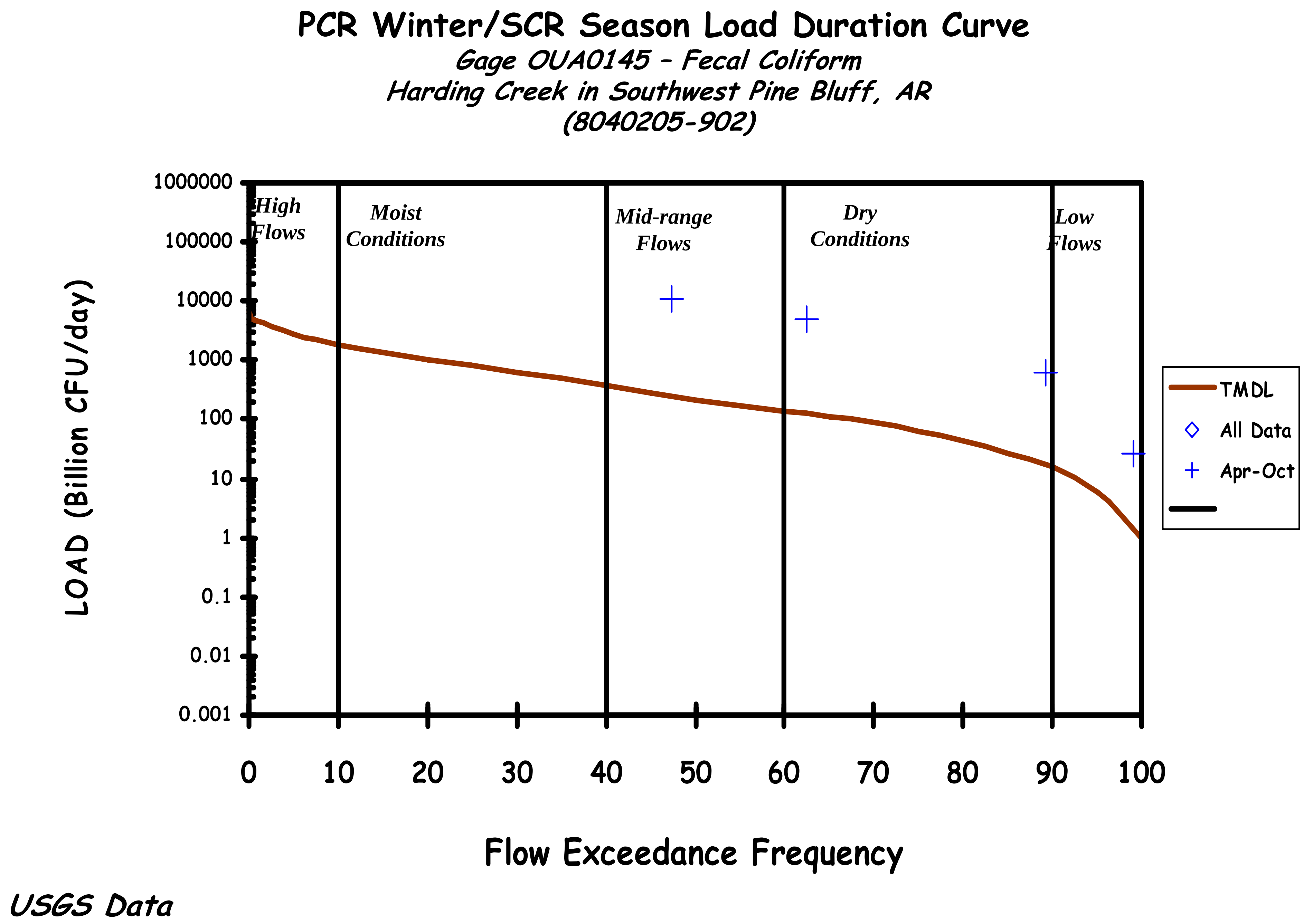
USGS Data

Figure D.2



USGS Data

Figure D.3

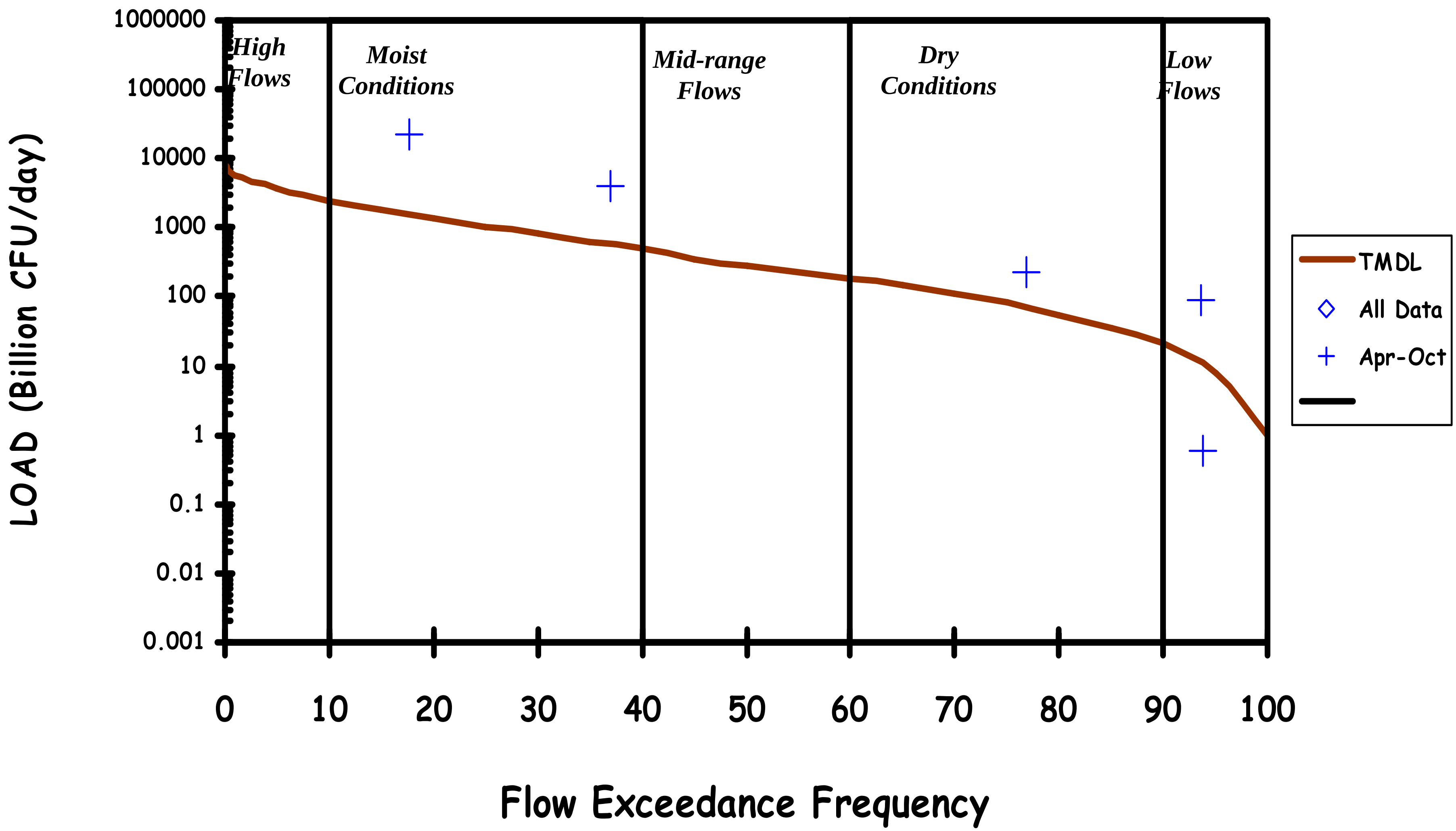


PCR Winter/SCR Season Load Duration Curve
Gage OUA0145 - Fecal Coliform
Harding Creek in Southwest Pine Bluff, AR
(8040205-902)
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
LOAD (Billion CFU/day)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
0
10
20
30
40
50
60
70
80
90
100
Flow Exceedance Frequency
TMDL
All Data
Apr-Oct
USGS Data

Figure D.4

PCR Winter/SCR Season Load Duration Curve

Gage OUA0150 - Fecal Coliform
Jack's Bayou South of Tamo, AR
(8040205-904)

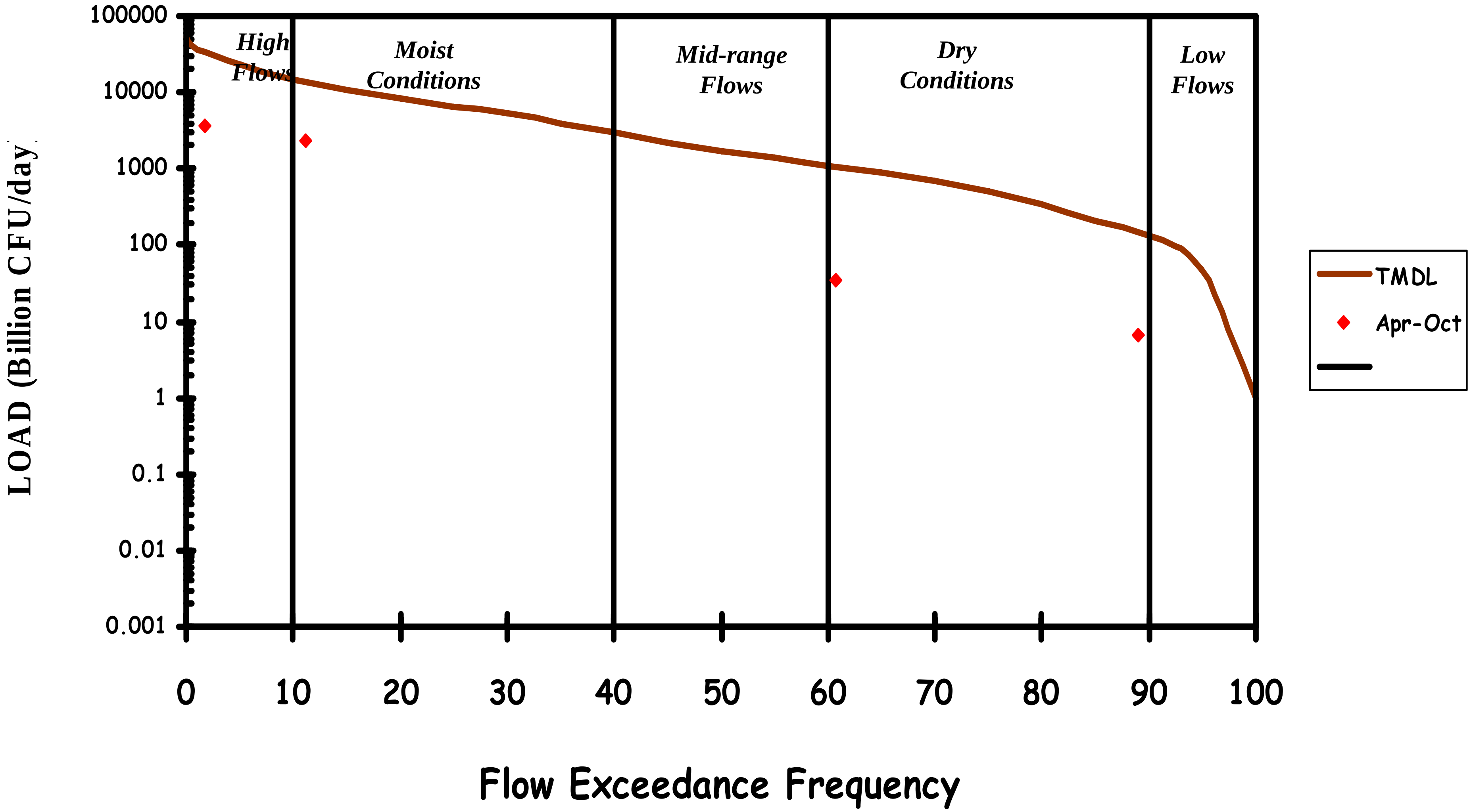


USGS Data

Figure D.5

PCR Winter/SCR Season Load Duration Curve

Gage OUA0151 - Fecal Coliform
Deep Bayou South of Grady, AR
(8040205-005)

