Environmental Protection Agency
Region 7
Total Maximum Daily Load

Cedar River Watershed, Iowa

for Indicator Bacteria, *Escherichia coli* (*E. coli*)

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2/26/10
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Table of Contents

Executive Summary 12
Cedar River Watershed Description 12
Iowa *E. coli* Bacteria Water Quality Standards 14
Informational Implementation Plan 23
1. Introduction 25
2. Description of the Cedar River Watershed 31
2.1. Physiography 31
2.2. Land Use 34
2.3. Water Use 36
2.4. Climate 36
2.5. Surface Water Hydrology 36
3. TMDL for *E. coli* 39
3.1. Problem Identification for Cedar River Watershed 39
3.2. Impaired Beneficial Uses and Applicable Water Quality Standards 39
3.3. Data Sources 40
3.4. Interpretation of Watershed Wide Data 40
3.5. Identification of Watershed Pollutant Sources 47
3.5.1. Direct Sources 50
3.5.2. Indirect Sources 55
3.6. TMDL Development Methodology 58
4. Indicator Bacteria Impairment for Cedar River from Rock Creek to Iowa/Minnesota Border (IA 02-CED-0110_3) 63
4.1. Problem Identification 63
4.1.1. Problem Statement 63
4.1.2. Data Interpretation 63
4.2. Pollution Source Assessment 63
4.2.1. Identification of Pollutant Sources 63
4.3. Flow Variable TMDL Approach and Target 67
4.3.1. Existing Load and Departure From Load Capacity 67
4.3.2. Flow Variable TMDL Targets for Daily Loads 68
4.4. Pollutant Allocation 69
4.4.1. Source Allocation 69
4.4.2. Waste Load Allocation 70
4.4.3. Load Allocation 70
4.4.4. Margin of Safety 70
5. Indicator Bacteria Impairment for Cedar River from Charles City Dam No. 2 to Confluence with Rock Creek (IA 02-CED-0110_2). 71
5.1. Problem Identification 71
5.1.1. Problem Statement 71
5.1.2. Data Interpretation 71
5.2. Pollution Source Assessment 72
5.2.1. Identification of Pollutant Sources 72
5.3. Flow Variable TMDL Approach and Target 75
5.3.1. Existing Load and Departure From Load Capacity 75
5.3.2. Flow Variable TMDL Targets for Daily Loads 76
5.4. Pollutant Allocation 77
5.4.1. Source Allocation 77

5.4.2. Waste Load Allocation ... 78
5.4.3. Load Allocation ... 78
5.4.4. Margin of Safety ... 78
6. Indicator Bacteria Impairment for Shell Rock River from Confluence with the Winnebago River to Confluence with Rose Creek (IA 02-SHL-0020_1) ... 79
6.1. Problem Identification ... 79
6.1.1. Problem Statement ... 79
6.1.2. Data Interpretation ... 79
6.2. Pollution Source Assessment ... 79
6.2.1. Identification of Pollutant Sources ... 79
6.3. Flow Variable TMDL Approach and Target ... 83
6.3.1. Existing Load and Departure From Load Capacity ... 83
6.3.2. Flow Variable TMDL Targets for Daily Loads ... 84
6.4. Pollutant Allocation ... 85
6.4.1. Source Allocation ... 85
6.4.2. Waste Load Allocation ... 86
6.4.3. Load Allocation ... 86
6.4.4. Margin of Safety ... 86
7. Indicator Bacteria Impairment for Cedar River from the Dam of Cedar Falls Impoundment to the Upper End of the Impoundment (IA 02-CED-0050-L_0) ... 87
7.1. Problem Identification ... 87
7.1.1. Problem Statement ... 87
7.1.2. Data Interpretation ... 87
7.2. Pollution Source Assessment ... 87
7.2.1. Identification of Pollutant Sources ... 87
7.3. Flow Variable TMDL Approach and Target ... 91
7.3.1. Existing Load and Departure From Load Capacity ... 91
7.3.2. Flow Variable TMDL Targets for Daily Loads ... 92
7.4. Pollutant Allocation ... 93
7.4.1. Source Allocation ... 93
7.4.2. Waste Load Allocation ... 94
7.4.3. Load Allocation ... 94
7.4.4. Margin of Safety ... 94
8. Indicator Bacteria Impairment for Cedar River from Wolf Creek to Bridge Crossing in LaPorte City (IA 02-CED-0040_1) ... 96
8.1. Problem Identification ... 96
8.1.1. Problem Statement ... 96
8.1.2. Data Interpretation ... 96
8.2. Pollution Source Assessment ... 96
8.2.1. Identification of Pollutant Sources ... 96
8.3. Flow Variable TMDL Approach and Target ... 100
8.3.1. Existing Load and Departure From Load Capacity ... 100
8.3.2. Flow Variable TMDL Targets for Daily Loads ... 101
8.4. Pollutant Allocation ... 102
8.4.1. Source Allocation ... 102
8.4.2. Waste Load Allocation ... 102
8.4.3. Load Allocation ... 103

8.4.4. Margin of Safety 103
9. Indicator Impairment for Cedar River from McCloud Run to Confluence with Bear Creek (IA 02-CED-0030_2) 104
9.1. Problem Identification 104
9.1.1. Problem Statement 104
9.1.2. Data Interpretation 104
9.2. Pollution Source Assessment 104
9.2.1. Identification of Pollutant Sources 104
9.3. Flow Variable TMDL Approach and Target 108
9.3.1. Existing Load and Departure From Load Capacity 108
9.3.2. Flow Variable TMDL Targets for Daily Loads 109
9.4. Pollutant Allocation 110
9.4.1. Source Allocation 110
9.4.2. Waste Load Allocation 110
9.4.3. Load Allocation 111
9.4.4. Margin of Safety 111
10. Indicator Bacteria Impairment for Cedar River from Prairie Creek to Confluence with McCloud Run (IA 02-CED-0030_1) 112
10.1. Problem Identification 112
10.1.1. Problem Statement 112
10.1.2. Data Interpretation 112
10.2. Pollution Source Assessment 112
10.2.1. Identification of Pollutant Sources 112
10.3. Flow Variable TMDL Approach and Target 116
10.3.1. Existing Load and Departure From Load Capacity 116
10.3.2. Flow Variable TMDL Targets for Daily Loads 117
10.4. Pollutant Allocation 118
10.4.1. Source Allocation 118
10.4.2. Waste Load Allocation 118
10.4.3. Load Allocation 119
10.4.4. Margin of Safety 119
11. Indicator Bacteria Impairment for Cedar River from Highway 30 Bridge at Cedar Rapids to Confluence with Prairie Creek (IA 02-CED-0020_3) 120
11.1. Problem Identification 120
11.1.1. Problem Statement 120
11.1.2. Data Interpretation 120
11.2. Pollution Source Assessment 121
11.2.1 Identification of Pollutant Sources 121
11.3. Flow Variable TMDL Approach and Target 124
11.3.1. Existing Load and Departure From Load Capacity 124
11.3.2. Flow Variable TMDL Targets for Daily Loads 125
11.4. Pollutant Allocation 126
11.4.1. Source Allocation 126
11.4.2. Waste Load Allocation 127
11.4.3. Load Allocation 127
11.4.4. Margin of Safety 127
12. Indicator Bacteria Impairment for Cedar River from Rock Run Creek to Highway 30 Bridge at Cedar Rapids (IA 02-CED-0020_2) 129
12.1. Problem Identification 129

12.1.1. Problem Statement 129
12.1.2. Data Interpretation 129
12.2. Pollution Source Assessment 129
12.2.1. Identification of Pollutant Sources 129
12.3.1. Existing Load and Departure From Load Capacity 133
12.3.2. Flow Variable TMDL Targets for Daily Loads 134
12.4. Pollutant Allocation 135
12.4.1. Source Allocation 135
12.4.3. Load Allocation 136
12.4.4. Margin of Safety 136
13. Cedar River Watershed Model 137
13.1. Model Description 137
13.2. Model Development, Calibration, and Verification 137
13.3. Collection and Development of Time-Series Data 137
13.4. Characterization and Segmentation of the Watershed 138
13.5. Model Calibration/Verification 140
13.6. Hydrology Calibration/Verification Results 146
13.7. Water Quality Calibration/Verification Results 147
14. Implementation Plan 148

Appendices 153
Appendix A — Glossary of Terms and Acronyms 153
Appendix B — General and Designated Uses of Iowa's Waters 158
Appendix C — Water Quality Data 160
Appendix D — Waste Load Allocations for NPDES Permits 318
Appendix E — Flow and Water Quality Calibration/Verification (1995 – 2005) 322
Appendix F — HSPF Perennial Stream Analysis 432
Appendix G — Supplemental Implementation Plan 433

List of Figures

Figure ES-1. Location Map of the Cedar River Watershed and CWA 303(d) Impaired Waterbodies in Iowa and Minnesota...13
Figure ES-2. Percent of Watershed-Wide Data Exceeding the Iowa WQS of 235 Colony-Forming Units/100 Milliliters Geometric Mean. 14
Figure ES-3. Boxplots for Cedar River Watershed Wide Concentrations of *E. coli* by Flow Range Compared to the Geometric Mean Iowa WQS for *E. coli* of 235 Organisms/ 100 ml Water. 16
Figure ES-4. Model Framework Developed for the Comprehensive Inventory of Potential Bacteria Sources within the Cedar River Watershed. 17
Figure ES-5. Load Duration Curve for *E. coli* Measured at Station 10570001. 19
Figure 1-1. Location Map of Cedar River Watershed and Impaired Waterbodies.......................27
Figure 2-1. Location of the Cedar River Watershed within the Landform Regions of Iowa. 33
Figure 2-2. Urbanized Area Locations and Population Distribution within the Cedar River Watershed. 35
Figure 2-3. Active USGS Flow Gages within the Cedar River Watershed..................................37
Figure 3-1. Bacteria Monitoring Stations with Fecal Coliform Samples. 42
Figure 3-2. Bacteria Monitoring Stations with *E. coli* Samples. 43
Figure 3-3. Paired Water Quality and Flow Monitoring Sites..44
Figure 3-4. Percent of Watershed Wide Data Exceeding 235 cfu/100 ml...................................45
Figure 3-5. Spatial Distribution of Watershed Wide Data Exceeding 235 cfu/100 ml. 46
Figure 3-6. Boxplots for Watershed Wide Concentrations by Flow Range. 47
Figure 3-7. Boxplots of Watershed Wide Monthly Concentration...49
Figure 3-8. Boxplots of Watershed Wide Seasonal Concentrations...49
Figure 3-9. Sources of Bacteria. 51
Figure 3-10. Watershed Wide Pollutant Sources...52
Figure 3-11. Watershed Wide Distribution of Septic System...54.
Figure 3-12. Load Duration Curve for *E. coli* Measured at Station 10070003. 60
Figure 4-1. Boxplots for Water Quality Station 10340003 by Flow Range. 64
Figure 4-2. Boxplots for Water Quality Station 10340003 by Season. 65
Figure 4-3. Boxplots for Water Quality Station 1034003 by Recreation Season. 65
Figure 4-4. Pollutant Sources for Cedar River Segment IA 02-CED-0110_3..............................66
Figure 4-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10340003........67
Figure 4-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0110_3. 69
Figure 5-1. Boxplots for Water Quality Station 10340001 by Flow Range. 72
Figure 5-2. Boxplots for Water Quality Station 10340001 by Season. 73
Figure 5-3. Boxplots of Water Quality Station 10340001 by Recreation Season. 73
Figure 5-4. Pollutant Sources for Cedar River Segment IA 02-CED-0110_2..............................74
Figure 5-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10340001...75
Figure 5-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0110_2. 77
Figure 6-2. Boxplots for Water Quality Station 11340001 by Season 81
Figure 6-3. Boxplots for Water Quality Station 11340001 by Recreation Season........................81
Figure 6-4. Pollutant Sources for Shell Rock River Segment IA 02-SHL-0020_1 82
Figure 6-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 1134001..........83
Figure 6-6. HSPF Source Allocation for Shell Rock River Segment IA 02-SHL-0020_1............85
Figure 7-1. Boxplots for Water Quality Station 10070005 by Flow Range. 88
Figure 7-2. Boxplots for Water Quality Station 10070005 by Season. 89
Figure 7-3. Boxplots of Water Quality Station 10070005 by Recreation Season. 89
Figure 7-4. Pollutant Sources for Cedar River Segment IA 02-CED-0050-L_0...........................90
Figure 7-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10070005........91

Figure 7-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0050-L_0. 93
Figure 8-1. Boxplots for Water Quality Station 10070006 by Flow Range. 97
Figure 8-2. Boxplots for Water Quality Station 10070006 by Season. 98
Figure 8-3. Boxplots of Water Quality Station 10070006 by Recreation Season. 98
Figure 8-4. Pollutant Sources for Cedar River Segment IA 02-CED-0040_1...............................99
Figure 8-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10070006......100
Figure 8-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0040_1. 102
Figure 9-1. Boxplots for Water Quality Station 10570002 by Flow Range. 105
Figure 9-2. Boxplots for Water Quality Station 10570002 by Season. 106
Figure 9-3. Boxplots of Water Quality Station 10570002 by Recreation Season. 106
Figure 9-4. Pollutant Sources for Cedar River Segment IA 02-CED-0030_2............................107
Figure 9-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10570002......108
Figure 10-1. Boxplots for Water Quality Station 10570001 by Flow Range. 113
Figure 10-2. Boxplots for Water Quality Station 10570001 by Season. 114
Figure 10-3. Boxplots of Water Quality Station 10570001 by Recreation Season. 114
Figure 10-4. Pollutant Sources for Cedar River Segment IA 02-CED-0030_1............................115
Figure 10-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10570001......116
Figure 10-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0030_1. 118
Figure 11-1. Boxplots for Water Quality Station 10570001 by Flow Range. 121
Figure 11-2. Boxplots for Water Quality Station 10570001 by Season. 122
Figure 11-3. Boxplots of Water Quality Station 10570001 by Recreation Season. 122
Figure 11-4. Pollutant Sources for Cedar River Segment IA 02-CED-0020_3............................123
Figure 11-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10570001......124
Figure 11-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0020_3. 126
Figure 12-1. Boxplots for Water Quality Station 10160001 by Flow Range. 130
Figure 12-2. Boxplots for Water Quality Station 10160001 by Season. 131
Figure 12-3. Boxplots of Water Quality Station 10160001 by Recreation Season. 131
Figure 12-4. Pollutant Sources for Cedar River Segment IA 02-CED-0020_2............................132
Figure 12-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10160001......133
Figure 12-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0020_2. 135
Figure 13-1. Meteorological Gage Locations Used for Cedar River Watershed Model Simulations in HSPF...139
Figure 13-2. Iowa 2002 Land Use / Land Cover Distribution and Aggregated Model Categories for the Cedar River Watershed (IDNR, 2002). 141
Figure 13-3. Reach Segmentation for the Cedar River Watershed...142
Figure 13-4. Locations of Calibration / Verification Gages for Flow and Water Quality within the Cedar River Watershed. 144

List of Tables

Table ES-1. Applicable *E. coli* bacteria Iowa WQS criteria (organisms per 100 milliliters of water) for Primary Contact Recreational Use, i.e., Class A1 waters. 14
Table ES-2. Cedar River Watershed-scale descriptive *E. coli c*oncentration (cfu/100 ml) statistics by flow and season....17
Table ES-3. *E. coli* TMDLs for the nine impaired waterbody segments in the Cedar River Watershed. 20
Table 1-1. Iowa 2006 303(d) impaired waters for indicator bacteria, *E. coli*, ...26
in the Cedar River Watershed TMDL....26
Table 2-1. Summary of land use above the end point of each TMDL reach segment. 34
Table 2-2. United States Geological Survey streamflow gages within the 38
Cedar River Watershed. 38
Table 3-1. *E. coli* bacteria WQS criteria (organisms per 100 milliliters of water). [IAC 61.3]...39
Table 3-2. Watershed wide descriptive statistics. 47
Table 3-3. Watershed scale descriptive concentration (cfu/100 ml) statistics by flow and season.50
Table 3-4. Cities within the watershed with MS4 permits. 53
Table 4-1. Descriptive statistics for Water Quality Station 10340003....63
Table 4-2. Descriptive statistics for Water Quality Station 10340003 by season. 64
Table 4-3. Departure from load capacity for IA 02-CED-0110_3 by flow regime....68
Table 4-4. HSPF-Predicted departure from load capacity for IA 02-CED-0110_3. 68
Table 4-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_3. 69
Table 4-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load IA 02-CED-0110_3....70
Table 4-7. Flow variable MOS (cfu/day) for daily maximum load and daily median load IA 02-CED-0110_3....70
Table 5-1. Descriptive statistics for Water Quality Station 10340001....71
Table 5-2. Descriptive statistics for Water Quality Station 10340001 by season. 72
Table 5-3. Departure from load capacity for IA 02-CED-0110_2 by flow regime....76
Table 5-4. HSPF-Predicted departure from load capacity for IA 02-CED-0110_2. 76
Table 5-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_2. 78
Table 5-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_2. 78
Table 6-1. Descriptive statistics for Water Quality Station 11340001....79
Table 6-3. Departure from load capacity for IA 02-SHL-0020_1 by flow regime. 84
Table 6-4. HSPF-Predicted departure from load capacity for IA 02-SHL-0020_1....84
Table 6-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-SHL-0020_1. 85
Table 6-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-SHL-0020_1. 86
Table 6-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-SHL-0020_1. 86
Table 7-1. Descriptive statistics for Water Quality Station 10070005....87
Table 7-2. Descriptive statistics for Water Quality Station 10070005 by season. 88
Table 7-3. Departure from load capacity for IA 02-CED-0050-L_0 by flow regime. 92
Table 7-4. HSPF-Predicted departure from load capacity for IA 02-CED-0050-L_0. 92
Table 7-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0050-L_0. 92

Table 7-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0050-L_0. 94
Table 8-1. Descriptive statistics for Water Quality Station 10070006. 96
Table 8-2. Descriptive statistics for Water Quality Station 10070006 by season. 97
Table 8-3. Departure from load capacity for IA 02-CED-0040_1 by flow regime. 101
Table 8-4. HSPF-Predicted departure from load capacity for IA 02-CED-0040_1. 101
Table 8-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0040_1. 101
Table 8-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0040_1. 103
Table 8-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0040_1. 103
Table 9-1. Descriptive statistics for Water Quality Station 10570002. 104
Table 9-2. Descriptive statistics for Water Quality Station 10570002 by season. 105
Table 9-3. Departure from load capacity for IA 02-CED-0030_2 by flow regime. 109
Table 9-4. HSPF-Predicted departure from load capacity for IA 02-CED-0030_2. 109
Table 9-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_2. 109
Table 9-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load . for IA 02-CED-0030_2. 111
Table 9-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_2. 111
Table 10-1. Descriptive statistics for Water Quality Station 10570001. 112
Table 10-2. Descriptive statistics for Water Quality Station 10570001 by season. 113
Table 10-3. Departure from load capacity for IA 02-CED-0030_1 by flow regime. 117
Table 10-4. HSPF-Predicted departure from load capacity for IA 02-CED-0030_1. 117
Table 10-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_1. 117
Table 10-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_1. 119
Table 10-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_1. 119
Table 11-1. Descriptive statistics for Water Quality Station 10570001. 120
Table 11-2. Descriptive statistics for Water Quality Station 10570001 by season. 121
Table 11-3. Departure from load capacity for IA 02-CED-0020_3 by flow regime. 125
Table 11-4. HSPF-Predicted departure from load capacity for IA 02-CED-0020_3. 125
Table 11-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_3. 126
Table 11-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_3. 127
Table 11-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_3. 128
Table 12-1. Descriptive statistics for Water Quality Station 10160001. 129
Table 12-2. Descriptive statistics for Water Quality Station 10160001 by season. 130
Table 12-3. Departure from load capacity for IA 02-CED-0020_2 by flow regime. 134
Table 12-4. HSPF-Predicted departure from load capacity for IA 02-CED-0020_2. 134
Table 12-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_2. 135
Table 12-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_2. 136

Table 12-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_2. 136
Table 13-1. Meteorological gages used for model simulations within HSPF. 138
Table 13-2. USGS flow gages used for HSPF hydrologic calibration/verification in the Cedar River Watershed TMDL (1902 – 2006). 143
Table 13-3. USGS Water Quality Gages used for water quality calibration/verification by reach in the .... Cedar River Watershed HSPF model. 143
Table 13-4. General calibration/verification targets or tolerances for HSPF applications. 145
Table 13-5. Average and average annual mean error (%) for monthly runoff (inches) at 14 calibration/verification USGS gages used in the Cedar River Watershed HSPF model. 146
Table 13-6. Summary of mean monthy errors (%) for runoff (inches) for the 14 calibration/verification USGS gages by flow range. 147

Executive Summary

The Federal Clean Water Act (CWA) requires a Total Maximum Daily Load (TMDL) be developed for waters that are identified in Category 5 of Iowa's 2006 Integrated Report (303d list) as impaired by a pollutant. Eight segments of the Cedar River and one segment of Shell Rock River were identified as having their Primary Contact Recreation Class A1 (Class A1) use impaired by the bacteria indicator *Escherichia coli* (*E. coli)*. TMDLs were determined for the nine segments. The purpose of these TMDLs is to calculate the maximum allowable pathogen loads for the impaired segments within the Cedar River Watershed that will allow the river to meet Iowa water quality standards (WQS). Based on a review of the flow and water quality data available throughout the watershed, it was determined that bacterial concentrations were primarily a function of flow. U. S. Environmental Protection Agency (EPA) recommends using a flow variable expression for the TMDL when critical conditions are associated with precipitation/runoff events and sources include multiple-source types (EPA, 2007a). Thus, a flow-variable daily load was selected to represent these TMDLs.

In 2003, Iowa's WQS and methodology for assessing indicator bacteria were changed. As of July 2003, *E. coli* is now the indicator bacterium (Iowa Administrative Code (IAC) Chapter 61.3(3)(1). According to IAC Chapter 61.3(1)b, all perennial rivers and streams, as identified by the U. S. Geological Survey (USGS) 1:100,000 Digital Line Graph Hydrography Data Map (published July 1993), or intermittent streams with perennial pools in Iowa, are designated as Class A1 waters (Appendix B). While this is the presumptive use, individual streams within the greater watershed may have different uses as a result of an EPA approved use attainability analysis (UAA).

Based on the change in WQS and the available data, it makes sense to use a watershed approach in developing the nine TMDLs and a watershed implementation plan. A proactive and holistic approach in this watershed implementation plan will potentially eliminate the need for additional TMDLs in the Iowa portion of the watershed. *During preparation of this TMDL, the contractor included an implementation plan. EPA does not include implementation plans in EPA established TMDLs. EPA also does not approve implementation plans in state submittals, but encourages the states to include them in their TMDLs. The implementation plan included in this TMDL is for informational purposes only and should not be considered a part of the EPA established TMDL.*

Cedar River Watershed Description

The Cedar River Watershed is approximately 7,830 square miles and located in eastern Iowa and southeastern Minnesota. Approximately 87 percent of the watershed is located in Iowa (Figure ES-1). There are 30 counties in the watershed, with the origin of the watershed located in Dodge County, Minnesota. The Cedar River flows generally south for approximately 335 miles to the confluence with the Iowa River near Columbus Junction, Iowa. The Iowa River then flows into the Mississippi River. The major tributaries are the Little Cedar River, Winnebago River, Shell Rock River, Beaverdam Creek, West Fork Cedar River, Beaver Creek, Blackhawk Creek, Wolf Creek, and Prairie Creek. The area upstream from the southernmost impaired stream segment endpoint is 7,060 square miles or about 90 percent of the Cedar River Watershed.

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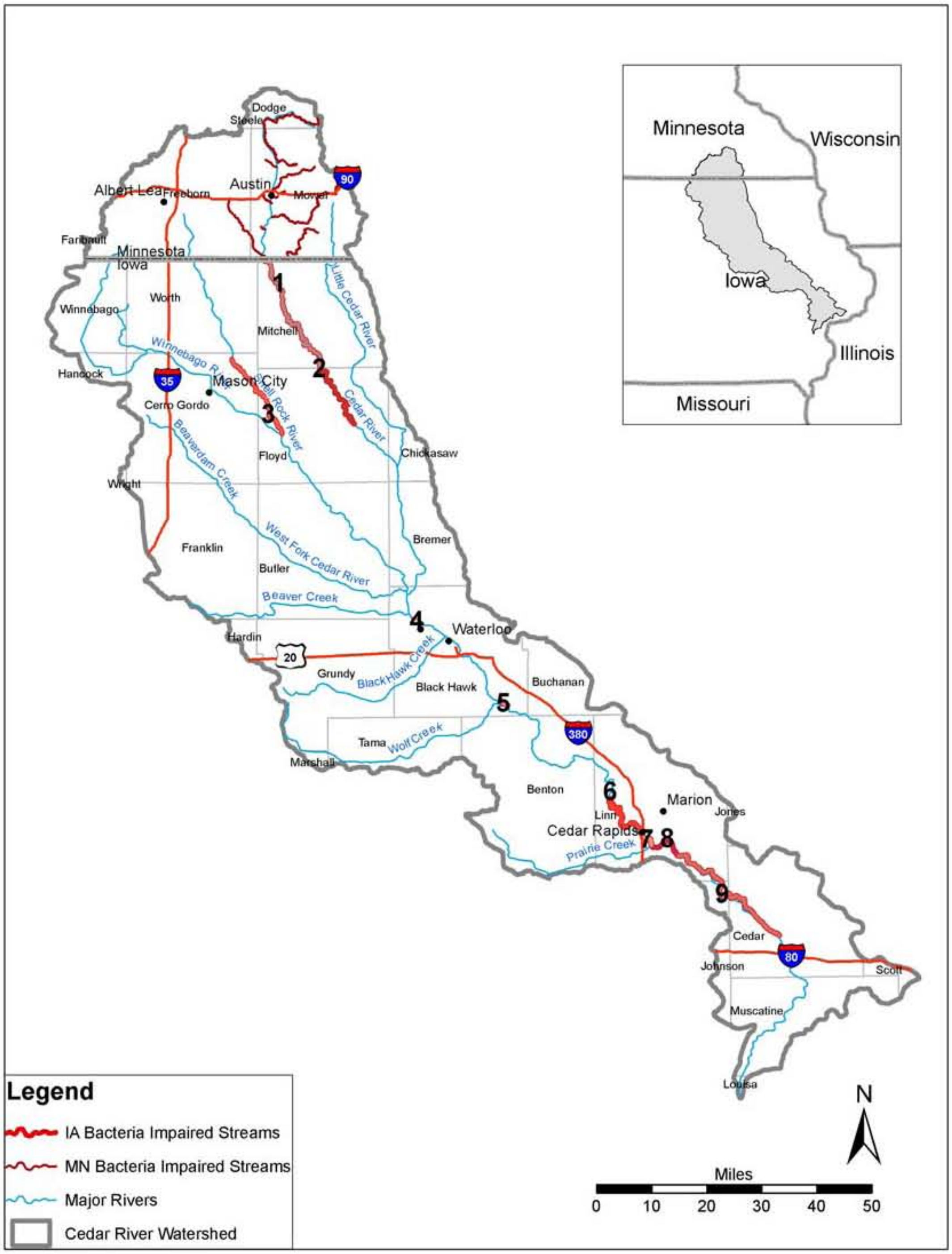

Figure ES-1. Location Map of the Cedar River Watershed and CWA 303(d) Impaired Waterbodies in Iowa and Minnesota.