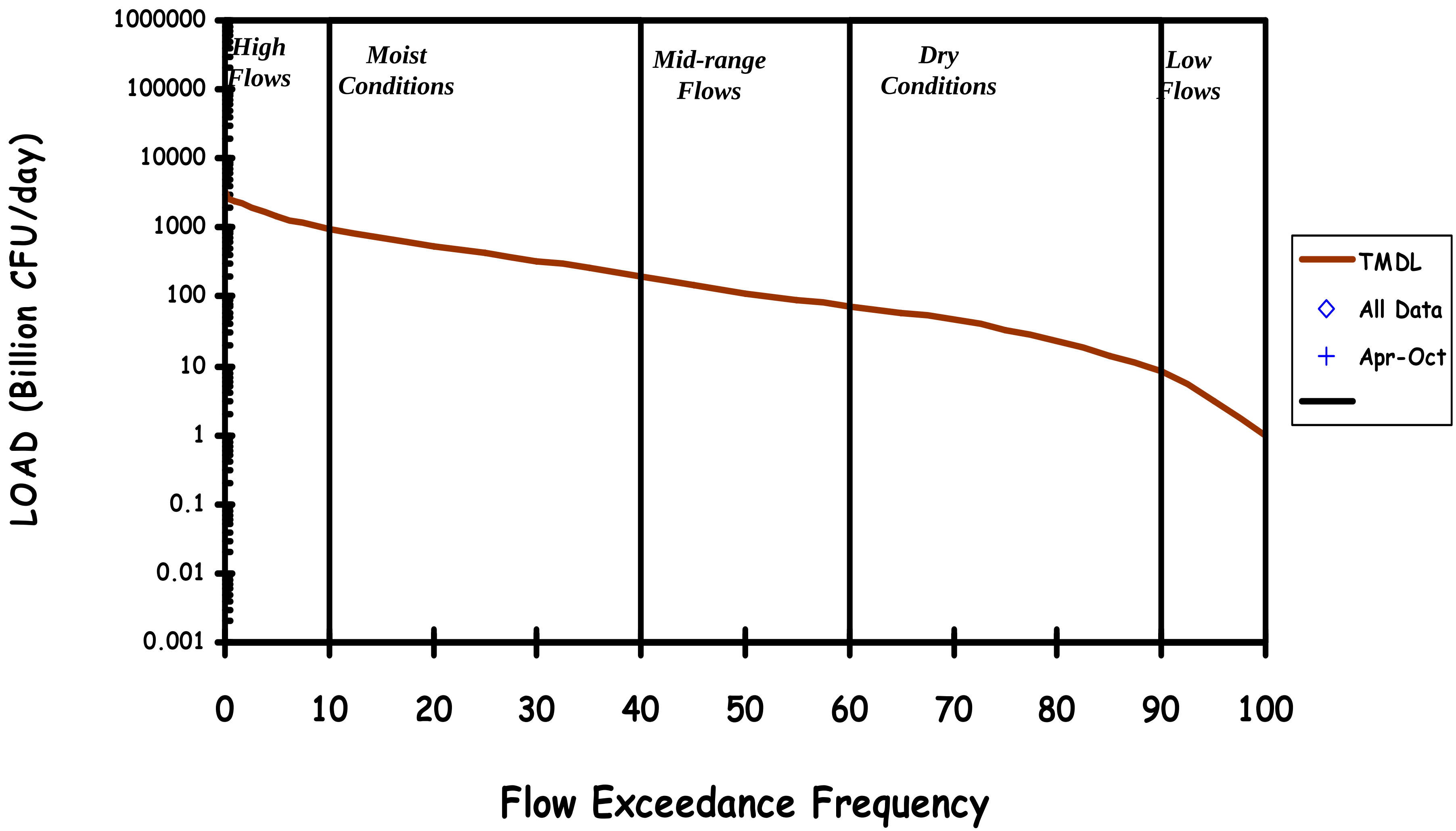


USGS Data

Figure D.2

PCR Winter/SCR Season Load Duration Curve

Gage OUA0152 - Fecal Coliform
Cross Bayou Southeast of Fresno, AR
(8040205-905)

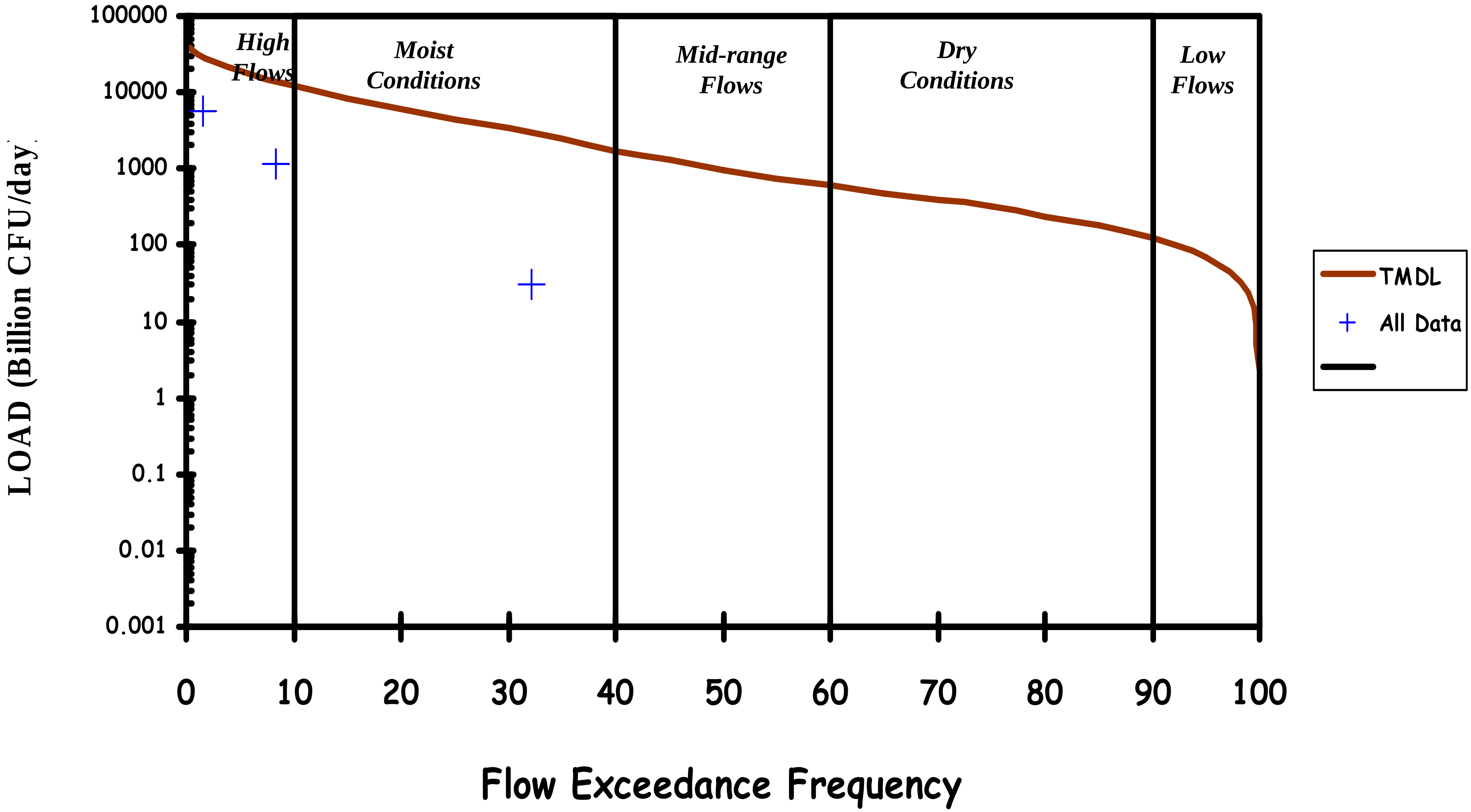


USGS Data

Figure D.7

PCR Winter/SCR Season Load Duration Curve

Gage OUAO155 - Fecal Coliform
Bearhouse Creek near Snyder, AR
(8040205-901)

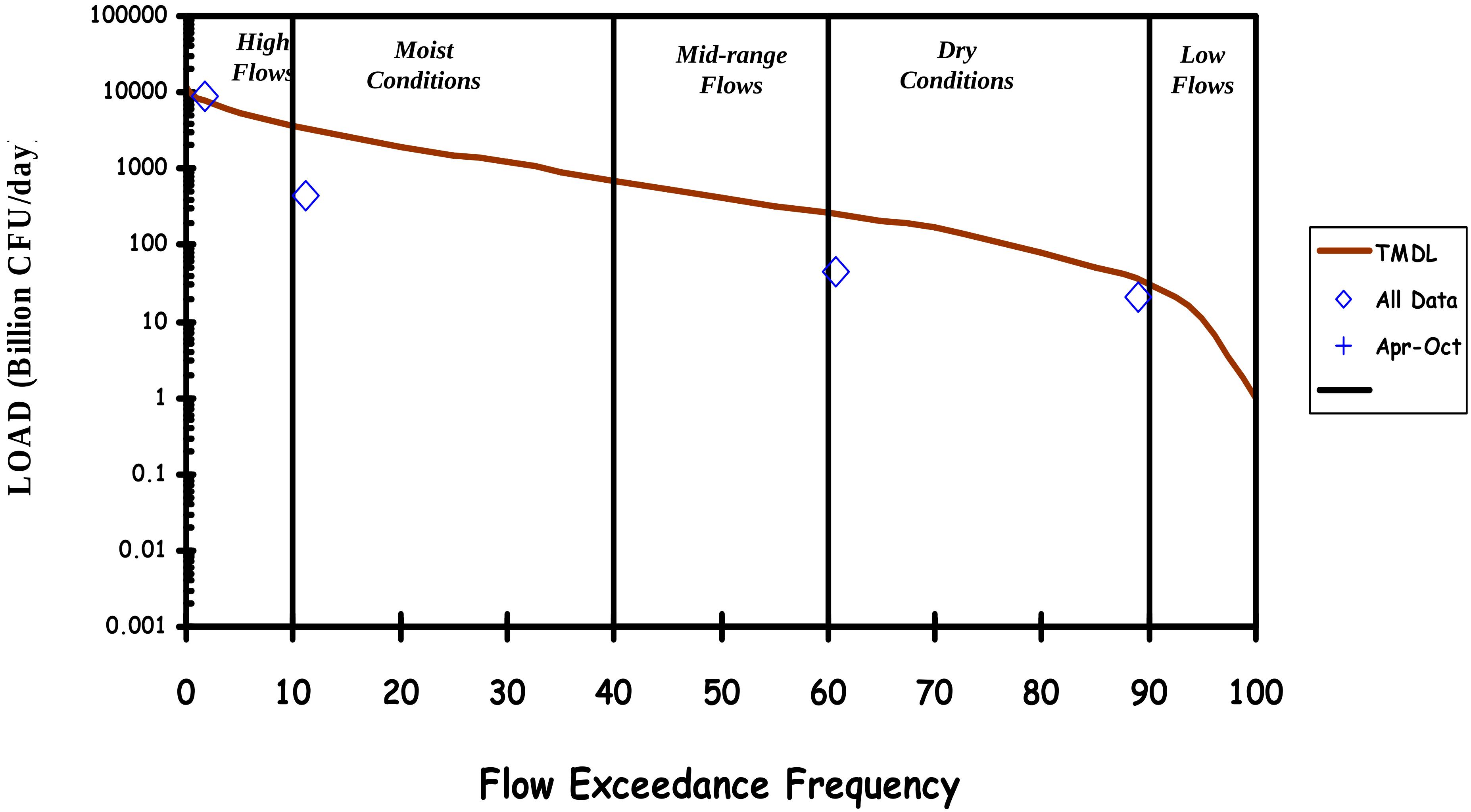


USGS Data

Figure D.8

PCR Winter/SCR Season Load Duration Curve

Gage OUA0160 - Fecal Coliform
Melton's Creek, AR
(8040205-903)



USGS Data

Appendix E

Primary Contact Recreation Summer Season Load Duration Curves for E. coli Bacteria

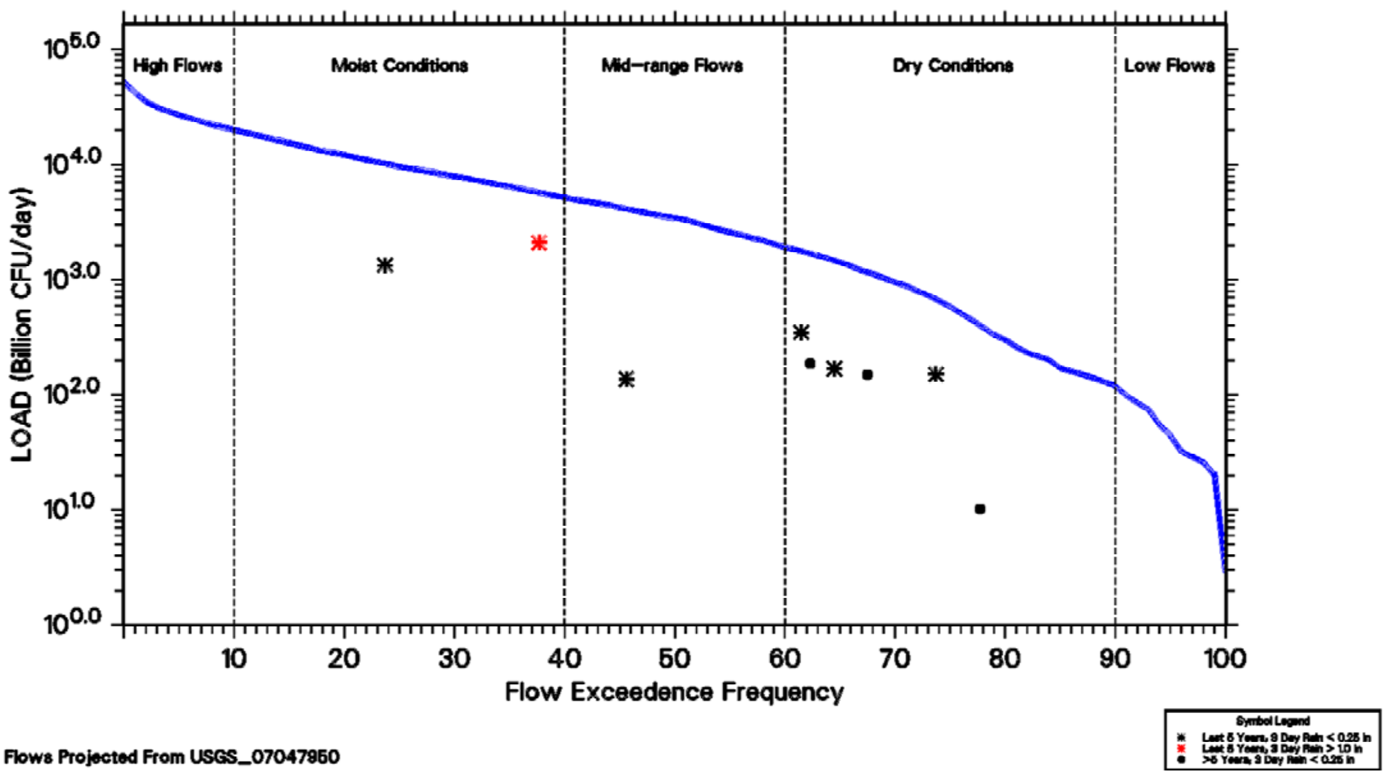
Figure E.1

Primary Contact Recreation Summer Season Load Duration Curve

UWBYB03 – E. coli

Bayou Bartholomew at Garrett Bridge, AR

(8040205-013)

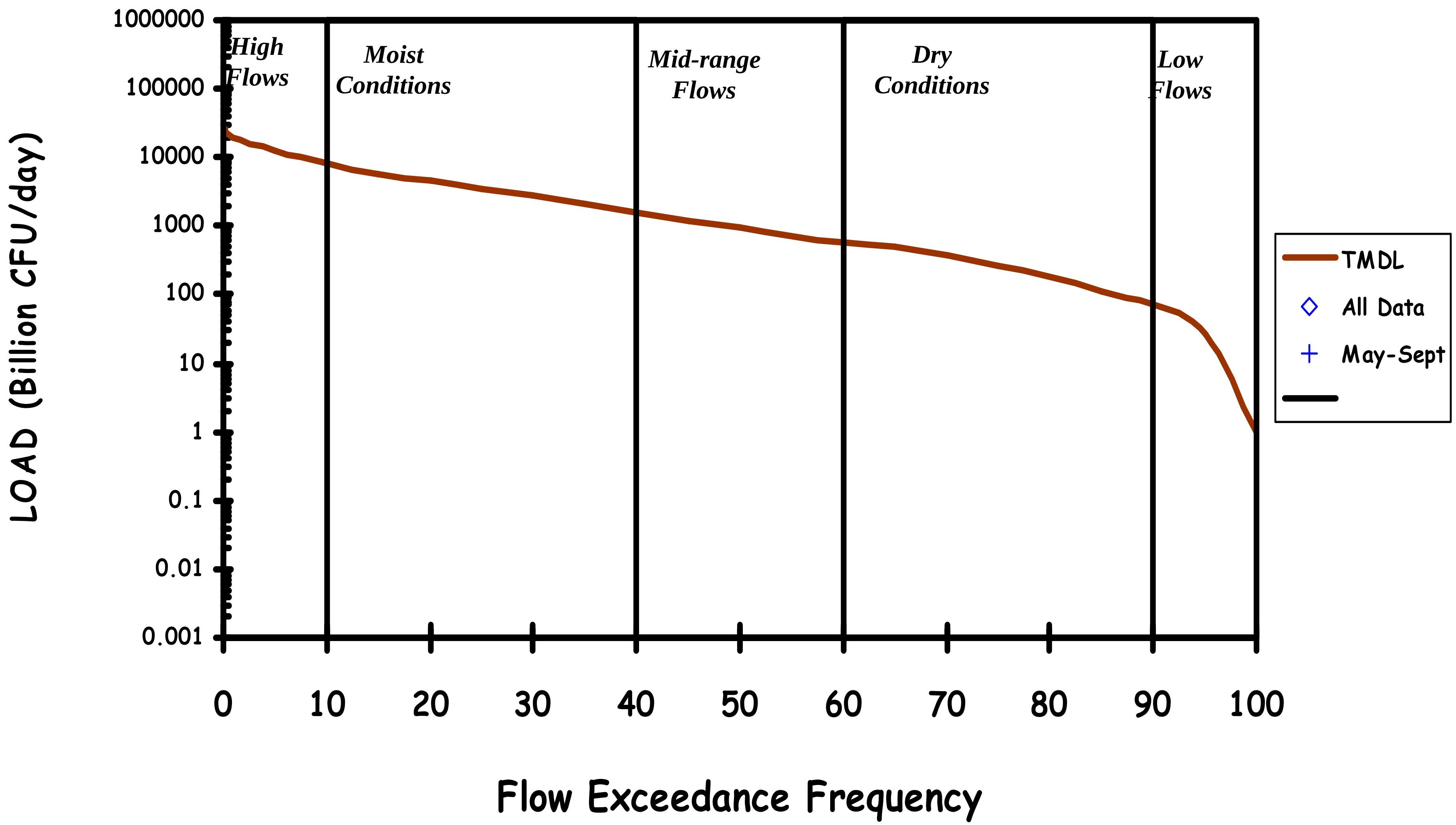


NOTE: Flows Projected From USGS_07047950

Figure E.2

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA12 - Escherichia Coli
Chemin-A-Haut Creek, AR
(8040205-907)

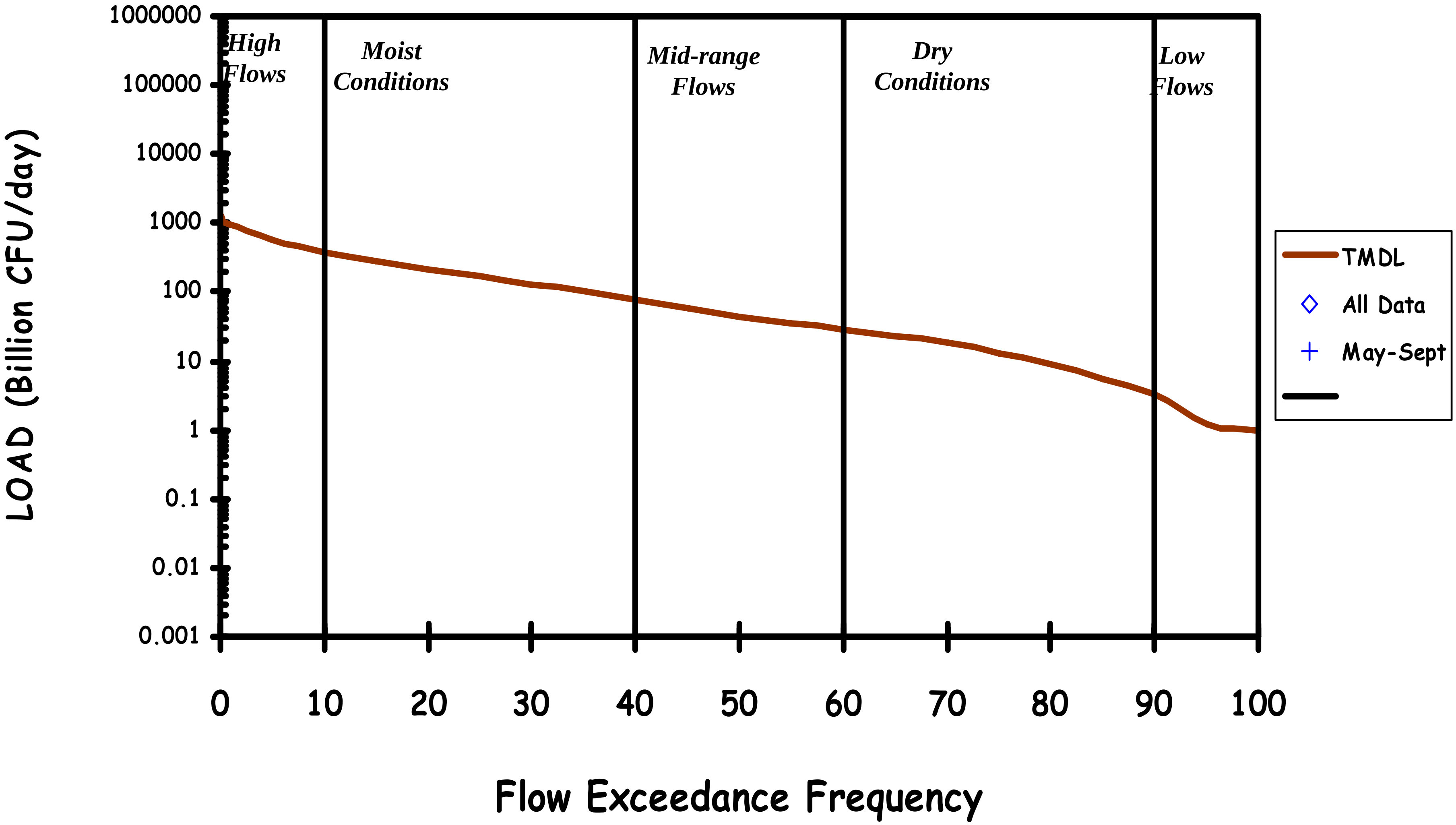


USGS Data

Figure E.3

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA145 - Escherichia Coli
Harding Creek, AR
(8040205-902)

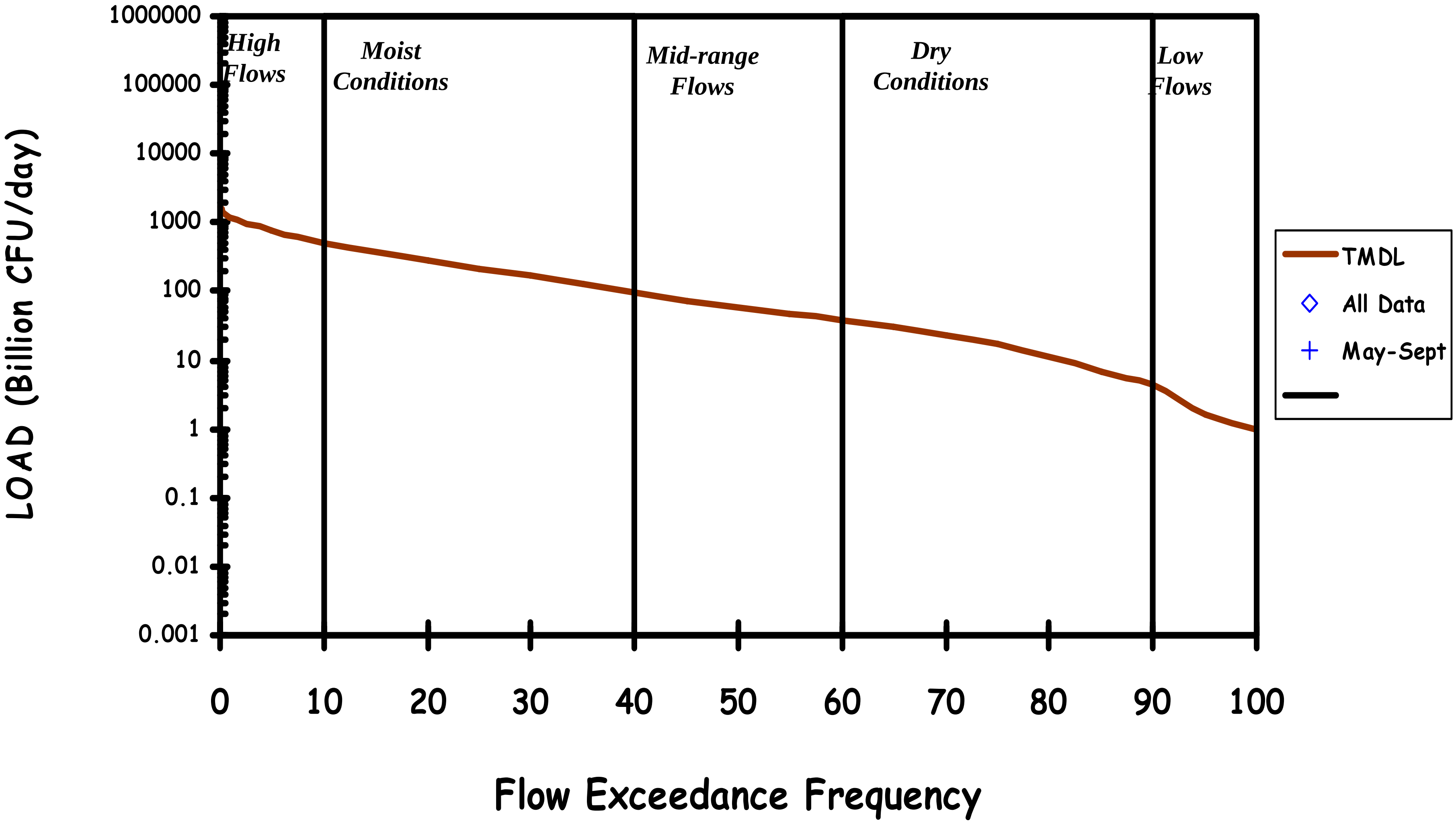


USGS Data

Figure E.4

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA150 - Escherichia Coli
Jack's Bayou, AR
(8040205-904)