Iowa *E. coli* Bacteria Water Quality Standards

The Iowa Department of Natural Resources (IDNR) 2006 Integrated Report (IDNR, 2007b), Category 5 (303d list), identified nine segments within the Cedar River Watershed as either "not supporting" or "partially supporting" their Primary Contact Recreation Class A1 designated use based upon results of monitoring from 2002 to 2004 for indicator bacteria (Figure ES-2, Appendix C). The Class A1 uses are not supported because of high levels of indicator bacteria that violate the applicable WQS for Class A1 waters. The applicable WQS for Class A1 waters (IAC, 2006a) is listed in Table ES-1.

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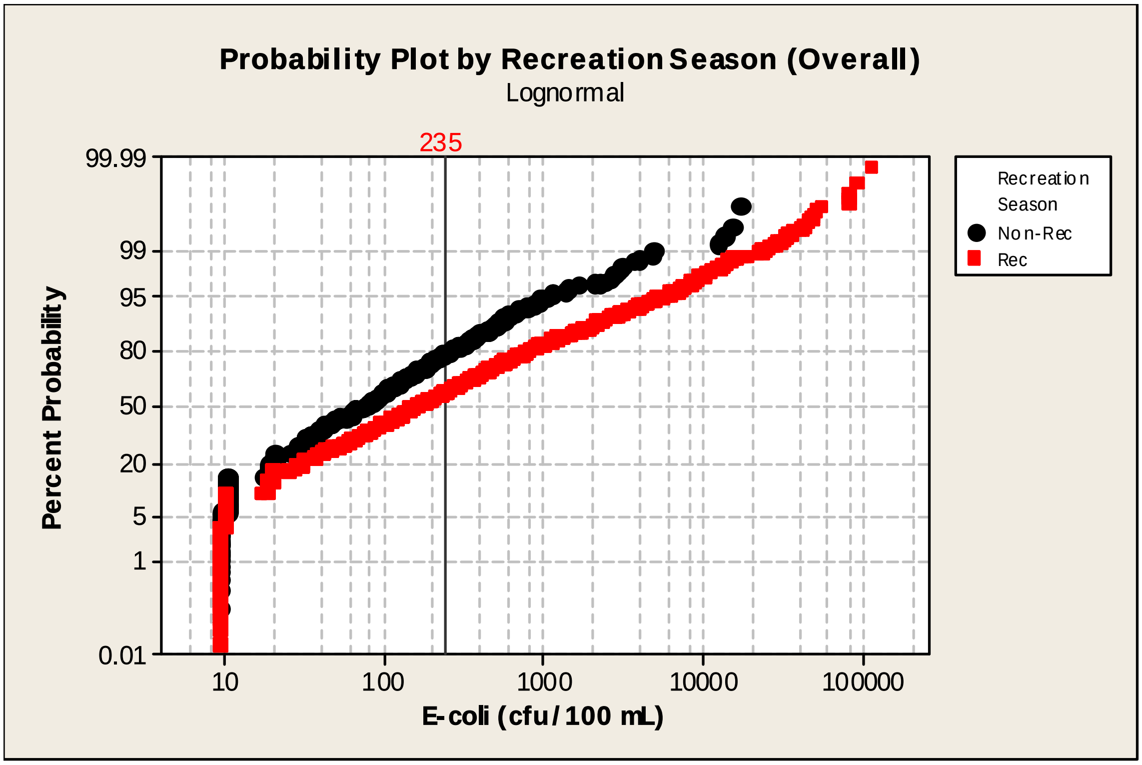

Figure ES-2. Percent of Watershed-Wide Data Exceeding the Iowa WQS of 235 Colony-Forming Units/100 Milliliters Geometric Mean.

Table ES-1. Applicable *E. coli* bacteria Iowa WQS criteria (organisms per 100 milliliters of water) for Primary Contact Recreational Use, i.e., Class A1 waters.

Use	Geometric mean	Sample maximum
Class A1		
3/15 - 11/15	126	235
11/16 - 3/14	Does not apply	Does not apply

All of the waterbodies listed on the EPA approved Category 5 of the 2004 Integrated Report were included on Category 5 of the 2006 Integrated Report with the exception of Black Hawk Creek. The Black Hawk Creek TMDL was developed by IDNR and approved by EPA on November 9, 2006.

The definition of Primary Contact Recreational Class A1 water in IAC 61.3(1)b(1) (IAC, 2006a) states:

> "Primary contact recreational use (Class "A1"). Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk or ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing and water contact recreational canoeing."

The applicable *E. coli* criteria for Class A1 waters, IAC 61.3(3)a(1) (IAC, 2006a) are listed in Table ES-1.

E. coli Bacteria Data

Bacteria data have historically been collected by several agencies within the watershed. These data are stored within the EPA's **Storage and Retrieval** (**STORET**) system. There are 57 ambient monitoring sites and 86 snapshot monitoring sites within the Cedar River Watershed with collectively over 5,000 *E. coli* and fecal coliform bacteria samples. IDNR provided paired *E. coli* and fecal coliform bacteria data for approximately 6,310 samples taken throughout the state to develop a translator from fecal coliform bacteria to *E. coli* (Appendix C). Since *E. coli* is a subset of fecal coliform bacteria, the ratio of the two indicator bacteria typically does not exceed one. Most frequently, *E. coli* concentrations are within 0.8 to 1.0 times the fecal coliform bacteria concentrations. Using a statewide comparison of sampling events when both indicator bacteria were measured, multiplying the fecal coliform bacteria concentration by 0.92 was found to be appropriate for estimating *E. coli* concentrations in the Cedar River Watershed ($R^2 = 0.92$) (Black Hawk Creek TMDL, IDNR 2006a). An analysis of these data indicate that approximately 50 percent of the samples taken during the recreational season in the Cedar River Watershed on perennial streams exceed 235 *E. coli* colony-forming units per 100 milliliters (cfu/100 ml) (Figure ES-2).

Figure ES-3 presents boxplots (Appendix A) of *E. coli* concentration data grouped by flow range (high, mid, and low) recorded at the time of sampling for 17 USGS gages where flow and water quality were concurrently collected. From these plots, it is evident that there are exceedances for all flow ranges; however, there is a clear trend of more exceedances occurring during larger flows with precipitation runoff events. This trend indicates indirect or nonpoint sources are a predominant cause of exceedances within the watershed. However, exceedances at lower-range flows are also prevalent and are likely caused by direct sources, such as wastewater treatment plants (WWTP) not using disinfection practices. Approximately 40 percent of the 130 WWTPs above TMDL Reach 9 in Figure ES-1 do not use disinfection during the recreational season. Table ES-2 summarizes the median concentrations measured by flow regime and season.

Cedar River Watershed Model

A comprehensive inventory of all potential bacteria sources within the Cedar River Watershed was conducted. EPA's **Bacterial Indicator Tool** (**BIT**) (EPA, 2000) was used in conjunction with the EPA's **Hydrological Simulation Program-FORTRAN** (**HSPF**) (Bicknell, et. al., 2001) to estimate pollutant source loading. **BIT** was used to estimate rates of bacterial loading by source; **HSPF** was then used to predict the hydrologic response, transport, and fate of bacteria from these sources under existing and alternative management conditions. **HSPF**-predicted flows were also used to supplement the available flow data for load duration curve (LDC) (Appendix A) development and source assessment at TMDL reach endpoints. MathWorks **MATLAB®** program was used to analyze the immense amount of model results and data. This included LDC development, departure performance and critical condition analysis, TMDL calculation, and the predicted impact of alternative scenario analysis. **MATLAB®** was also used to assist in **HSPF** model calibration as is discussed in the TMDL Workplan (RESPEC, 2007) and Chapter 13 and Appendix F of this TMDL. The framework developed is highly flexible and reusable. Figure ES-4 presents a schematic of the framework.

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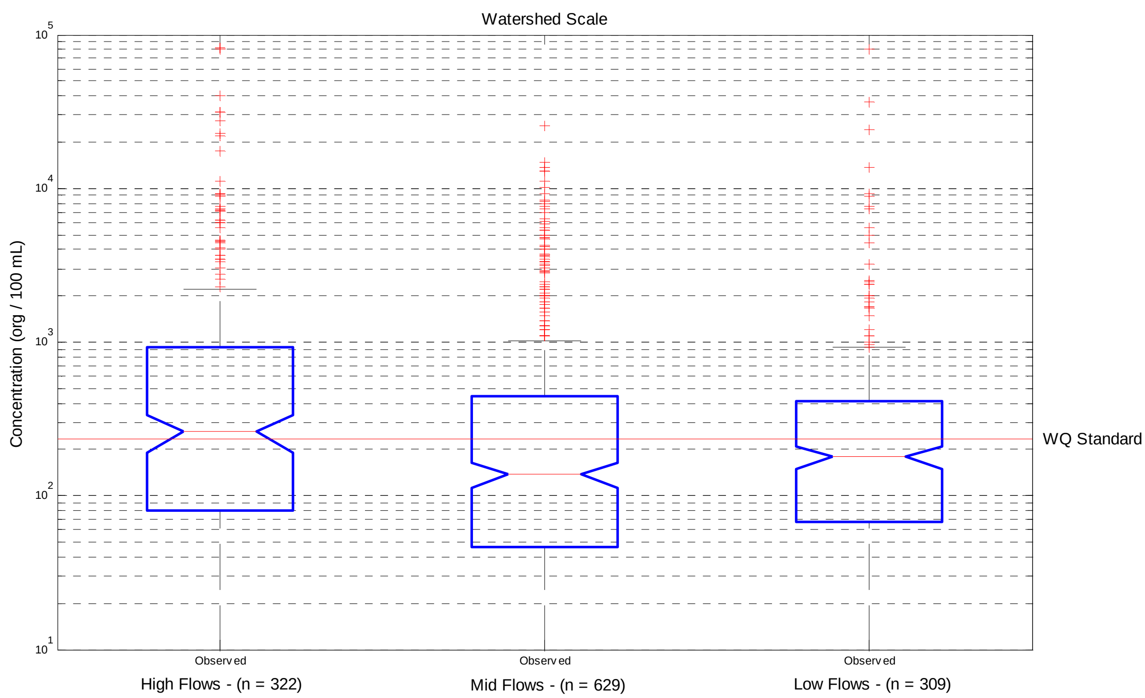

Figure ES-3. Boxplots for Cedar River Watershed Wide Concentrations of *E. coli* by Flow Range Compared to the Geometric Mean Iowa WQS for *E. coli* of 235 Organisms/100 ml Water.

Table ES-2. Cedar River Watershed-scale descriptive *E. coli* concentration (cfu/100 ml) statistics by flow and season.

Season	Statistical Metric	Low flow	Mid flow	High flow	All flows
Spring	Median (cfu/100 ml)	9	55	320	180
	Number of Samples (n)	8	206	252	466
Summer	Median (cfu/100 ml)	135	197	890	240
	Number of Samples (n)	74	276	125	475
Fall	Median (cfu/100 ml)	60	129	810	100
	Number of Samples (n)	127	171	21	319
Winter	Median (cfu/100 ml)	18	20	70	28
	Number of Samples (n)	33	64	13	110
All seasons	Median (cfu/100 ml)	74	129	432	150
	Number of Samples (n)	242	717	411	1,370

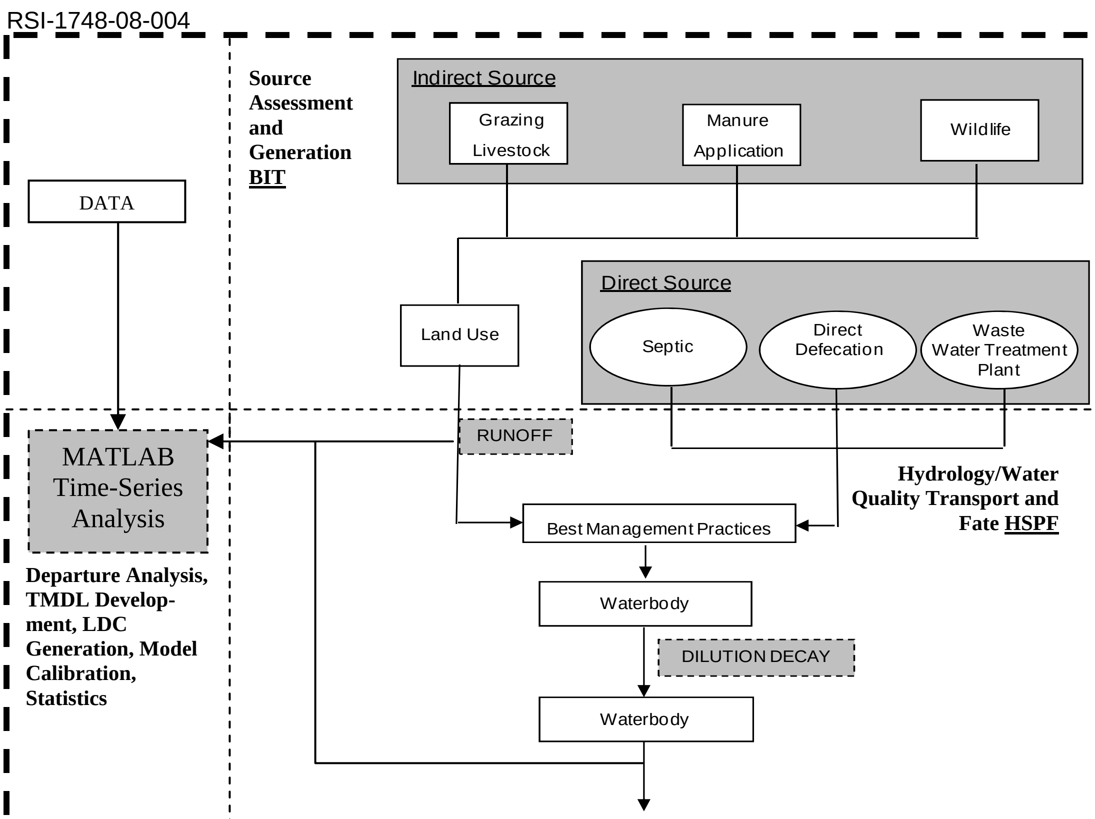

Figure ES-4. Model Framework Developed for the Comprehensive Inventory of Potential Bacteria Sources within the Cedar River Watershed.

The focus of the Cedar River Watershed Model (CRWM) was to analyze the watershed as a whole with sufficient detail to establish localized waste load allocations (WLA), load allocations (LA), and TMDLs for each of the impaired segments. The watershed model was also used to analyze water quality conditions in all of the major perennial streams throughout the watershed. The model provided predictions of the existing and future water quality conditions in these perennial streams. The predictions for future conditions gave insight into the effectiveness of various alternative best management practices (BMP) in mitigating impairments.

As previously mentioned, the watershed modeling package selected for this project was **HSPF**. **HSPF** is a comprehensive, continuous, long-term, watershed model of hydrology and water quality that includes modeling land surface and subsurface hydrologic and water quality processes that are linked and closely integrated with corresponding stream and reservoir processes. It is considered a premier, high-level model among those currently available for comprehensive watershed assessments. **HSPF** has enjoyed widespread usage and acceptance since its initial release in 1980 as demonstrated through hundreds of applications across the United States and abroad. **HSPF** is jointly supported and maintained by both the EPA and the USGS. In addition, **HSPF** is the primary watershed model included in the EPA's **Better Assessment Science Integrating Point and Nonpoint Sources** (**BASINS**) modeling system (http://www.epa.gov/waterscience/basins/) and was recently incorporated into the U.S. Army Corps of Engineers (Corps) **Watershed Modeling System** (**WMS**) (http://chl.erdc.usace.army.mil/wms). The wide use and support has helped ensure the continuing availability and maintenance of the code for more than two decades, in spite of varying federal priorities and budget restrictions. **HSPF** is used extensively to develop bacteria TMDLs.

HSPF divides streams in a modeled watershed into defined reaches (for a more expansive explanation of the model see Chapter 13). Based on modeling all 126 reaches defined in the Cedar River Watershed were predicted to have exceedances occurring more than 10 percent of the time under existing conditions. The Iowa portion of the watershed has 105 reaches of which 91 had exceedances occurring more than 20 percent of the time. These results are within reason based on the fact that the median exceedance rate for the 57 water quality monitoring stations analyzed within the watershed was 56 percent.

E. coli TMDLs

A combination of the LDC modeling approach and dynamic watershed model (**HSPF**) was used to develop flow-variable daily TMDL expressions. The LDC method involves the development of a flow duration curve or a representation of the percentage of days when a given instream flow is equaled or exceeded and a flow specific load which will meet WQS. Figure ES-5 shows an example of a LDC developed using **MATLAB®** at the lower boundary of an impaired segment (TMDL endpoint). A lower percentile rank of flow indicates periods of flow that rarely occur and typically represent high flow periods (precipitation runoff events), whereas a high percentile rank of flow indicates periods when flow is exceeded most of the time (low flow periods). The allowable pollutant load curve (solid blue line in Figure ES-5) was calculated using the flow duration curve and multiplying the flow values by the applicable TMDL concentration target. The curve represents a dynamic expression of the allowable daily load as a function of the measured flow for the respective day. This allowable load includes the sum of the LA, WLA, and margin of safety (MOS).

For this TMDL, flow percentiles are grouped into quartiles, and for each flow quartile a daily maximum load and daily average load were identified as daily load expressions. This effectively sets loads that can occur for each of the four flow ranges which will result in compliance with the

WQS. The daily maximum load uses the single sample maximum criterion of 235 *E. coli* cfu/100 ml while the daily average represents the desired persistent loading conditions and uses the geometric mean criterion of 126 *E. coli* cfu/100 ml (IAC 61.3(3)a(1)). Table ES-3 presents the resulting TMDL calculations for each of the nine impaired segments. The TMDLs presented in Table ES-3 include a MOS. The MOS was set explicitly at 35 cfu×flow for the daily maximum and 19 cfu×flow for the median loads, or 15 percent when expressed as a percentage of the TMDL. This explicit MOS is used to account for uncertainties in modeled loads.

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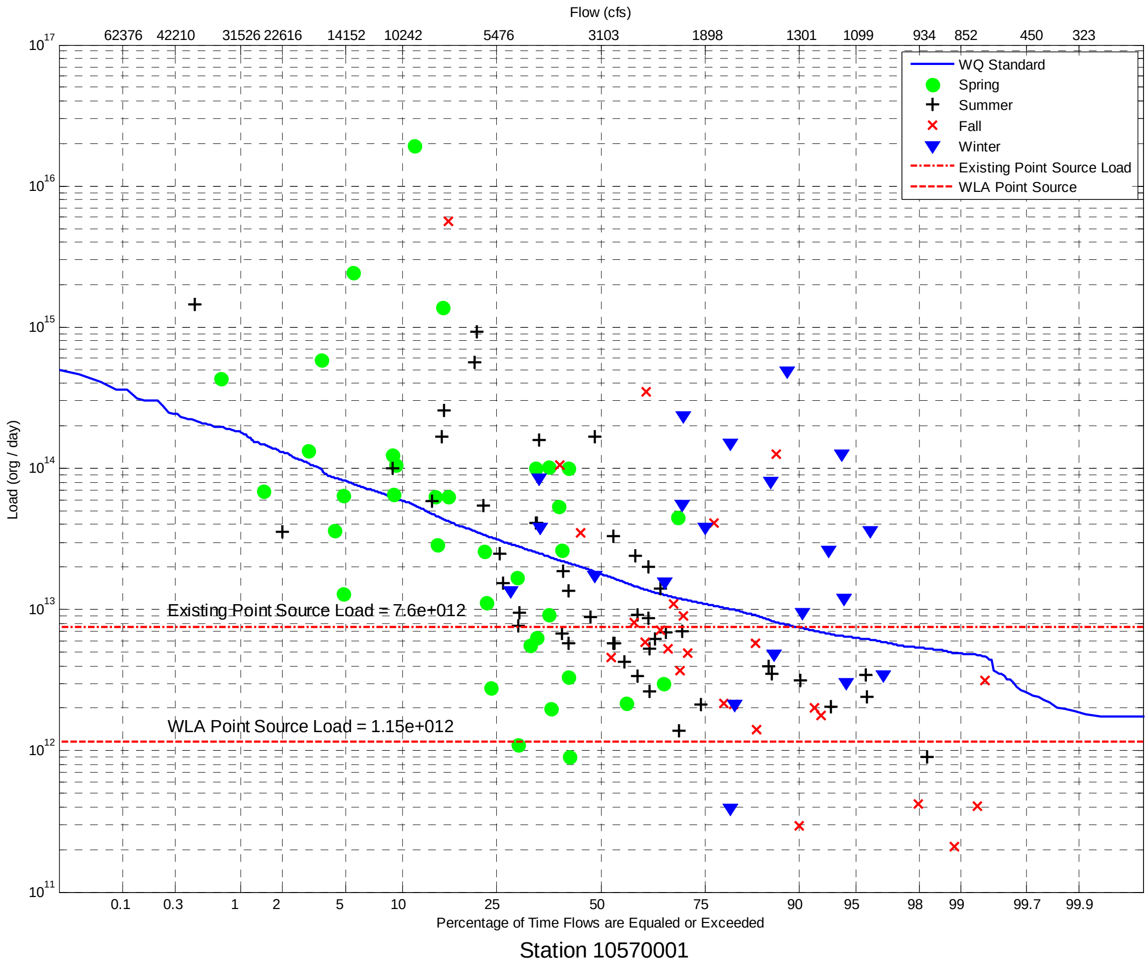

Figure ES-5. Load Duration Curve for *E. coli* Measured at Station 10570001.

The observed pollutant load in the river for a local sampling point is plotted on the LDC to show the departure or lack there of from Iowa WQS for existing conditions of *E. coli* concentrations. The points that fall above the allowable load curve indicate exceedances of WQS while the points that fall below the curve indicate loads that meet *E. coli* WQS. The observed pollutant loads are also symbolized by season to provide a temporal aspect to the analysis. Using this curve, departure statistics by flow range and season were calculated. Calibrated **HSPF**-predicted flows were used for the LDCs when measured flows were not concurrently collected with water quality samples or not available at a TMDL endpoint.

Table ES-3. *E. coli* TMDLs for the nine impaired waterbody segments in the Cedar River Watershed.