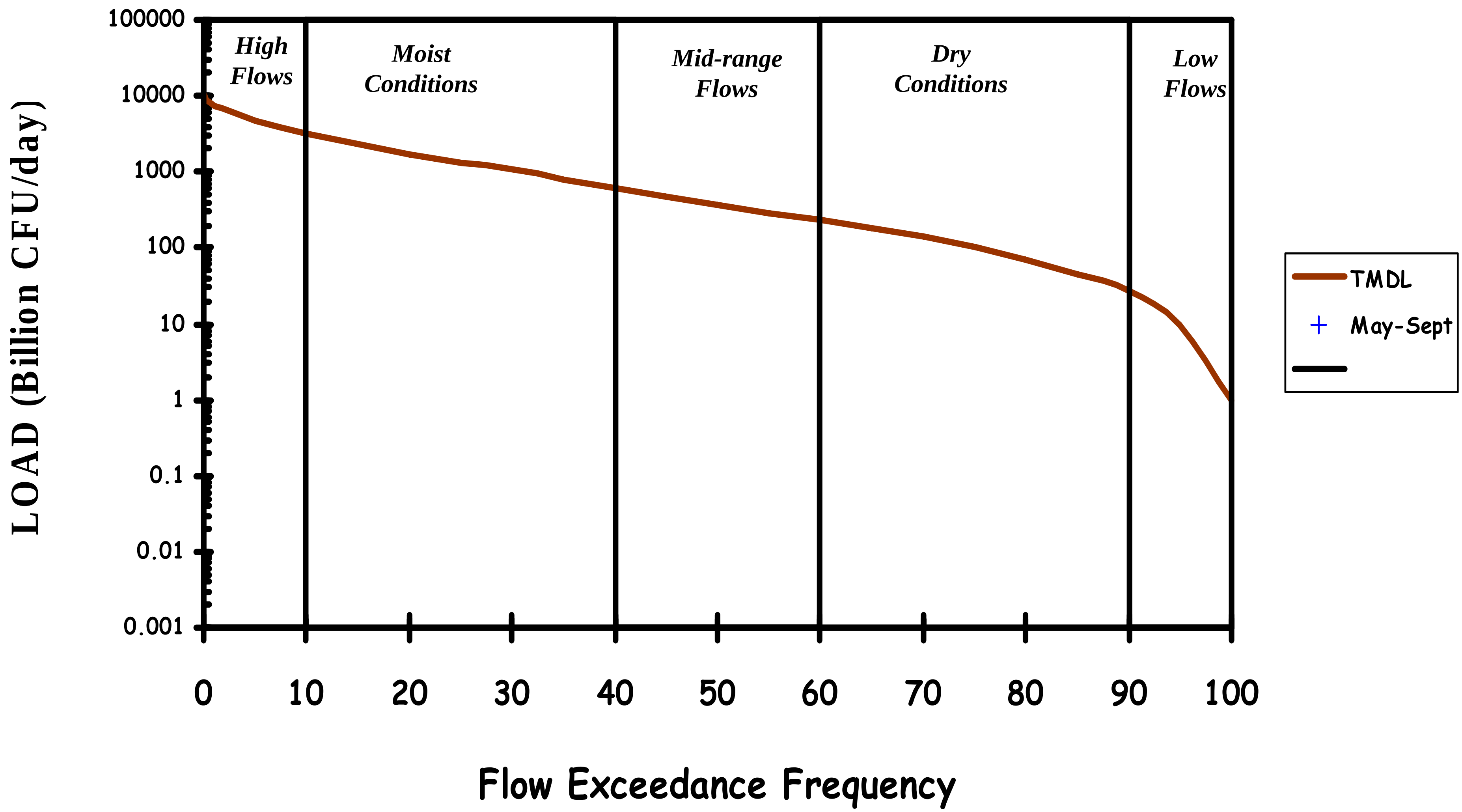


USGS Data

Figure E.5

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUAO151 - Escherichia Coli
Deep Bayou South of Grady, AR
(8040205-005)

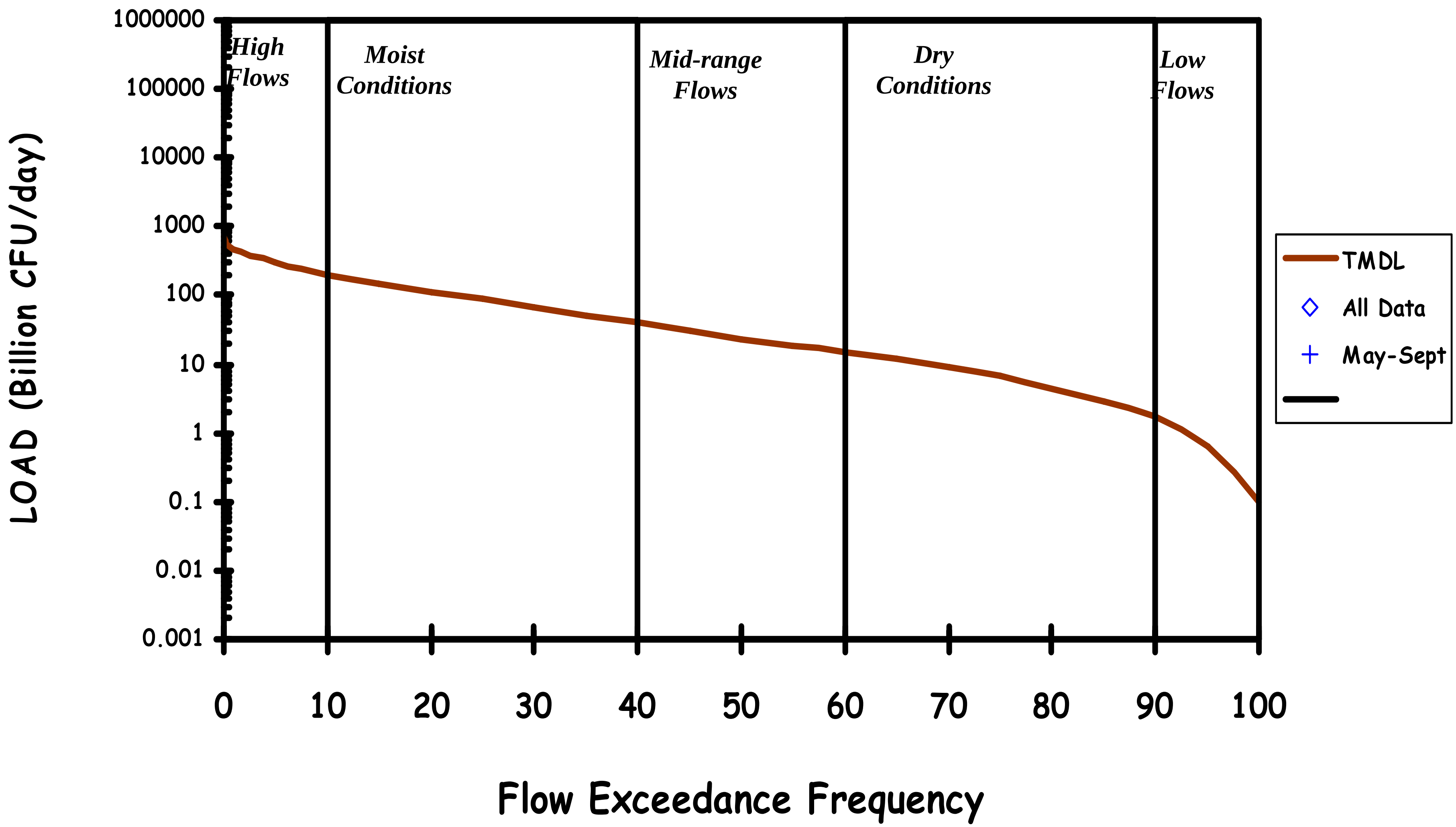


USGS Data

Figure E.6

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA152 - Escherichia Coli
Cross Bayou, AR
(8040205-905)

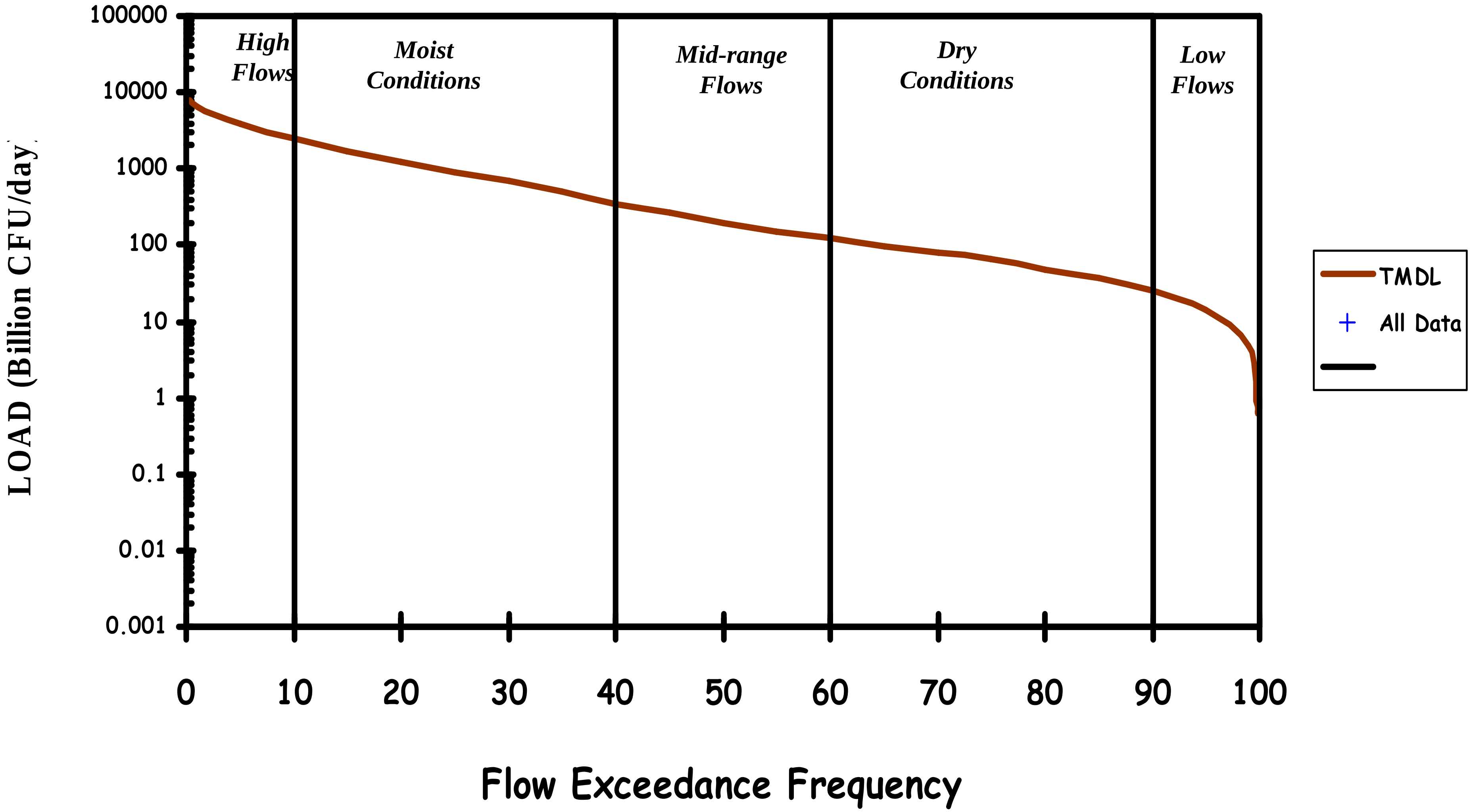


USGS Data

Figure E.7

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0155 - Escherichia Coli
Bearhouse Creek near Snyder, AR
(8040205-901)

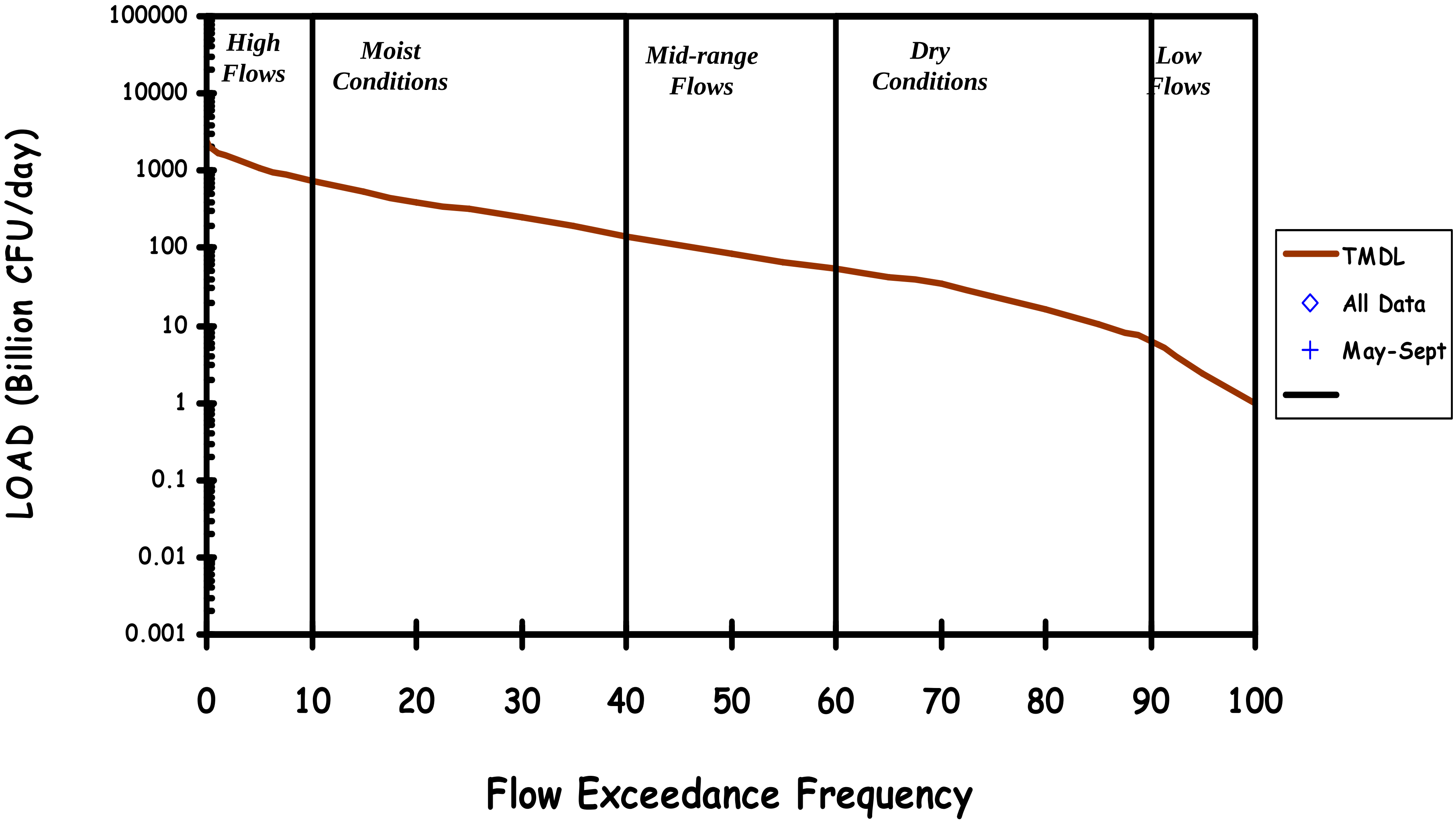


USGS Data

Figure E.8

Primary Contact Recreation Summer Season Load Duration Curve

Gage OUA0160 - Escherichia Coli
Melton's Creek, AR
(8040205-903)