***E. coli* Load (cfu/day at TMDL endpoint)**	**Flow Quartiles (low to high flows)**			
	<25	25–50	50–75	>75
Cedar River from Rock Creek to Iowa/Minnesota Border TMDL Reach IA 02-CED-0110_3				
Daily median				
WLA	3.93E+10			
LA	3.88E+11	8.12E+11	1.40E+12	3.15E+12
MOS	7.45E+10	1.50E+11	2.54E+11	5.62E+11
TMDL	5.02E+11	1.00E+12	1.70E+12	3.75E+12
Daily maximum				
WLA	3.93E+10			
LA	1.09E+12	1.95E+12	3.45E+12	2.46E+13
MOS	1.99E+11	3.52E+11	6.16E+11	4.34E+12
TMDL	1.33E+12	2.35E+12	4.11E+12	2.89E+13
Cedar River from Charles City Dam No. 2 to Confluence With Rock Creek TMDL Reach IA 02-CED-0110_2				
Daily median				
WLA	6.72E+10			
LA	4.49E+11	9.36E+11	1.63E+12	3.63E+12
MOS	9.11E+10	1.77E+11	2.99E+11	6.52E+11
TMDL	6.07E+11	1.18E+12	1.99E+12	4.35E+12
Daily maximum				
WLA	6.72E+10			
LA	1.27E+12	2.26E+12	4.04E+12	2.76E+13
MOS	2.36E+11	4.11E+11	7.25E+11	4.88E+12
TMDL	1.58E+12	2.74E+12	4.84E+12	3.25E+13
Shell Rock River from Confluence With the Winnebago River to Confluence With Rose Creek TMDL Reach IA 02-SHL-0020_1				
Daily median				
WLA	4.67E+10			
LA	1.76E+11	4.30E+11	7.45E+11	1.72E+12
MOS	3.93E+10	8.42E+10	1.40E+11	3.12E+11
TMDL	2.62E+11	5.61E+11	9.31E+11	2.08E+12
Daily maximum				
WLA	4.67E+10			
LA	5.45E+11	1.06E+12	1.89E+12	1.37E+13
MOS	1.04E+11	1.95E+11	3.42E+11	2.43E+12
TMDL	**6.96E+11**	**1.30E+12**	**2.28E+12**	**1.62E+13**

Cedar River ***from the Dam of Cedar Falls Impoundment to the Upper End of the Impoundment*** ***TMDL Reach IA 02_CED-0050-L_0***				
Daily median				
WLA	2.90E+11	2.92E+11	2.96E+11	3.10E+11
LA	1.76E+12	3.69E+12	6.73E+12	1.59E+13
MOS	3.62E+11	7.02E+11	1.24E+12	2.86E+12
TMDL	2.41E+12	4.68E+12	8.26E+13	1.91E+13
Daily maximum				
WLA	2.90E+11	2.92E11	2.96E+11	3.10E+11
LA	5.13E+12	9.29E+12	1.73E+13	1.06E+14
MOS	9.56E+11	1.69E+12	3.10E+12	1.88E+13
TMDL	6.38E+12	1.13E+13	2.06E+13	1.26E+14
Cedar River ***from Wolf Creek to Bridge Crossing in LaPorte City*** ***TMDL Reach IA 02-CED-0040_1***				
Daily median				
WLA	6.72E+11			
LA	1.84E+12	3.96E+12	7.34E+12	1.73E+13
MOS	4.44E+11	8.17E+11	1.41E+12	3.18E+12
TMDL	2.96E+12	5.45E+12	9.43E+12	2.12E+13
Daily maximum				
WLA	6.72E+11			
LA	5.77E+12	1.04E+13	1.92E+13	1.14E+14
MOS	1.14E+12	1.96E+12	3.51E+12	2.02E+13
TMDL	7.58E+12	1.30E+13	2.34E+13	1.35E+14
Cedar River ***from McCloud Run to Confluence With Bear Creek*** ***TMDL Reach IA 02-CED-0030_2***				
Daily median				
WLA	6.60E+11	6.68E+11	6.82E+11	7.32E+11
LA	2.53E+12	4.84E+12	9.04E+12	2.10E+13
MOS	5.64E+11	9.73E+11	1.72E+12	3.83E+12
TMDL	3.76E+12	6.49E+12	1.14E+13	2.55E+13
Daily maximum				
WLA	6.60E+11	6.68E+11	6.82E+11	7.32E+11
LA	7.39E+12	1.28E+13	2.32E+13	1.28E+14
MOS	1.42E+12	2.37E+12	4.21E+12	2.28E+13
TMDL	**9.48E+12**	**1.58E+13**	**2.81E+13**	**1.52E+14**

Cedar River from Prairie Creek to Confluence With McCloud Run TMDL Reach IA 02-CED-0030_1				
Daily median				
WLA	6.74E+11	6.92E+11	7.28E+11	8.91E+12
LA	2.65E+12	5.08E+12	9.40E+12	2.17E+13
MOS	5.87E+11	1.02E+12	1.79E+12	3.99E+12
TMDL	3.92E+12	6.78E+12	1.19E+13	2.66E+13
Daily maximum				
WLA	6.74E+11	6.92E+11	7.28E+11	8.91E+12
LA	7.79E+12	1.33E+13	2.41E+13	1.30E+14
MOS	1.49E+12	2.48E+12	4.38E+12	2.32E+13
TMDL	9.95E+12	1.65E+13	2.92E+13	1.54E+14
Cedar River from Highway 30 Bridge at Cedar Rapids to Confluence With Prairie Creek TMDL Reach IA 02-CED-0020_3				
Daily median				
WLA	1.20E+12	1.25E+12	1.34E+12	1.60E+12
LA	2.45E+12	4.90E+12	9.27E+12	2.18E+13
MOS	6.44E+11	1.09E+12	1.87E+12	4.13E+12
TMDL	4.29E+12	7.24E+12	1.25E+13	2.75E+13
Daily maximum				
WLA	1.20E+12	1.25E+12	1.34E+12	1.60E+12
LA	7.92E+12	1.35E+13	2.43E+13	1.31E+14
MOS	1.61E+12	2.61E12	4.52E+12	2.33E+13
TMDL	1.07E+13	1.74E+13	3.02E+13	1.56E+14
Cedar River from Rock Run Creek to Highway 30 Bridge at Cedar Rapids TMDL Reach IA 02-CED-0020_2				
Daily median				
WLA	1.15E+12			
LA	2.75E+12	5.33E+12	1.01E+13	2.32E+13
MOS	6.88E+11	1.14E+12	1.98E+12	4.30E+12
TMDL	4.59E+12	7.62E+12	1.32E+13	2.87E+13
Daily maximum				
WLA	1.15E+12			
LA	8.51E+12	1.44E+13	2.58E+13	1.36E+14
MOS	1.71E12	2.74E+12	4.75E+12	2.42E+13
TMDL	1.14E+13	1.83E+13	3.17E+13	1.61E+14

(a) Waste Load Allocation (WLA) expressed as daily maximum load for daily median and daily maximum flow conditions to account for critical conditions of low flow.
(b) Load Allocation (LA).

The estimated WLA component of the TMDL delivered to a TMDL reach endpoint is also shown on the LDCs for existing and post-TMDL implementation conditions. The TMDL endpoint is the downstream end of an impaired waterbody segment. The **HSPF** application for the Cedar River Watershed was used to estimate the WLA that was delivered to each TMDL endpoint by limiting the sources of bacteria within the model application to the WLA sources (e.g., National Pollutant Discharge Elimination System (NPDES) facility loads) and allowing the model to predict the transport and fate of these loads. The daily load shown on the plots represents the waste load predicted to be delivered to the TMDL endpoint. The WLA is expressed as a static, flow-independent load for existing permits plus reserve allocations for future growth, based on the population of unsewered communities by segment. This expression is consistent with the nature and limited variability of point sources.

In addition, for Segments 02-CED-0050_0, 02-CED-0030_2, 02-CED-0030_1, and 02-CED-0020_3 that contain Municipal Separate Storm Sewer Systems (MS4), Table ES-3 includes WLAs by quartile of flow. These WLAs take into account a numerical WLA for stormwater discharge based on runoff volume for the MS4 area estimated by the HSPF application. For example, the endpoint shown in Figure ES-5 shows a WLA calculated to be 1.15E+12 *E. coli* cfu/day. The existing point source load is 7.60E+12 *E. coli* cfu/day. To obtain the WLA, the existing point source load needs to be reduced by 85 percent. Table ES-3 presents the sum of WLA calculations for each of the nine impaired waterbody segments.

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad \text{(ES-1)}$$

The TMDL LA is illustrated graphically in Figure ES-5 as the region between the red WLA line and the solid blue line representing the daily maximum *E. coli* bacteria load at 235 *E. coli* cfu/100 ml. Table ES-3 presents the daily maximum LA and the allowable daily median LA for each of the quartile flow categories.

Informational Implementation Plan

During preparation of this TMDL, the contractor included an implementation plan. EPA does not include implementation plans in EPA established TMDLs. EPA also does not approve implementation plans in state submittals, but encourages the states to include them in their TMDLs. The implementation plan included in this TMDL is for informational purposes only and should not be considered a part of the EPA established TMDL.

The **HSPF** application developed for this TMDL provides the ideal framework to evaluate existing conditions in the perennial streams and to evaluate the impact various implementation plans would likely have in achieving WQS in these streams. The relative contribution to pollution during the recreational season of all stressors (e.g., cropland, open feedlots, and septic systems) included within the **HSPF** model application can also be summarized to guide the implementation process.

The BMPs listed below represent four management practices thought to be highly effective at improving water quality conditions within the Cedar River Watershed and in achieving the TMDLs stated in this document:

1. All WWTP effluent and rivers entering Iowa will have bacteria concentrations less than or equal to the Iowa WQS.
2. Unpermitted feedlots will control/capture the first one-half inch of rain.
3. Cropland bacteria loading will be reduced by 40 percent through proper timing and application of animal waste.
4. Cattle in streams will be reduced by 40 percent and leaking septic systems will be eliminated.

Each scenario was sequentially added to the base management scenario to determine cumulative reductions achieved for each perennial reach represented in the model. Scenario 2 (unpermitted feedlots will control/capture the first one-half inch of rain) resulted in significant loading reductions across the watershed. This is not surprising since open feedlots were consistently the largest predicted stressor for each of these reaches, and capturing the first one-half inch of rain from runoff can result in high pollutant removal efficiencies. It would seem that the cost-versus-benefit gained from implementing a form of Scenarios 1 and 2 would be a logical first step in achieving WQS in this watershed. Scenarios 3 and 4 do provide extra benefit to this watershed but the reductions are not as significant as Scenarios 1 and 2. Based on model predictions, it is clear the TMDLs established in this document are feasible and water quality conditions throughout the watershed can come into compliance with *E. coli* WQS through technically feasible BMPs. Additional cost benefit analysis and review of the model results will allow the development of a more focused and phased implementation plan.

1. Introduction

The Federal CWA requires that a TMDL be completed for waters that were identified on the state of Iowa's 303(d) list as impaired by a pollutant. Eight segments of the Cedar River and one segment of Shell Rock River were identified as impaired by the bacteria indicator *E. coli* (Table 1-1, Figure 1-1). TMDLs were determined for the nine segments. The purpose of the TMDLs is to calculate the maximum allowable pathogen loading for the impaired segments within the Cedar River Watershed that will result in meeting WQS.

This TMDL was prepared in compliance with the current regulations for TMDL development that were promulgated in 1992 as 40 CFR Part 130.7 in compliance with the CWA. These regulations and consequent TMDL development are summarized below.

1.1. Name and geographic location of the impaired or threatened waterbody(ies) for which the TMDL is being established.

Eight segments of the Cedar River and one segment of the Shell Rock River are impaired for pathogen indicator *E. coli*. The impaired segments on the Cedar River are: two continuous Segments IA 02-CED-0110_2 and IA 02-CED-0110_3 in Floyd and Mitchell Counties; Segments IA-02-CED-0040_1 and IA 02-CED-0050-L_0 in Black Hawk County; and four continuous Segments IA 02-CED-0020_2, IA 02-CED-0020_3, IA 02-CED-0030_1 and IA 02-CED-0030_2 in Cedar, Johnson, and Linn Counties. One impaired segment of the Shell Rock River, IA 02-SHL-0020_1, is in Floyd and Cerro Gordo Counties.

1.2. Identification of the pollutant and applicable water quality standards.

The identified segments are impaired by pathogen indicator *E. coli* for primary contact recreation (Class A1). These segments were assessed as either "not supporting" or "partially supporting" because of levels of indicator bacteria that exceed the state criteria. The applicable WQS for indicator bacteria *E. coli* are a seasonal geometric mean of 126 cfu/100 ml of water and a single maximum value of 235 cfu/100 ml (IAC Chapter 61.3(3)(1)). These WQS are applied to surface water during the recreation season, which is from March 15 to November 15. All segments are also designated for warm water aquatic life Type 1 (Class B (WW-1)), and fish consumption (HH) (Appendix B). In addition, segment 02-CED-0030_2 is designated for drinking water supply (Class C) and segment 02-CED-0020_2 is designated as high quality water (Class HQR) (Appendix B).

1.3. Quantification of the pollutant load that may be present in the waterbody and still allow attainment and maintenance of water quality standards.

The maximum allowable load for indicator bacteria *E. coli* is the single-sample maximum concentration of 235 cfu/100 ml times the flow rate. Based on a review of the flow and water quality data available throughout the watershed, it was determined that bacterial concentrations were primarily a function of flow. EPA recommends using a flow variable expression for the TMDL when critical conditions are associated with precipitation/runoff events and sources include multiple-source types (EPA, 2007a).

Table 1-1. Iowa 2006 303(d) impaired waters for indicator bacteria, *E. coli*, in the Cedar River Watershed TMDL.