USGS Data

Appendix F

PCR Winter/SCR Season Load Duration Curves for E. coli Bacteria

Figure F.1

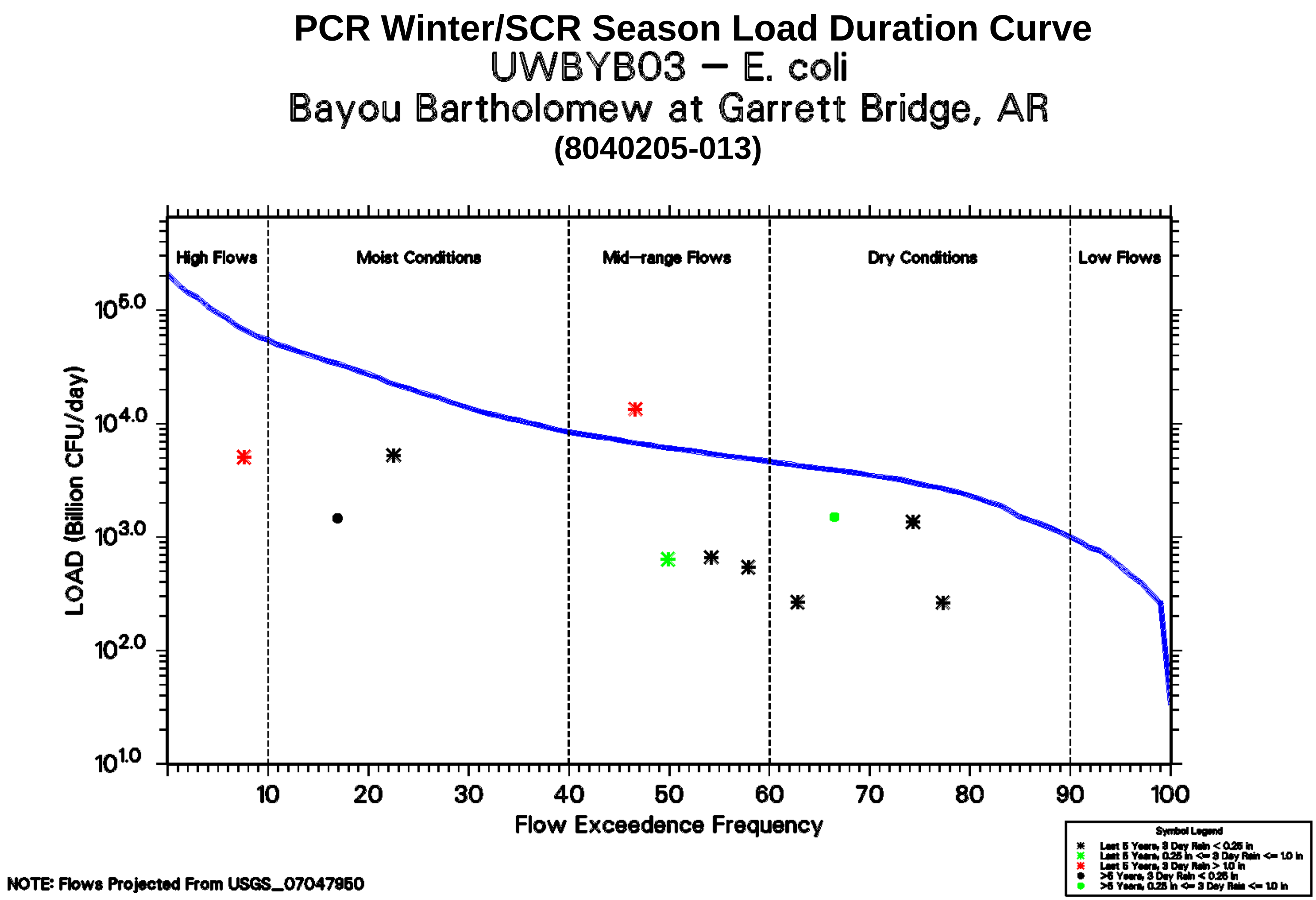
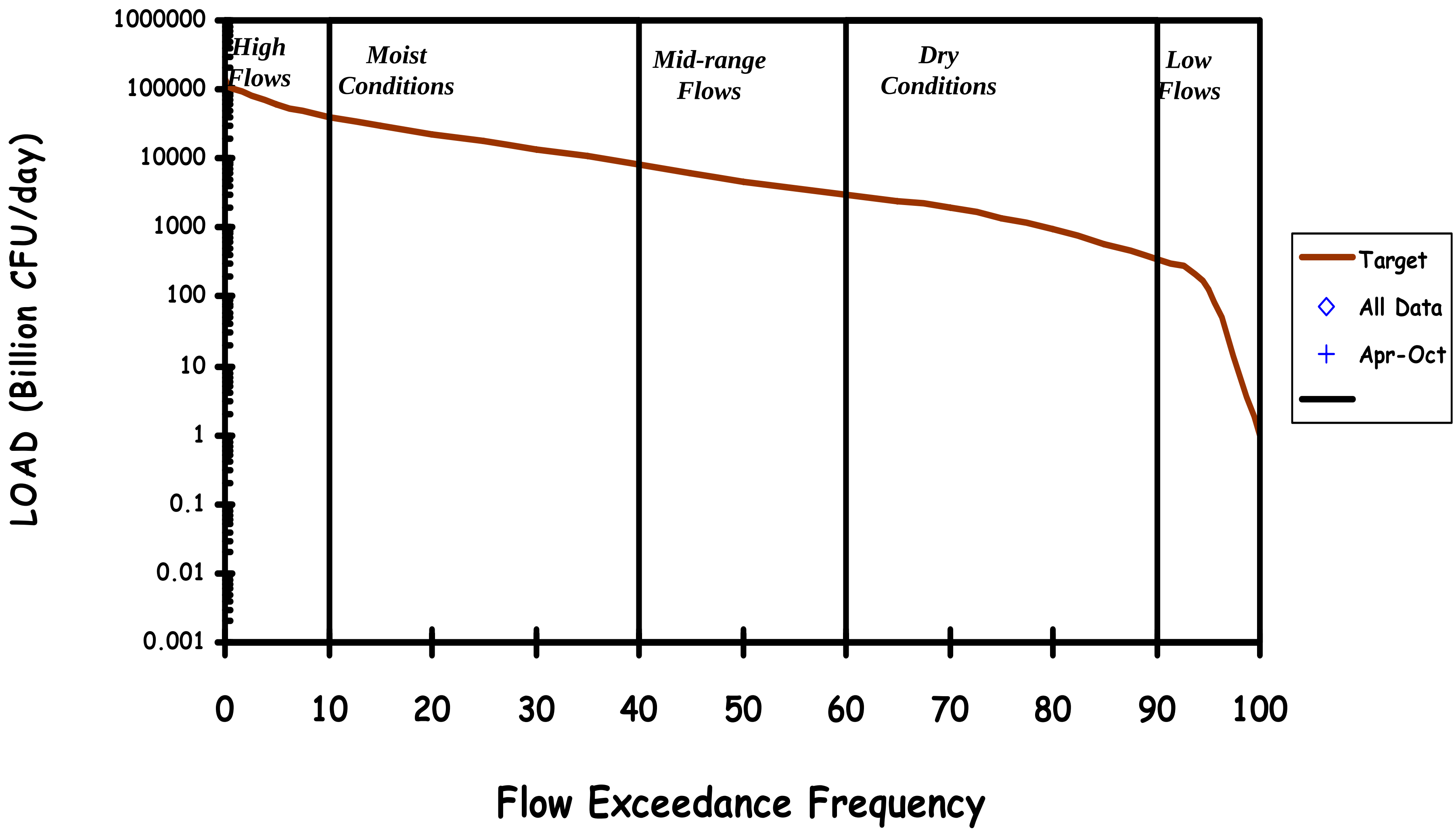

PCR Winter/SCR Season Load Duration Curve
UWBYB03 – E. coli
Bayou Bartholomew at Garrett Bridge, AR
(8040205-013)
High Flows
Moist Conditions
Mid–range Flows
Dry Conditions
Low Flows
LOAD (Billion CFU/day)
$10^{5.0}$
$10^{4.0}$
$10^{3.0}$
$10^{2.0}$
$10^{1.0}$
10
20
30
40
50
60
70
80
90
100
Flow Exceedence Frequency
Symbol Legend
Last 5 Years, 3 Day Rain < 0.25 in
Last 5 Years, 0.25 in <= 3 Day Rain <= 1.0 in
Last 5 Years, 3 Day Rain > 1.0 in
>5 Years, 3 Day Rain < 0.25 in
>5 Years, 0.25 in <= 3 Day Rain <= 1.0 in
NOTE: Flows Projected From USGS_07047950

Figure F.2

PCR Winter/SCR Season Load Duration Curve

Gage OUA12 - Escherichia Coli
Chemin-A-Haut Creek, AR
(8040205-907)