Figure ID[(a)]	Waterbodies ID	Waterbody name	Location description	Segment length (miles)	Designated use
1	IA 02-CED-0110_3	Cedar River	from Rock Cr. near Orchard (S24, T97N, R17W, Floyd Co.) to Iowa/Minnesota state line (S8, T100N, R18W, Mitchell Co.)	30.2	Not supporting primary contact recreation (A1)
2	IA 02-CED-0110_2	Cedar River	from Charles City Dam No. 2 (NW 1/4, NE 1/4, S12, T95N, R16W, Floyd Co.) to confluence with Rock Cr. (S24, T97N, R17W, Floyd Co.)	19	Not supporting primary contact recreation (A1)
3	IA 02-SHL-0020_1	Shell Rock River	from confluence with the Winnebago River (Floyd Co.) to confluence with Rose Cr. (NW 1/4, S8, T97N, R18W, Cerro Gordo Co.)	21.8	Partially supporting primary contact recreation (A1)
4	IA 02_CED-0050-L_0[(b)]	Cedar River (Cedar Falls Impoundment)	from dam of Cedar Falls Impoundment (NW 1/4, S12, T89N, R14W, Black Hawk Co.) to upper end of impoundment (W line, S2, T89N, R14W, Black Hawk Co.)	1.5	Partially supporting primary contact recreation (A1)
5	IA 02-CED-0040_1[(b)]	Cedar River	from Wolf Cr. (NE 1/4, S29, T87N, R11W, Black Hawk Co.) to bridge crossing in LaPorte City (S19, T87N, R11W, Black Hawk Co.)	1.4	Partially supporting primary contact recreation (A1)
6	IA 02-CED-0030_2	Cedar River	from confluence with McCloud Run (SW 1/4, S16, T83N, R7W, Linn Co.) to confluence with Bear Cr. (NE 1/4, S21, T84N, R8W, Linn Co.)	11.6	Partially supporting primary contact recreation (A1)
7	IA 02-CED-0030_1[(b)]	Cedar River	from Prairie Cr. (SE 1/4, S34, T83N, R7W, Linn Co.) to confluence with McCloud Run (SW 1/4, S16, T83N, R7W, Linn Co.)	4.5	Not supporting primary contact recreation (A1)
8	IA 02-CED-0020_3[(b)]	Cedar River	from Hwy 30 bridge at Cedar Rapids (S9, T82N, R6W, Linn Co) to confluence with Prairie Cr. (SE 1/4, S34, T83N, R7W, Linn Co.)	6.8	Not supporting primary contact recreation (A1)
9	IA 02-CED-0020_2[(b)]	Cedar River	from Rock Run Cr. (S28, T80N,R3W, Cedar Co) to Hwy 30 bridge at Cedar Rapids(S9, T82N, R6W, Linn Co.)	30.3	Not supporting primary contact recreation (A1)

(a) Figure ID number is used to reference impaired stream segments in Figure 1-1.
(b) Included on approved 2004 Section 303(d) list.

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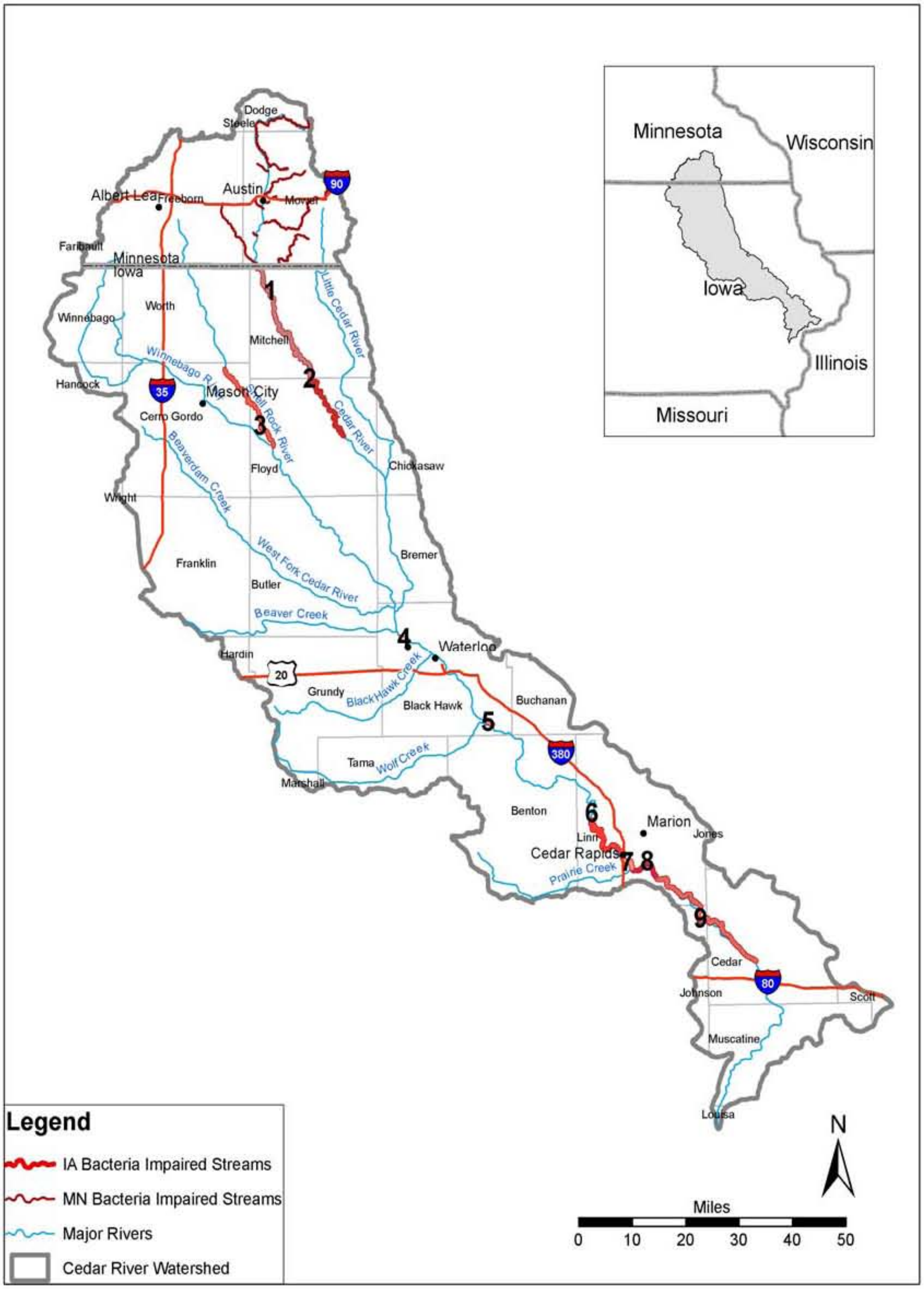

Figure 1-1. Location Map of Cedar River Watershed and Impaired Waterbodies.

Thus a flow-variable daily load was selected to represent the TMDLs. The flows are grouped into quartiles, and for each of these quartiles, a daily maximum load and a daily average load were identified as the daily load expression. The daily maximum allows for infrequent high-concentration inputs while the daily average represents the desired persistent loading conditions.

1.4. Quantification of the amount or degree by which the current pollutant loading in the waterbody, including the pollutant from upstream sources that is being accounted for as background loadings, deviates from the pollutant load needed to attain and maintain water quality standards.

A LDC approach was used in this TMDL to compare measured pollutant concentrations and daily flow data to the WQS at a range of flow conditions. The observed pollutant loads in the river for the local sampling point are plotted on the LDC to show the departure or lack of from WQS. The points that fall above the allowable load curve indicate exceedances while the points that fall below the curve indicate acceptable loads. The observed pollutant loads are also symbolized by season to provide a temporal aspect to the analysis. Using this curve, departure statistics were calculated by flow range and season for each of the nine TMDLs.

1.5. Identification of pollution source categories.

In the absence of an NPDES permit, the discharges associated with sources were applied to the LA, as opposed to the WLA **for purposes of this TMDL**. The decision to allocate these sources to the LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDLs with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL are found to be, or become, **NPDES-**regulated **discharges**, their loads must be considered as part of the calculated sum of the WLAs in this TMDL. WLA in addition to that allocated here is not available.

Any CAFO that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance. However, many large CAFOs (mostly the poultry and swine sectors) contend that they do not discharge nor propose to discharge therefore are not required to obtain an NPDES permit. It is EPA's opinion that many of the "no discharge" CAFOs do not have adequate land application area to ensure the agronomic uptake of land applied waste. Furthermore, there are many AFOs that meet the definition of a medium CAFO (i.e., discharge via a man-made conveyance) but are unpermitted and have not limited their impact on waters by applying Best Professional Judgment to effluent reductions.

Permitted CAFOs identified in this TMDL are part of the assigned WLA. AFOs and unpermitted CAFOs are considered under the LA because we do not currently have enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by EPA that any such facility does not meet the definition of a CAFO nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges or proposes to discharge has a duty to obtain a permit. If it is determined that any such operation is an AFO or CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL as approved.

The predominant pollution contributions are mainly from precipitation mediated runoff events from open feedlots and manure applied to cropland. Direct sources, such as wastewater treatment plants (WWTP) that do not implement disinfection during the recreation season, are also a large pollutant source.

1.6. Waste Load allocations for pollutants from point sources.

The WLA includes contribution from all upstream permitted point sources, MS4, permitted feeding operations, and also includes a reserve (WLA-R) to account for future permitted facilities as unsewered communities develop wastewater treatment plants. The WLA for *E. coli* at all Class A1 streams is set based on a concentration standard of 235 cfu/100 ml. Considering that all the permitted WWTPs and other point source dischargers in the Cedar River Watershed discharge to a Class A1 stream, the daily WLA for all individual point sources in the watershed is established, by rule reference (IAC 62.8(2)), to be based on a daily maximum concentration standard of 235 cfu/100 ml. Examples of individual WLAs for each of the permitted point sources and WLA-Rs for unsewered communities are presented in Table D-1 and D-2 in Appendix D. The **Hydrological Simulation Program-FORTRAN** (**HSPF**) application for the Cedar River was used to estimate the cumulative WLA that was delivered after transport and fate processes to each TMDL endpoint. The transport and fate of bacteria was calculated as a function of hydraulic residence time, a first-order decay rate (1.65 per day) and a temperature correction coefficient (1.20). The decay rate was calibrated within the range reported for similar river systems (Bowie, et. al., 1985).

1.7. Load allocations for pollutants from nonpoint sources.

The LA includes contribution from all nonpoint sources as well as unregulated small animal feeding operations. The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (1\text{-}1)$$

1.8. Margin of safety.

The MOS was set explicitly at 35 *E. coli* cfu times flow for sample maximums and 19 *E. coli* cfu times flow for median flow, or 15 percent when expressed as a percentage of the TMDL. This is consistent with other *E. coli* TMDLs developed within Iowa by the IDNR and allows for uncertainties in modeled flows.

1.9. Consideration of seasonal variation.

Based on the available data, the impact of seasonality on critical conditions can be encapsulated within the flow regime. Thus seasonal variation in *E. coli* loads was evaluated by using LDCs that account for seasonal and annual variations in streamflow.

1.10. Allowance for reasonably foreseeable increases in pollutant loads.

There was no allowance for future LA growth included in this TMDL because current watershed land uses are predominantly agricultural and the addition and/or deletion of animal-feeding operations (which could increase or decrease pathogen indicator loads) cannot be predicted or quantified at this time. Future WLA growth was calculated based on the estimated population in the drainage area for each impaired segment (populations provided by IDNR), a generalized per capita discharge volume of 100 gallons per day (EPA 2008), and a concentration standard of 235 *E. coli* cfu/100 ml to account for a maximum daily waste load.

1.11. Implementation plan.

During preparation of this TMDL the contractor included an implementation plan. EPA does not include or approve implementation plans but encourages the states to include them in TMDL submittals. The implementation plan included in this TMDL is for informational purposes only and should not be considered part of the established TMDL.

Appendix F of the report presents model predictions that estimate the current condition of all perennial streams within the watershed and the feasibility of BMPs achieving WQS throughout the watershed.

It is clear from the model predictions that the TMDLs established in this document are realistic and water quality conditions throughout the watershed can come into compliance through technically feasible BMPs.

2. Description of the Cedar River Watershed

The Cedar River Watershed is approximately 7,830 square miles and is located in eastern Iowa and southeastern Minnesota. Approximately 87 percent of the watershed is located in Iowa. There are 30 counties in this watershed with the origin of the watershed located in Dodge County, Minnesota. The Cedar River generally flows south approximately 335 miles to the confluence with the Iowa River near Columbus Junction, Iowa, which flows into the Mississippi River. The major tributaries are the Little Cedar River, Winnebago River, Shell Rock River, Beaverdam Creek, West Fork Cedar River, Beaver Creek, Black Hawk Creek, Wolf Creek and Prairie Creek. The area upstream from the endpoint of the southernmost impaired stream segment is 7,060 square miles, which is approximately 90 percent of the Cedar River Watershed.

2.1. Physiography

The Cedar River Watershed is located within Level III Ecoregion 47, the Western Corn Belt Plains. This Ecoregion is mainly used for cropland agriculture with the remaining areas used for livestock forage. A combination of nearly level to gently rolling glaciated till plains and hilly loess plains, along with adequate moisture during the growing season makes this a productive area for corn and soybeans (EPA, 2007b).

The major landform regions included in the watershed are the Des Moines Lobe, the Iowan Surface and the Southern Iowa Drift Plain (Squillace, et. al., 1996) consisting of 18 percent, 73 percent and 9 percent, respectively (Figure 2-1).

The northwestern portion of the watershed is located on the Des Moines Lobe. The lobe is constructional or depositional glacial terrain that is characterized by Wisconsin-age glacial drift, undulating topography, and poorly established drainage. There are occasional depressions that form lakes, ponds, and swamps. The soil region of the Des Moines Lobe is the Loamy Wisconsin Glacial Till. Most of this area is a nearly level to gently rolling till plain. Natural lakes dot this region and numerous bogs, swales, and circular depressions indicate sites of previously ponded water. Much of the area is tile drained with extensive drainage ditches providing outlets for the tile drain. End moraines have a banded pattern across this area and are typically described as knob and kettle topography. Nearly all this area is cropland with corn and soybeans being the major crops. Some cropland is used for hay. Native vegetation is mixed tall- and short-grass prairie. Clarion, Nicollet, Webster, and Canisteo are some of the major soil series in this area. These soils formed in loamy glacial till, glacial outwash and/or local alluvium (National Resources Conservation Service, Iowa, 2007).

The central and eastern part of the Cedar River Watershed is located on the Iowan Surface. The landscape is characterized as gently rolling with low relief and well-established drainage patterns. The major streams have broad valleys and are flanked by low, rolling hills that merge with the moderately dissected stream divides. The stream gradients are usually slight and some areas of poor drainage are present. The surface contains shallow limestone in the form of karst features. Where the karst is near the surface, sinkholes may appear. This region is highly cultivated. The soil regions found in the Iowan Surface consist of the Loamy Wisconsin Glacial Till and the Shallow Loess over Glacial Till. The Loamy Wisconsin Glacial Till soils in this area formed in a mantle of silty or loamy sediments and the underlying glacial till. Recent alluvium consisting of clay, silt, sand, and gravel fill the major river valleys. Drainage is well established, though stream gradients are often low and a few areas of poor drainage or bog conditions occur. A typical feature of this area is scattered large boulders partially buried or lying on the earth surface. These erratics, composed of rock types not found in the area, are most likely of glacial origin. A few scattered hills occur in the southern part of this area. Typically, they are elongated and oriented in a distinct northwest-southeast direction. A small portion is wooded, mainly on wet bottom land and on steep slopes bordering stream valleys. Kenyon, Clyde, and Floyd are a few of the major soils in this region. The Shallow Loess over Glacial Till is characterized in this region by wide, gently sloping, convex ridge tops and moderately sloping side slopes. The upland soils in this region, such as Dinsdale and Klinger, formed in a thin mantle of loess and the underlying glacial till. Colo soils formed in alluvium and are in drainage ways and river bottoms. Nearly all the land within these two soil regions is in cropland. Corn and soybeans are the major crops. Many of the wet soils require artificial drainage for timely field operations and good growth of crops. Native vegetation is mixed tall- and short-grass prairie (National Resources Conservation Service, Iowa, 2007).

The southern part of the watershed is located on the Southern Iowa Drift Plain. The landscape varies from steeply rolling hills, flat-topped uplands of uniform elevation, and lowland valley floors with a deepening network of rivers and streams. Moderately well-drained soils have developed on the loess. The valleys obtained their present width, depth, and alluvial fill during melt-water flooding as the Wisconsin ice sheet receded from north-central Iowa (Squillace, et. al., 1996). The Loess Ridges and Loess Sideslopes found in the Southern Iowa Drift Plain landform consist of nearly level to steep soils that formed in loess. The sideslopes typically have many drainage ways. Tama, Muscatine and Downs are the major soils in this area. Tama and Muscatine soils formed under tall prairie grasses and Downs soils, which typically are located on steeper slopes along the major river systems, formed under a mix of deciduous trees and tall-grass prairie. In places, various soils derived from glacial till occur on the steepest slopes. Most of this region is cultivated. Corn and soybeans are the principal crops. Some of the steeper areas are used for hay and pasture or remain in timber (National Resources Conservation Service, Iowa, 2007).

The topography of the watershed generally slopes from the northwest to the southeast. The elevation ranges from approximately 560 feet above sea level at the confluence of the Cedar and Iowa Rivers to approximately 1,445 feet above sea level in the northern portion of the watershed. The average slope within the watershed is approximately 2 percent.

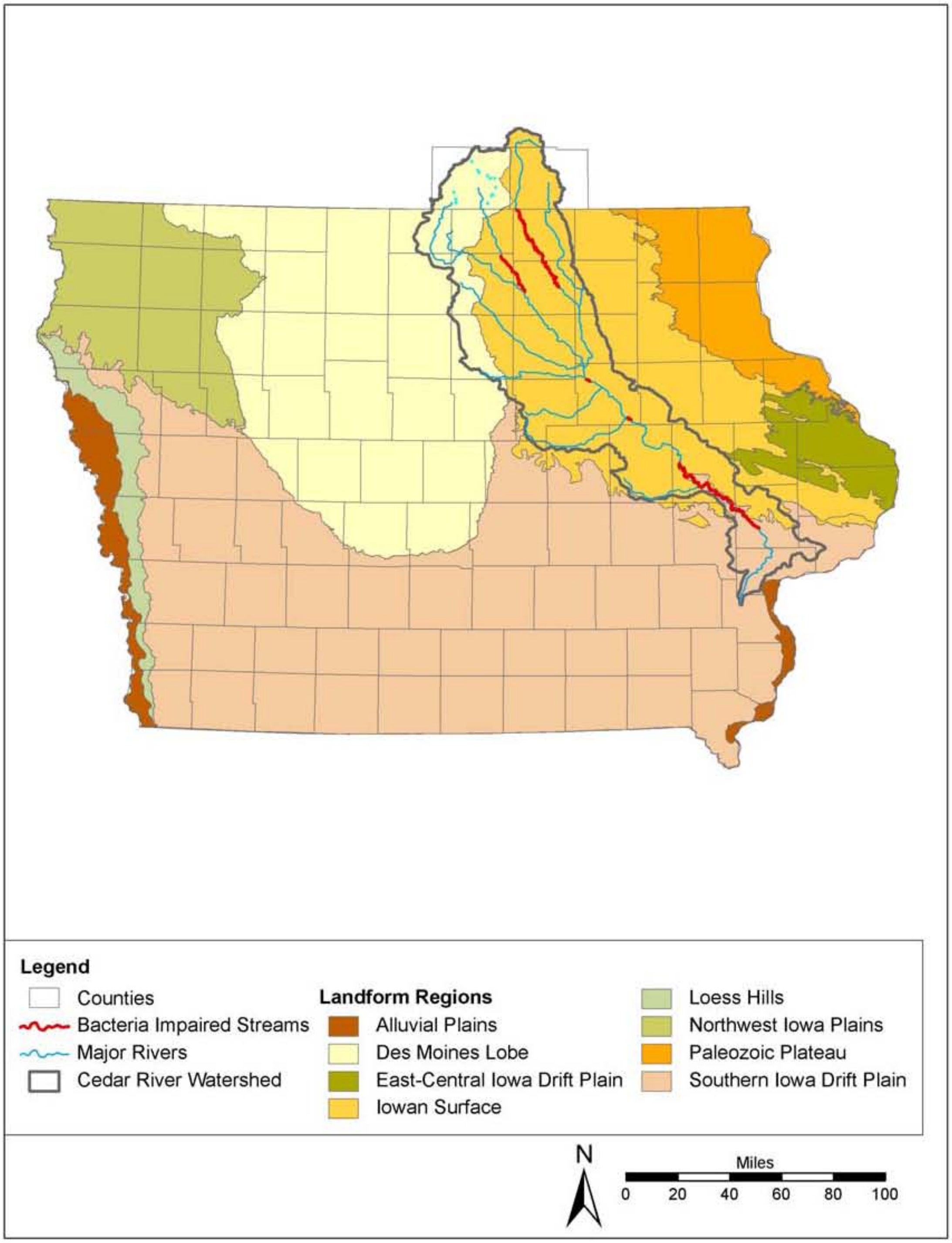

Figure 2-1. Location of the Cedar River Watershed within the Landform Regions of Iowa.

2.2. Land Use

The land use in the Cedar River Watershed is primarily agricultural (approximately 77 percent). Based on the Iowa Land Cover Map, the majority of the agricultural land is row crops, primarily corn and soybeans and grazed grassland (IDNR, 2002). Additionally, there are several confined and open animal-feeding operations within the watershed. Livestock within the watershed consists of beef cattle, dairy cattle, hogs, sheep, and poultry (Squillace, et. al., 1996).

The land uses from the Iowa Land Cover Map (IDNR, 2002) were divided into five generalized categories for modeling purposes. The five generalized land uses for the watershed areas above the end point of each of the impaired stream segments are listed in Table 2-1.

Table 2-1. Summary of land use above the end point of each TMDL reach segment.

Segment ID	Waterbody ID	Urban		Cropland		Grazed grassland		Ungrazed grassland/forest		Water/ wetland		Total
		Area (sq mi)	%	Area (sq mi)	%	Area (sq mi)	%	Area (sq mi)	%	Area (sq mi)	%	Area (sq mi)
1	IA 02-CED-0110_3	29	3	725	80	16	2	123	14	9	1	902
2	IA 02-CED-0110_2	35	3	856	80	20	2	150	14	11	1	1,072
3	IA 02-SHL-0020_1	44	4	873	72	32	3	221	18	35	3	1,205
4	IA02_CED-0050-L_0	147	3	3,597	77	119	3	760	16	63	1	4,686
5	IA 02-CED-0040_1	194	4	4,075	76	134	3	856	16	70	1	5,329
6	IA 02-CED-0030_2	230	4	4,885	76	172	3	1,080	17	83	1	6,450
7	IA 02-CED-0030_1	255	4	5,039	76	177	3	1,118	17	85	1	6,674
8	IA 02-CED-0020_3	268	4	5,091	75	181	3	1,155	17	89	1	6,784
9	IA 02-CED-0020_2	274	4	5,241	74	190	3	1,264	18	91	1	7,060
Entire Cedar River Watershed		291	4	5,787	74	203	3	1,448	18	101	1	7,830

There are several large and small urban areas within the watershed. Many of the large urban areas are located along the Cedar River (Figure 2-2). Based on the 2000 Census, the population within the watershed is approximately 530,000 (U. S. Census Bureau, 2000). Approximately 65 percent of the watershed population resides within an urbanized area and the remaining 35 percent of the population is considered rural. The population distribution is also shown in Figure 2-2.

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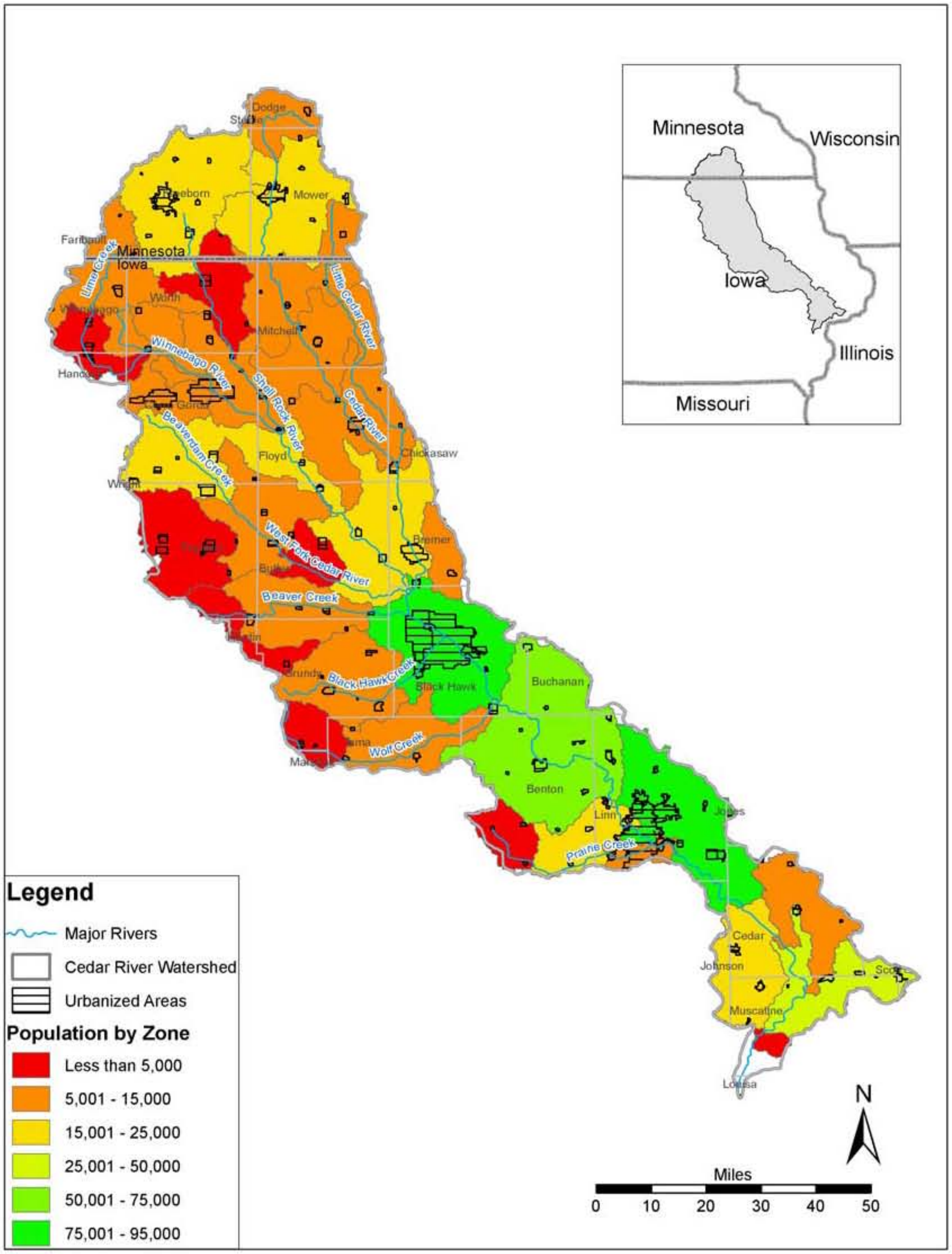

Figure 2-2. Urbanized Area Locations and Population Distribution within the Cedar River Watershed.