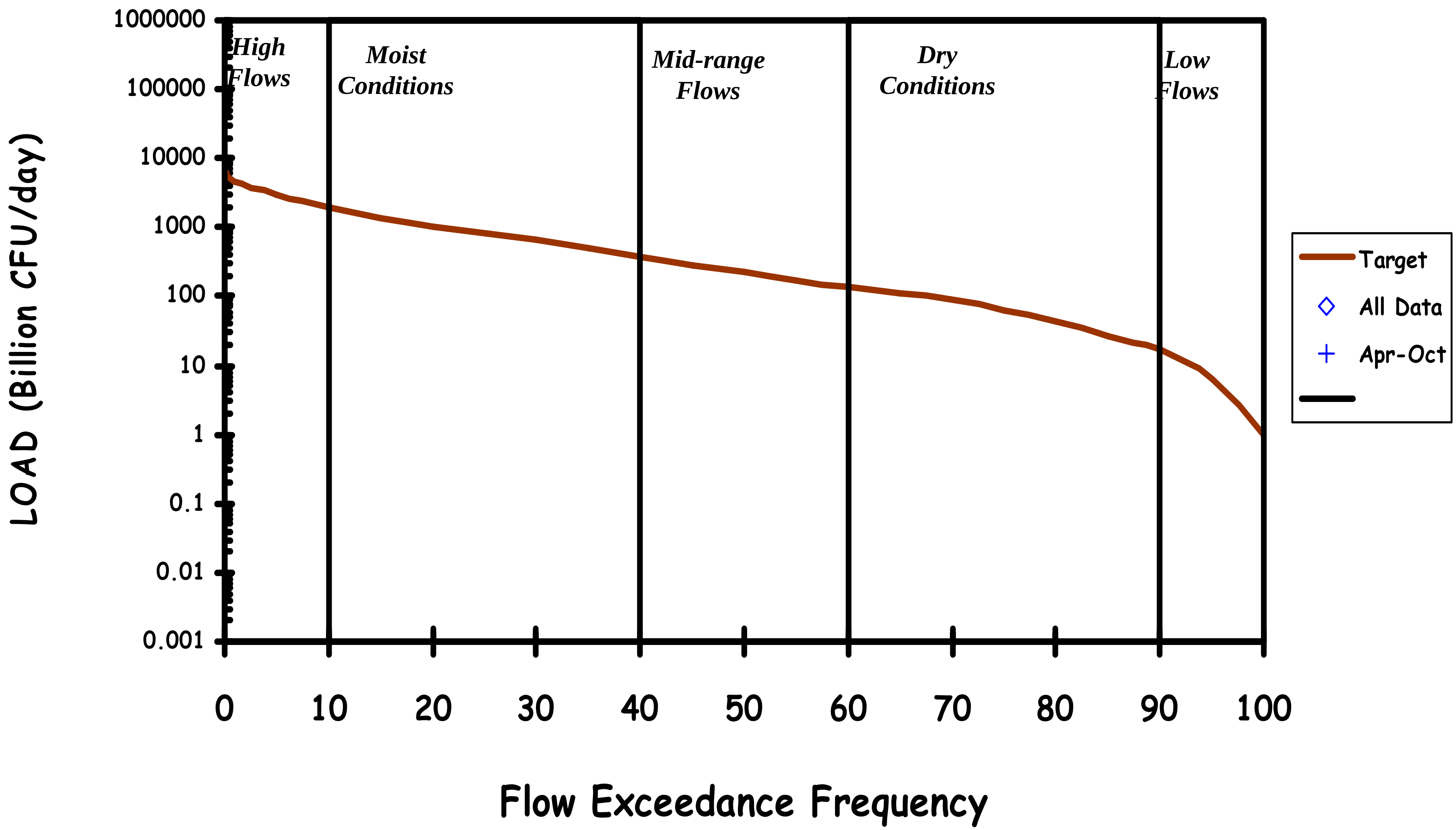


USGS Data

Figure F.3

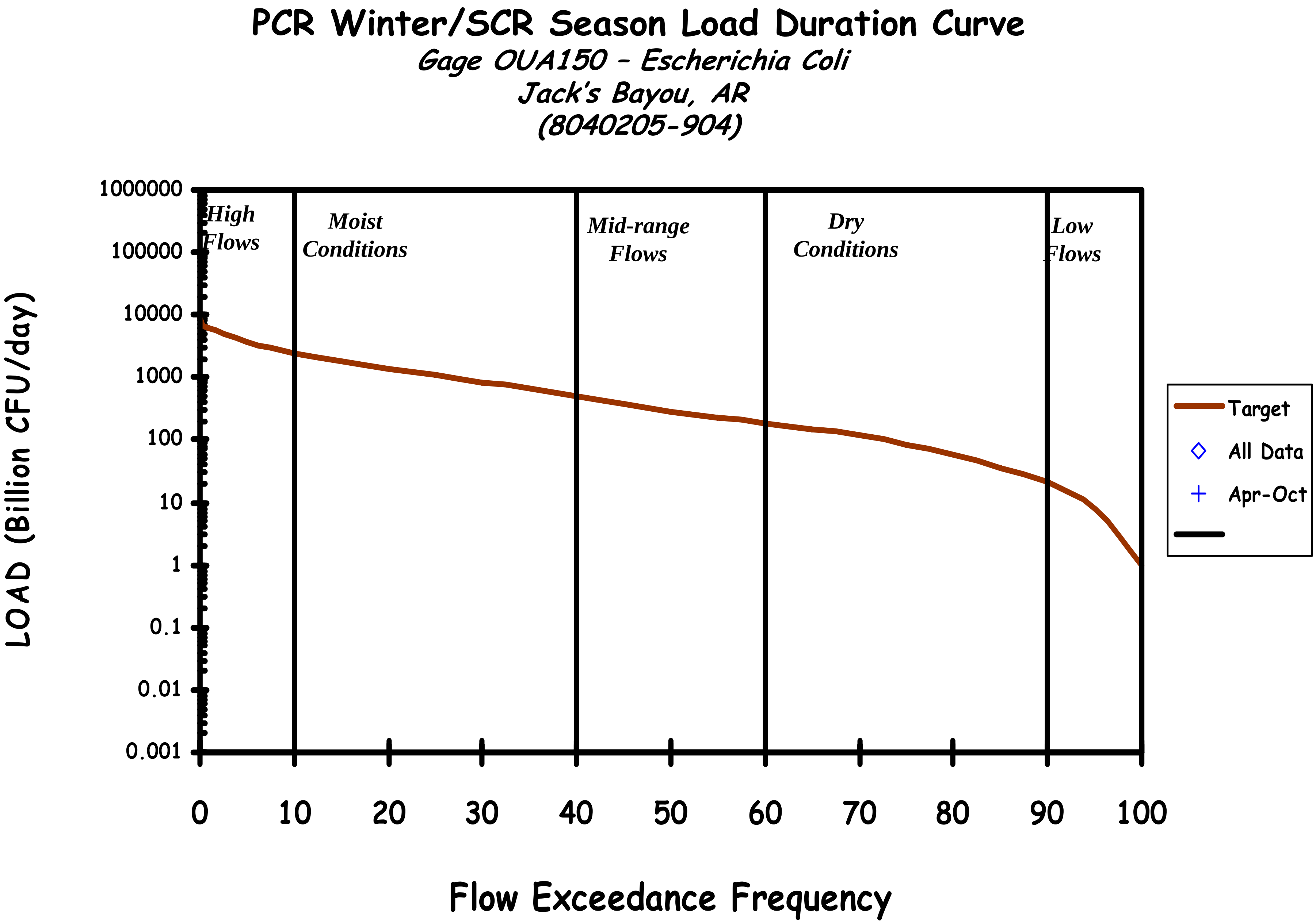
PCR Winter/SCR Season Load Duration Curve

Gage OUA145 - Escherichia Coli
Harding Creek, AR
(8040205-902)



USGS Data

Figure F.4

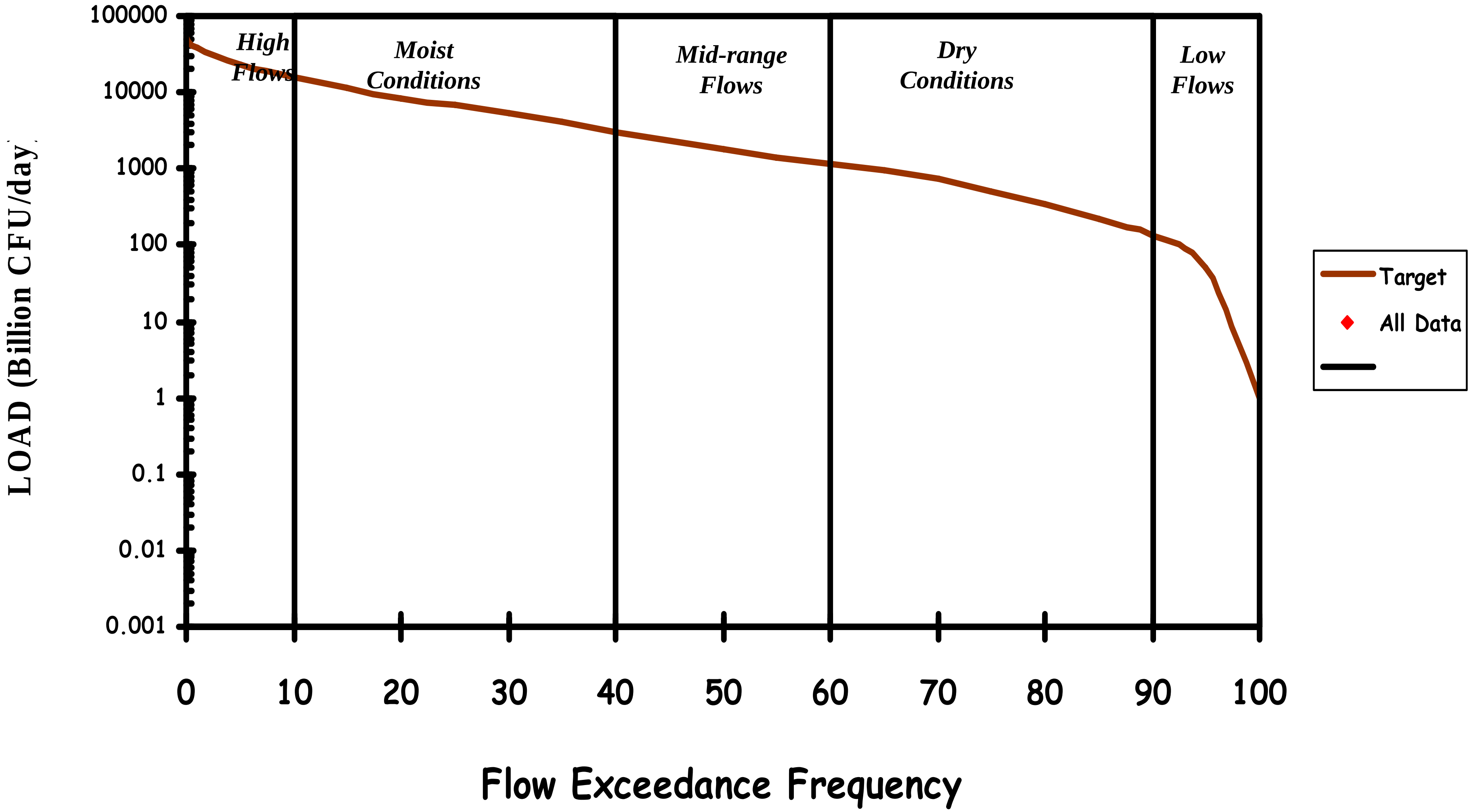


USGS Data

Figure F.5

PCR Winter/SCR Season Load Duration Curve

Gage OUAO151 - Escherichia Coli
Deep Bayou South of Grady, AR
(8040205-005)



USGS Data

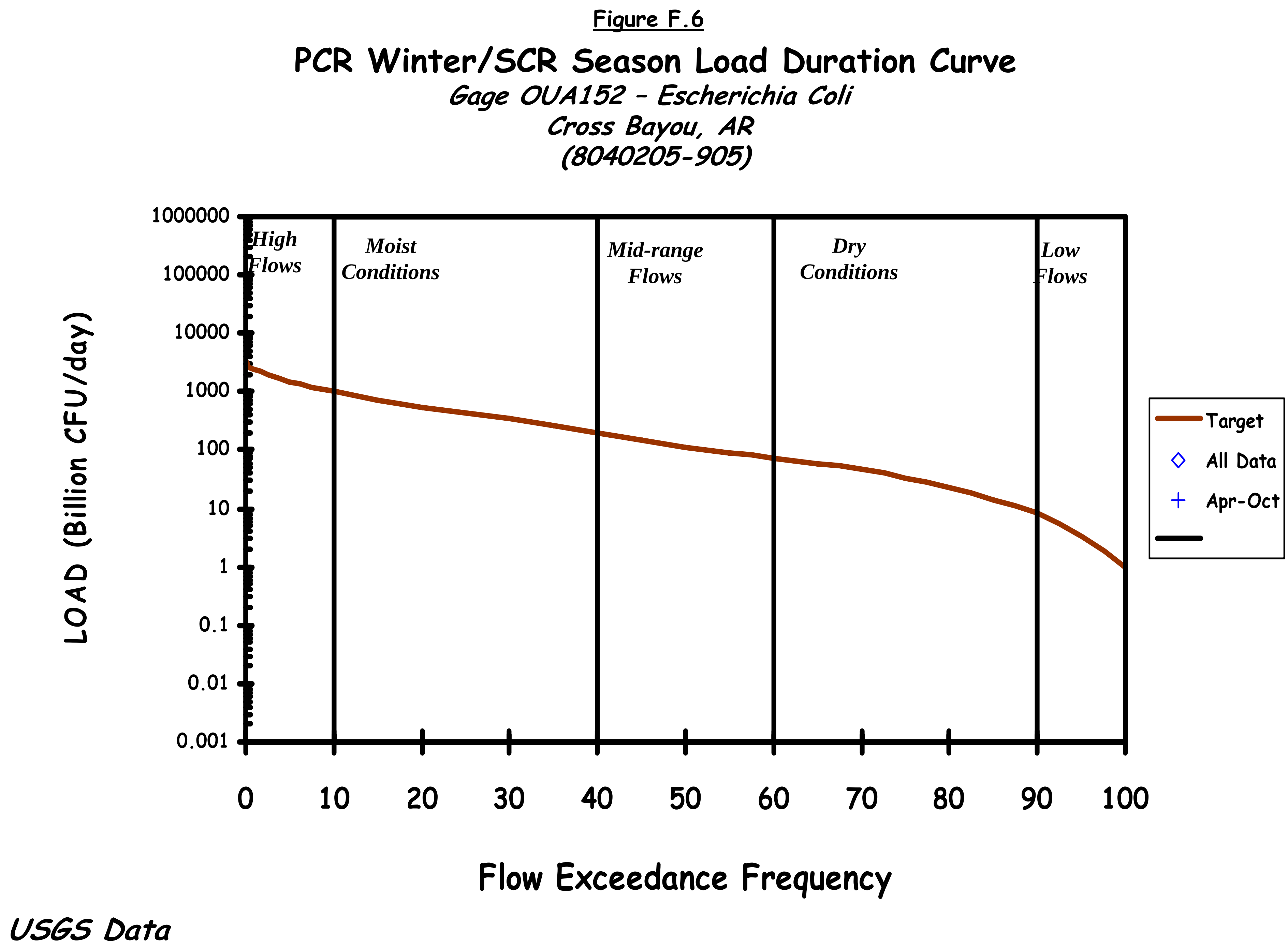
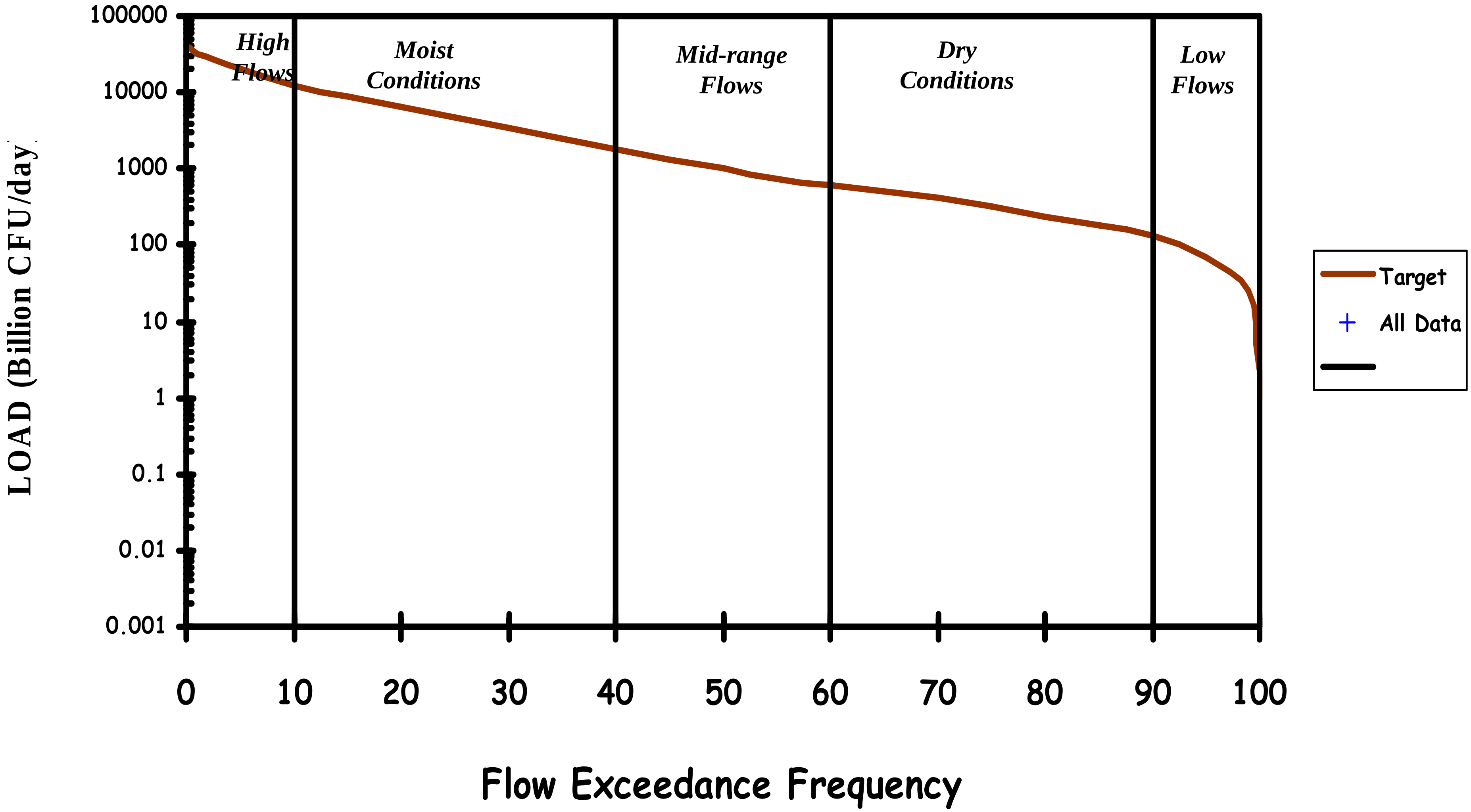


Figure F.6
PCR Winter/SCR Season Load Duration Curve
Gage OUA152 - Escherichia Coli
Cross Bayou, AR
(8040205-905)
LOAD (Billion CFU/day)
1000000
100000
10000
1000
100
10
1
0.1
0.01
0.001
High Flows
Moist Conditions
Mid-range Flows
Dry Conditions
Low Flows
0
10
20
30
40
50
60
70
80
90
100
Flow Exceedance Frequency
Target
All Data
Apr-Oct
USGS Data

Figure F.7

PCR Winter/SCR Season Load Duration Curve

Gage OUAO155 - Escherichia Coli
Bearhouse Creek near Snyder, AR
(8040205-901)

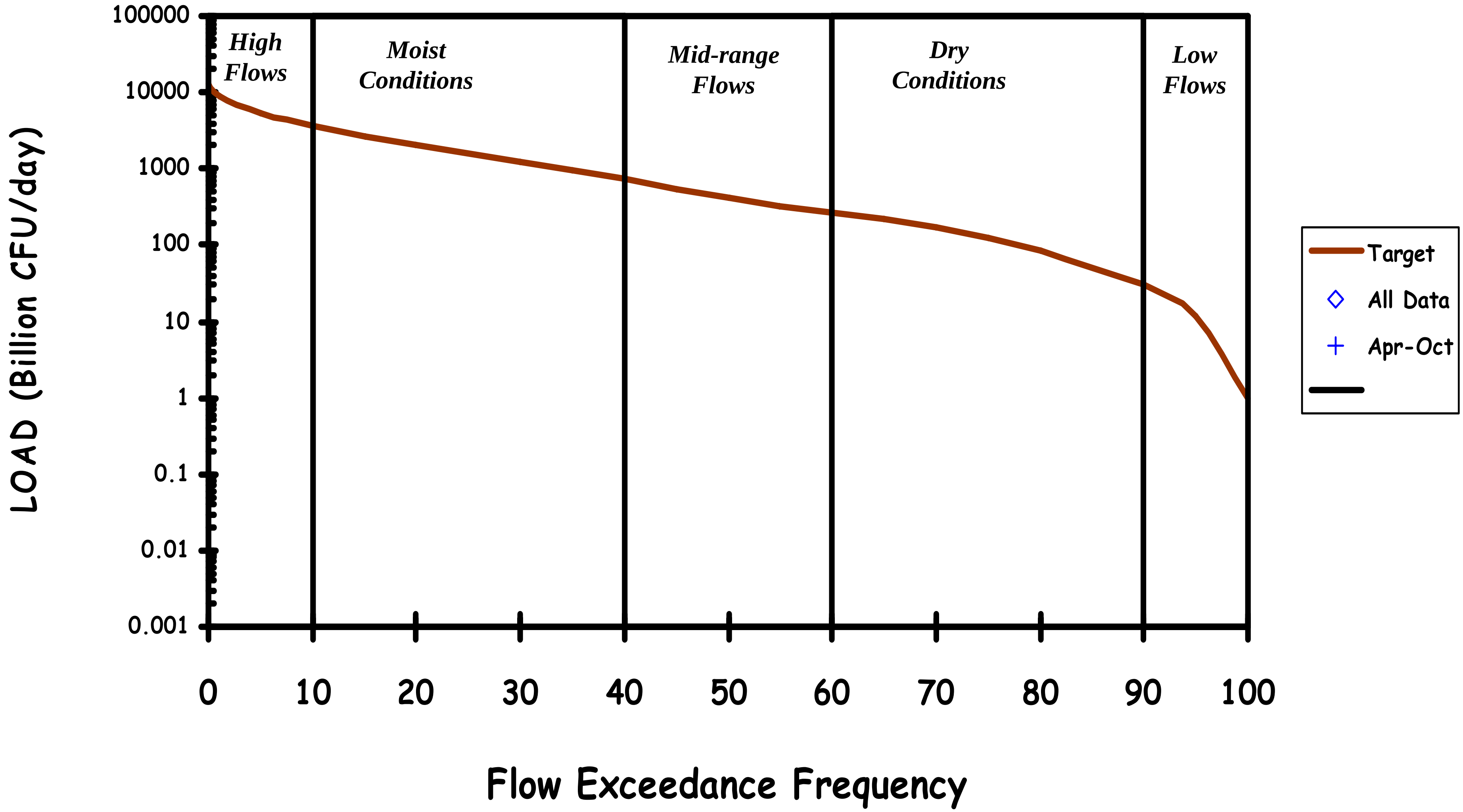


USGS Data

Figure F.8

PCR Winter/SCR Season Load Duration Curve

Gage OUA0160 - Escherichia Coli
Melton's Creek, AR
(8040205-903)



USGS Data

Appendix G

Flow Exceedance Frequency, Load and Flow Tables

Table G.1
Bayou Bartholomew (HUC-Reach 8040205-013)
Fecal Coliform: 400 col/100 ml(PCR-Summer and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	5210	5.09802E+13	2.54901E+14
0.1	4610	4.51092E+13	2.25546E+14
0.27	4306	4.21388E+13	2.10694E+14
1	3600	3.52263E+13	1.76131E+14
5	2260	2.21143E+13	1.10571E+14
10	1500	1.46776E+13	7.33881E+13
15	1090	1.06657E+13	5.33287E+13
20	825	8.07269E+12	4.03634E+13
25	650	6.3603E+12	3.18015E+13
30	510	4.99039E+12	2.49519E+13
35	390	3.81618E+12	1.90809E+13
40	297	2.90617E+12	1.45308E+13
45	222	2.17229E+12	1.08614E+13
50	172	1.68303E+12	8.41516E+12
55	136	1.33077E+12	6.65385E+12
60	110	1.07636E+12	5.38179E+12
65	89	8.70872E+11	4.35436E+12
70	70	6.84955E+11	3.42478E+12
75	50	4.89254E+11	2.44627E+12
80	34	3.32693E+11	1.66346E+12
85	21	2.05487E+11	1.02743E+12
90	13	1.27206E+11	6.3603E+11
95	5	46968360468	2.34842E+11
100	0	0	0

<u>Table G.2</u>

Bayou Bartholomew (HUC-Reach 8040205-013)

E. Coli: 410 col/100 ml(PCR-Summer and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	5210	5.22547E+13	2.61274E+14
0.1	4610	4.62369E+13	2.31185E+14
0.27	4306	4.31923E+13	2.15961E+14
1	3600	3.61069E+13	1.80535E+14
5	2260	2.26671E+13	1.13336E+14
10	1500	1.50446E+13	7.52228E+13
15	1090	1.09324E+13	5.46619E+13
20	825	8.2745E+12	4.13725E+13
25	650	6.51931E+12	3.25965E+13
30	510	5.11515E+12	2.55757E+13
35	390	3.91158E+12	1.95579E+13
40	297	2.97882E+12	1.48941E+13
45	222	2.22659E+12	1.1133E+13
50	172	1.72511E+12	8.62554E+12
55	136	1.36404E+12	6.8202E+12
60	110	1.10327E+12	5.51634E+12
65	89	8.92643E+11	4.46322E+12
70	70	7.02079E+11	3.5104E+12
75	50	5.01485E+11	2.50743E+12
80	34	3.4101E+11	1.70505E+12
85	21	2.10624E+11	1.05312E+12
90	13	1.30386E+11	6.51931E+11
95	5	48142569480	2.40713E+11
100	0	0	0

Table G.3

Chemin-A-Haut Creek (HUC-Reach 8040205-907)
Fecal Coliform: 400 col/ 100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	2818.32866	2.76E+13	1.38E+14
0.1	2493.76106	2.44E+13	1.22E+14
0.27	2329.5506	2.28E+13	1.14E+14
1	1947.4056	1.91E+13	9.53E+13
5	1222.53796	1.20E+13	5.98E+13
10	811.419	7.94E+12	3.97E+13
15	589.63114	5.77E+12	2.89E+13
20	446.28045	4.37E+12	2.18E+13
25	351.6149	3.44E+12	1.72E+13
30	275.88246	2.70E+12	1.35E+13
35	210.96894	2.06E+12	1.03E+13
40	160.660962	1.57E+12	7.86E+12
45	120.090012	1.18E+12	5.88E+12
50	93.042712	9.11E+11	4.55E+12
55	73.568656	7.20E+11	3.60E+12
60	59.50406	5.82E+11	2.91E+12
65	48.144194	4.71E+11	2.36E+12
70	37.86622	3.71E+11	1.85E+12
75	27.0473	2.65E+11	1.32E+12
80	18.392164	1.80E+11	9.00E+11
85	11.359866	1.11E+11	5.56E+11
90	7.032298	6.88E+10	3.44E+11
95	2.5965408	2.54E+10	1.27E+11
100	0	0.00E+00	0.00E+00

Table G.4
Chemin-A-Haut Creek (HUC-Reach 8040205-907);
E. Coli: 410 col/ 100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	2818.32866	2.83E+13	1.41E+14
0.1	2493.76106	2.50E+13	1.25E+14
0.27	2329.5506	2.34E+13	1.17E+14
1	1947.4056	1.95E+13	9.77E+13
5	1222.53796	1.23E+13	6.13E+13
10	811.419	8.14E+12	4.07E+13
15	589.63114	5.91E+12	2.96E+13
20	446.28045	4.48E+12	2.24E+13
25	351.6149	3.53E+12	1.76E+13
30	275.88246	2.77E+12	1.38E+13
35	210.96894	2.12E+12	1.06E+13
40	160.660962	1.61E+12	8.06E+12
45	120.090012	1.20E+12	6.02E+12
50	93.042712	9.33E+11	4.67E+12
55	73.568656	7.38E+11	3.69E+12
60	59.50406	5.97E+11	2.98E+12
65	48.144194	4.83E+11	2.41E+12
70	37.86622	3.80E+11	1.90E+12
75	27.0473	2.71E+11	1.36E+12
80	18.392164	1.84E+11	9.22E+11
85	11.359866	1.14E+11	5.70E+11
90	7.032298	7.05E+10	3.53E+11
95	2.5965408	2.60E+10	1.30E+11
100	0	0.00E+00	0.00E+00

Table G.5

Harding Creek (HUC-Reach 8040205-902)
Fecal Coliform: 400 col/ 100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	133.376	1.31E+12	6.53E+12
0.1	118.016	1.15E+12	5.77E+12
0.27	110.244822	1.08E+12	5.39E+12
1	92.16	9.02E+11	4.51E+12
5	57.856	5.66E+11	2.83E+12
10	38.4	3.76E+11	1.88E+12
15	27.904	2.73E+11	1.37E+12
20	21.12	2.07E+11	1.03E+12
25	16.64	1.63E+11	8.14E+11
30	13.056	1.28E+11	6.39E+11
35	9.984	9.77E+10	4.89E+11
40	7.6032	7.44E+10	3.72E+11
45	5.6832	5.56E+10	2.78E+11
50	4.4032	4.31E+10	2.15E+11
55	3.4816	3.41E+10	1.70E+11
60	2.816	2.76E+10	1.38E+11
65	2.2784	2.23E+10	1.11E+11
70	1.792	1.75E+10	8.77E+10
75	1.28	1.25E+10	6.26E+10
80	0.8704	8.52E+09	4.26E+10
85	0.5376	5.26E+09	2.63E+10
90	0.3328	3.26E+09	1.63E+10
95	0.12288	1.20E+09	6.01E+09
100	0	0.00E+00	0.00E+00

<u>Table G.6</u>

Harding Creek (HUC-Reach 8040205-902)

E. Coli: 410 col/ 100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	133.376	1.34E+12	6.69E+12
0.1	118.016	1.18E+12	5.92E+12
0.27	110.244822	1.11E+12	5.53E+12
1	92.16	9.24E+11	4.62E+12
5	57.856	5.80E+11	2.90E+12
10	38.4	3.85E+11	1.93E+12
15	27.904	2.80E+11	1.40E+12
20	21.12	2.12E+11	1.06E+12
25	16.64	1.67E+11	8.35E+11
30	13.056	1.31E+11	6.55E+11
35	9.984	1.00E+11	5.01E+11
40	7.6032	7.63E+10	3.81E+11
45	5.6832	5.70E+10	2.85E+11
50	4.4032	4.42E+10	2.21E+11
55	3.4816	3.49E+10	1.75E+11
60	2.816	2.82E+10	1.41E+11
65	2.2784	2.29E+10	1.14E+11
70	1.792	1.80E+10	8.99E+10
75	1.28	1.28E+10	6.42E+10
80	0.8704	8.73E+09	4.37E+10
85	0.5376	5.39E+09	2.70E+10
90	0.3328	3.34E+09	1.67E+10
95	0.12288	1.23E+09	6.16E+09
100	0	0.00E+00	0.00E+00

<u>Table G.7</u>

Jack's Bayou (HUC-Reach 8040205-904)

Fecal Coliform: 400 col/ 100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	173.493	1.70E+12	8.49E+12
0.1	153.513	1.50E+12	7.51E+12
0.27	143.404397	1.40E+12	7.02E+12
1	119.88	1.17E+12	5.87E+12
5	75.258	7.36E+11	3.68E+12
10	49.95	4.89E+11	2.44E+12
15	36.297	3.55E+11	1.78E+12
20	27.4725	2.69E+11	1.34E+12
25	21.645	2.12E+11	1.06E+12
30	16.983	1.66E+11	8.31E+11
35	12.987	1.27E+11	6.35E+11
40	9.8901	9.68E+10	4.84E+11
45	7.3926	7.23E+10	3.62E+11
50	5.7276	5.61E+10	2.80E+11
55	4.5288	4.43E+10	2.22E+11
60	3.663	3.58E+10	1.79E+11
65	2.9637	2.90E+10	1.45E+11
70	2.331	2.28E+10	1.14E+11
75	1.665	1.63E+10	8.15E+10
80	1.1322	1.11E+10	5.54E+10
85	0.6993	6.84E+09	3.42E+10
90	0.4329	4.24E+09	2.12E+10
95	0.15984	1.56E+09	7.82E+09
100	0	0.00E+00	0.00E+00

Table G.8
Jack's Bayou (HUC-Reach 8040205-904)
E. Coli: 410 col/ 100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	173.493	1.74E+12	8.70E+12
0.1	153.513	1.54E+12	7.70E+12
0.27	143.404397	1.44E+12	7.19E+12
1	119.88	1.20E+12	6.01E+12
5	75.258	7.55E+11	3.77E+12
10	49.95	5.01E+11	2.51E+12
15	36.297	3.64E+11	1.82E+12
20	27.4725	2.76E+11	1.38E+12
25	21.645	2.17E+11	1.09E+12
30	16.983	1.70E+11	8.52E+11
35	12.987	1.30E+11	6.51E+11
40	9.8901	9.92E+10	4.96E+11
45	7.3926	7.42E+10	3.71E+11
50	5.7276	5.75E+10	2.87E+11
55	4.5288	4.54E+10	2.27E+11
60	3.663	3.67E+10	1.84E+11
65	2.9637	2.97E+10	1.49E+11
70	2.331	2.34E+10	1.17E+11
75	1.665	1.67E+10	8.35E+10
80	1.1322	1.14E+10	5.68E+10
85	0.6993	7.01E+09	3.51E+10
90	0.4329	4.34E+09	2.17E+10
95	0.15984	1.60E+09	8.02E+09
100	0	0.00E+00	0.00E+00

Table G.9

Deep Bayou (HUC-Reach 8040205-005)

Fecal Coliform: 400 col/100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	1078.47	1.05529E+13	5.27645E+13
0.1	954.27	9.3376E+12	4.6688E+13
0.27	891.43274	8.72274E+12	4.36137E+13
1	745.2	7.29184E+12	3.64592E+13
5	467.82	4.57765E+12	2.28883E+13
10	310.5	3.03827E+12	1.51913E+13
15	225.63	2.20781E+12	1.1039E+13
20	170.775	1.67105E+12	8.35523E+12
25	134.55	1.31658E+12	6.58291E+12
30	105.57	1.03301E+12	5.16505E+12
35	80.73	7.89949E+11	3.94975E+12
40	61.479	6.01577E+11	3.00788E+12
45	45.954	4.49663E+11	2.24832E+12
50	35.604	3.48388E+11	1.74194E+12
55	28.152	2.75469E+11	1.37735E+12
60	22.77	2.22806E+11	1.11403E+12
65	18.423	1.8027E+11	9.01352E+11
70	14.49	1.41786E+11	7.08929E+11
75	10.35	1.01276E+11	5.06378E+11
80	7.038	68867358537	3.44337E+11
85	4.347	42535721449	2.12679E+11
90	2.691	26331637088	1.31658E+11
95	0.9936	9722450617	48612253085
100	0	0	0

Table G.10
Deep Bayou (HUC-Reach 8040205-005)
E Coli: 410 col/100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	1078.47	1.08167E+13	5.40837E+13
0.1	954.27	9.57104E+12	4.78552E+13
0.27	891.43274	8.94080E+12	4.4704E+13
1	745.2	7.47413E+12	3.73707E+13
5	467.82	4.69210E+12	2.34605E+13
10	310.5	3.11422E+12	1.55711E+13
15	225.63	2.26300E+12	1.1315E+13
20	170.775	1.71282E+12	8.56411E+12
25	134.55	1.34950E+12	6.74748E+12
30	105.57	1.05884E+12	5.29418E+12
35	80.73	8.09698E+11	4.04849E+12
40	61.479	6.16616E+11	3.08308E+12
45	45.954	4.60905E+11	2.30452E+12
50	35.604	3.57098E+11	1.78549E+12
55	28.152	2.82356E+11	1.41178E+12
60	22.77	2.28376E+11	1.14188E+12
65	18.423	1.84777E+11	9.23886E+11
70	14.49	1.45330E+11	7.26652E+11
75	10.35	1.03807E+11	5.19037E+11
80	7.038	7.05890E+10	3.52945E+11
85	4.347	4.35991E+10	2.17996E+11
90	2.691	2.69899E+10	1.3495E+11
95	0.9936	9.96551E+09	49827559412
100	0	0.00000E+00	0

Table G.11
Cross Bayou (HUC-Reach 8040205-905)
Fecal Coliform: 400 col/ 100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	69.293	6.78E+11	3.39E+12
0.1	61.313	6.00E+11	3.00E+12
0.27	57.2756301	5.61E+11	2.80E+12
1	47.88	4.69E+11	2.34E+12
5	30.058	2.94E+11	1.47E+12
10	19.95	1.95E+11	9.76E+11
15	14.497	1.42E+11	7.09E+11
20	10.9725	1.07E+11	5.37E+11
25	8.645	8.46E+10	4.23E+11
30	6.783	6.64E+10	3.32E+11
35	5.187	5.08E+10	2.54E+11
40	3.9501	3.87E+10	1.93E+11
45	2.9526	2.89E+10	1.44E+11
50	2.2876	2.24E+10	1.12E+11
55	1.8088	1.77E+10	8.85E+10
60	1.463	1.43E+10	7.16E+10
65	1.1837	1.16E+10	5.79E+10
70	0.931	9.11E+09	4.56E+10
75	0.665	6.51E+09	3.25E+10
80	0.4522	4.43E+09	2.21E+10
85	0.2793	2.73E+09	1.37E+10
90	0.1729	1.69E+09	8.46E+09
95	0.06384	6.25E+08	3.12E+09
100	0	0.00E+00	0.00E+00

<u>Table G.12</u>

Cross Bayou (HUC-Reach 8040205-905)

E. Coli: 410 col/ 100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedence Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	69.293	6.95E+11	3.48E+12
0.1	61.313	6.15E+11	3.08E+12
0.27	57.2756301	5.75E+11	2.87E+12
1	47.88	4.80E+11	2.40E+12
5	30.058	3.02E+11	1.51E+12
10	19.95	2.00E+11	1.00E+12
15	14.497	1.45E+11	7.27E+11
20	10.9725	1.10E+11	5.50E+11
25	8.645	8.67E+10	4.34E+11
30	6.783	6.80E+10	3.40E+11
35	5.187	5.20E+10	2.60E+11
40	3.9501	3.96E+10	1.98E+11
45	2.9526	2.96E+10	1.48E+11
50	2.2876	2.29E+10	1.15E+11
55	1.8088	1.81E+10	9.07E+10
60	1.463	1.47E+10	7.34E+10
65	1.1837	1.19E+10	5.94E+10
70	0.931	9.34E+09	4.67E+10
75	0.665	6.67E+09	3.34E+10
80	0.4522	4.54E+09	2.27E+10
85	0.2793	2.80E+09	1.40E+10
90	0.1729	1.73E+09	8.67E+09
95	0.06384	6.40E+08	3.20E+09
100	0	0.00E+00	0.00E+00

Table G.13
Bearhouse Creek (HUC-Reach 8040205-901)
Fecal Coliform: 400 col/100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	804	7.8692E+12	3.9346E+13
0.1	789	7.71675E+12	3.85837E+13
0.27	773	7.56313E+12	3.78156E+13
1	647	6.33256E+12	3.16628E+13
5	394	3.85517E+12	1.92759E+13
10	249	2.43455E+12	1.21728E+13
15	172	1.68077E+12	8.40386E+12
20	125	1.22021E+12	6.10105E+12
25	92	8.98888E+11	4.49444E+12
30	68	6.67713E+11	3.33857E+12
35	49	4.84119E+11	2.42059E+12
40	35	3.42655E+11	1.71327E+12
45	26	2.56373E+11	1.28187E+12
50	20	1.92221E+11	9.61105E+11
55	15	1.48322E+11	7.41608E+11
60	12	1.18861E+11	5.94306E+11
65	10	95646173557	4.78231E+11
70	8	78931308275	3.94657E+11
75	7	63747807246	3.18739E+11
80	5	47027070919	2.35135E+11
85	4	35286937817	1.76435E+11
90	3	25081104490	1.25406E+11
95	1	13929054401	69645272007
99	0	4828738859	24143694296
99.865	0	657108713	3285543565
100	0	0	0

Table G.14
Bearhouse Creek (HUC-Reach 8040205-901)
E Coli: 410 col/100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	804	8.06593E+12	4.03296E+13
0.1	789	7.90967E+12	3.95483E+13
0.27	773	7.75221E+12	3.8761E+13
1	647	6.49087E+12	3.24544E+13
5	394	3.95155E+12	1.97578E+13
10	249	2.49542E+12	1.24771E+13
15	172	1.72279E+12	8.61396E+12
20	125	1.25072E+12	6.25358E+12
25	92	9.21361E+11	4.6068E+12
30	68	6.84406E+11	3.42203E+12
35	49	4.96222E+11	2.48111E+12
40	35	3.51221E+11	1.75611E+12
45	26	2.62783E+11	1.31391E+12
50	20	1.97026E+11	9.85132E+11
55	15	1.52030E+11	7.60149E+11
60	12	1.21833E+11	6.09164E+11
65	10	9.80373E+10	4.90187E+11
70	8	8.09046E+10	4.04523E+11
75	7	6.53415E+10	3.26708E+11
80	5	4.82027E+10	2.41014E+11
85	4	3.61691E+10	1.80846E+11
90	3	2.57081E+10	1.28541E+11
95	1	1.42773E+10	71386403807
99	0	4.94946E+09	24747286653
99.865	0	6.73536E+08	3367682154
100	0	0.00000E+00	0

<u>Table G.15</u>

Melton's Creek (HUC-Reach 8040205-903)

Fecal Coliform: 400 col/100 ml (PCR-Summer) and 2000 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	251.643	2.46235E+12	1.23117E+13
0.1	222.663	2.17877E+12	1.08939E+13
0.27	208.000973	2.03531E+12	1.01765E+13
1	173.88	1.70143E+12	8.50714E+12
5	109.158	1.06812E+12	5.3406E+12
10	72.45	7.08929E+11	3.54464E+12
15	52.647	5.15155E+11	2.57577E+12
20	39.8475	3.89911E+11	1.94955E+12
25	31.395	3.07202E+11	1.53601E+12
30	24.633	2.41036E+11	1.20518E+12
35	18.837	1.84321E+11	9.21607E+11
40	14.3451	1.40368E+11	7.01839E+11
45	10.7226	1.04921E+11	5.24607E+11
50	8.3076	81290489881	4.06452E+11
55	6.5688	64276201301	3.21381E+11
60	5.313	51988103994	2.59941E+11
65	4.2987	42063102322	2.10316E+11
70	3.381	33083338905	1.65417E+11
75	2.415	23630956361	1.18155E+11
80	1.6422	16069050325	80345251626
85	1.0143	9925001671	49625008357
90	0.6279	6144048654	30720243269
95	0.23184	2268571811	11342859053
100	0	0	0

<u>Table G.16</u>
Melton's Creek (HUC-Reach 8040205-903)
E Coli: 410 col/100 ml (PCR-Summer) and 2050 col/100 ml (PCR-Winter/SCR)

Flow Exceedance Frequency	Flow (cfs)	Load-PCR Sum (cfu/day)	Load-PCR Winter/SCR (cfu/day)
0.01	251.643	2.5239E+12	1.26195E+13
0.1	222.663	2.23324E+12	1.11662E+13
0.27	208.000973	2.08619E+12	1.04309E+13
1	173.88	1.74396E+12	8.71982E+12
5	109.158	1.09482E+12	5.47411E+12
10	72.45	7.26652E+11	3.63326E+12
15	52.647	5.28034E+11	2.64017E+12
20	39.8475	3.99659E+11	1.99829E+12
25	31.395	3.14882E+11	1.57441E+12
30	24.633	2.47062E+11	1.23531E+12
35	18.837	1.88929E+11	9.44647E+11
40	14.3451	1.43877E+11	7.19385E+11
45	10.7226	1.07544E+11	5.37722E+11
50	8.3076	83322752128	4.16614E+11
55	6.5688	65883106334	3.29416E+11
60	5.313	53287806593	2.66439E+11
65	4.2987	43114679880	2.15573E+11
70	3.381	33910422378	1.69552E+11
75	2.415	24221730270	1.21109E+11
80	1.6422	16470776583	82353882917
85	1.0143	10173126713	50865633566
90	0.6279	6297649870	31488249351
95	0.23184	2325286106	11626430529
100	0	0	0