2.3. Water Use

The principal source of water for commercial, domestic, industrial, and agricultural users within the watershed comes from groundwater. Approximately 76 percent of the agricultural water use is from a groundwater source (Squillace, et. al., 1996).

2.4. Climate

The climate within the watershed is generally continental and is characterized by large seasonal and daily temperature variations. Temperatures during the summer can be greater than 100°F and winter low temperatures can reach below 0°F (Squillace, et. al., 1996).

Annual precipitation within the Cedar River Watershed typically ranges from 31 to 37 inches; precipitation totals tend to increase along a north-to-south gradient. The greatest rainfall typically occurs during the growing season in spring and summer. The most intense 24-hour rainfall can be more than four inches. The greatest 24-hour snowfall seldom exceeds 10 inches (Kalkhoff, et. al., 2000).

2.5. Surface Water Hydrology

Excess precipitation that does not infiltrate the soil or evaporate runs off to the streams. Generally, poorly permeable till soils and/or steeper slopes typical of the Des Moines Lobe and the Southern Iowa Drift Plain generate greater overland flow than moderately well-drained loess soils and gentle slopes typical of the Iowa Surface. Runoff to streams averages about 25 percent of the annual precipitation and ranges from seven to nine inches per year throughout the watershed. Overland flow and groundwater discharge are the major sources of streamflow (Kalkholf, et. al., 2000).

USGS has historically collected long-term streamflow data at 25 gages within the Cedar River Watershed; 17 of these gages are still active (Figure 2-3). Table 2-2 lists these gages and their period of record.

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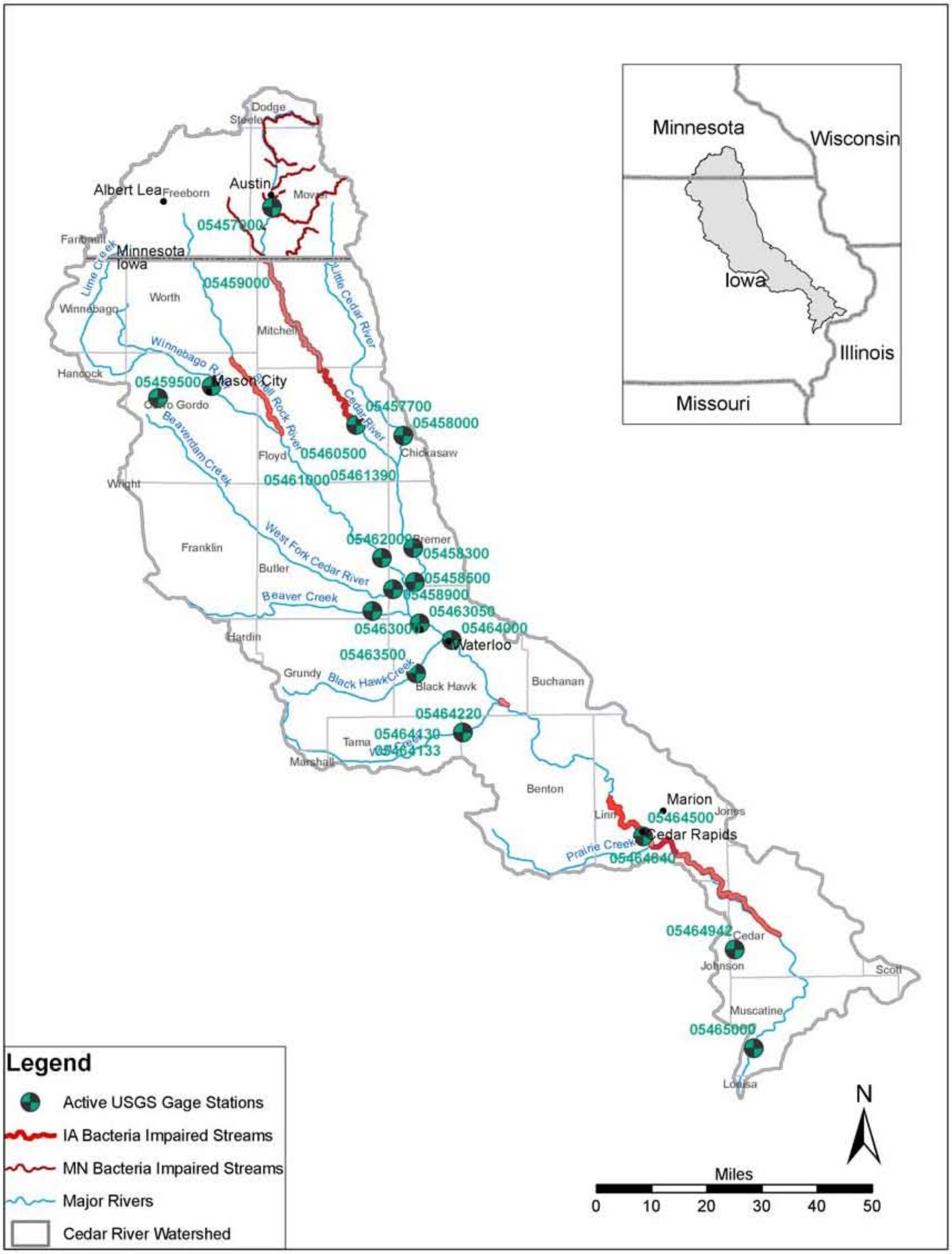

Figure 2-3. Active USGS Flow Gages within the Cedar River Watershed.

Table 2-2. United States Geological Survey streamflow gages within the Cedar River Watershed.

Hydrologic unit code	Site number	Station name	Drainage area (sq-mile)	Start date	End date	Median flow (cfs)	Average flow (cfs)
07080201	05457000	Cedar River near Austin, MN	399	6/1/1909	9/30/2006	98	243
07080201	05457700	Cedar River at Charles City, IA	1,054	10/1/1964	9/30/2006	360	734
07080201	05458000	Little Cedar River near Ionia, IA	306	10/1/1954	9/30/2006	72	188
07080201	05458300	Cedar River at Waverly, IA	1,547	10/1/2000	9/30/2006	440	1,045
07080201	05458500	Cedar River at Janesville, IA	1,661	10/1/1904	9/30/2006	476	956
07080202	05459000	Shell Rock River near Northwood, IA	300	10/1/1945	9/30/1986	65	162
07080202	05460500	Shell Rock River at Marble Rock, IA	1,318	10/1/1933	9/30/1953	250	612
07080202	05461000	Shell Rock River at Greene, IA	1,357	7/1/1933	9/30/1942	201	493
07080202	05461390	Flood Creek near Powersville, IA	124	10/4/1995	11/16/1998	11	53
07080202	05462000	Shell Rock River at Shell Rock, IA	1,746	3/11/1953	9/30/2004	535	1,084
07080203	05459500	Winnebago River at Mason City, IA	526	10/1/1932	9/30/2006	114	289
07080203	05460000	Clear Lake at Clear Lake, IA	22.6	5/20/1933	9/30/2006	4	4
07080204	05458900	West Fork Cedar River at Finchford, IA	846	10/1/1945	9/30/2006	242	561
07080205	05463000	Beaver Creek at New Hartford, IA	347	10/1/1945	9/30/2006	88	224
07080205	05463050	Cedar River at Cedar Falls, IA	4,734	1/25/2001	9/24/2001	83	84
07080205	05463500	Black Hawk Creek at Hudson, IA	303	4/4/1952	9/30/2006	75	188
07080205	05464000	Cedar River at Waterloo, IA	5,146	10/1/1940	9/30/2006	1,800	3,320
07080205	05464130	Fourmile Creek near Lincoln, IA	14	10/1/1962	9/30/1980	3	9
07080205	05464133	Half Mile Creek near Gladbrook, IA	1	10/1/1962	9/30/1980	0	1
07080205	05464137	Fourmile Creek near Traer, IA	20	10/1/1962	1/13/1981	4	12
07080205	05464220	Wolf Creek near Dysart, IA	299	6/5/1995	9/30/2006	70	176
07080205	05464500	Cedar River at Cedar Rapids, IA	6,510	10/1/1902	9/30/2006	2,160	3,780
07080205	05464640	Prairie Creek at Fairfax, IA	178	10/1/1966	9/30/1982	57	133
07080206	05464942	Hoover Creek at Hoover National Historic Site West Branch, IA	2	10/1/2000	9/30/2006	1	2
07080206	05465000	Cedar River near Conesville, IA	7,787	9/16/1939	9/30/2006	3,130	5,179

3. TMDL for *E. coli*

A TMDL is required for impaired streams in the Cedar River Watershed by the Federal CWA. This chapter quantifies the maximum amount of *E. coli* that each impaired stream (or segment) can receive without violating the state's WQS.

3.1. Problem Identification for Cedar River Watershed

The Iowa's 2006 Integrated Report (IDNR, 2007a) identifies nine segments in the Cedar River Watershed impaired by indicator bacteria. Bacteria sources include direct sources such as WWTPs, failed septic systems, and direct defecation by cattle in streams or indirect sources such as open feedlots, grazing livestock, and manure application. Direct sources discharge on a continuous basis while indirect sources are a result of precipitation runoff events.

3.2. Impaired Beneficial Uses and Applicable Water Quality Standards

In 2003, Iowa's WQS were changed. As of July 2003, *E. coli* is now the indicator bacterium (not fecal coliform) and applies to waters designated as primary contact recreation Class A1, secondary contact Class A2, or children's recreational Class A3 uses. According to IAC Chapter 61.3(1)b, all perennial rivers and streams, as identified by the USGS 1:100,000 Digital Scale Graph (DLG) Hydrography Data Map (published July 1993), or intermittent streams with perennial pools in Iowa are designated as Class A1 waters. While this is the presumptive use, individual streams within the greater watershed may have different uses as a result of an EPA approved use attainability analysis (UAA).

The 2006 Section 305(b) Assessment Report (IDNR, 2007b) identified nine segments within the Cedar River Watershed as either "not supporting" or "partially supporting" their primary contact recreation Class A1 designated use based on results of monitoring from 2002 to 2004 for indicator bacteria. The Class A1 uses are not supported because of high levels of indicator bacteria that violate the applicable WQS for Class A1 waters. The applicable WQS for Class A1 waters (IAC, 2006a) are listed in Table 3-1.

The definition of Class A1 water (IAC, 2006a) states in Chapter 61.3(1)b:

> Primary contact recreational use (Class A1). Waters in which recreational or other uses may result in prolonged and direct contact with the water, involving considerable risk of ingesting water in quantities sufficient to pose a health hazard. Such activities would include, but not be limited to, swimming, diving, water skiing and water contact recreational canoeing.

Table 3-1. *E. coli* bacteria WQS criteria (organisms per 100 milliliters of water). [IAC 61.3]

Use	Geometric mean	Sample maximum
Class A1		
3/15-11/15	126	235
11/16-3/14	Does not apply	Does not apply

3.3. Data Sources

Bacteria data have historically been collected by several agencies (USGS, IDNR) within the watershed. These data are stored within the EPA's **Storage and Retrieval** (**STORET**) system. IDNR provided these data to support the TMDL development. Figures 3-1 and 3-2 show the 57 ambient monitoring sites and 86 snapshot monitoring sites within the Cedar River Watershed for fecal coliform and *E. coli*, respectively. The figures show the location of gages and the number of samples collected. The ambient monitoring data are summarized in Table C-1 in Appendix C.

Because of the change of indicator bacteria from fecal coliform to *E. coli*, all indicator bacteria values reported in this TMDL are for *E. coli* only. When *E. coli* concentrations were measured at monitoring sites, they are reported in this TMDL. When fecal coliform concentrations were measured as the indicator bacteria, the fecal coliform concentrations were converted to estimated *E. coli* concentrations according to a regression relationship developed from monitoring data collected at ambient monitoring sites around the state of Iowa. IDNR provided paired *E. coli* and fecal coliform data for approximately 6,310 samples to develop a translator from fecal coliform to *E. coli*. Since *E. coli* is a subset of fecal coliform, the ratio of the two indicator bacteria typically does not exceed 1.0. Most frequently, *E. coli* concentrations are within 0.8 to 1.0 times fecal coliform concentrations. Using a statewide comparison of sampling events when both indicator bacteria were measured, multiplying the fecal coliform concentration by 0.92 is appropriate ($R^2 = 0.92$) for estimating *E. coli* concentrations in the Cedar River Watershed (IDNR 2006a). For the remainder of this TMDL, all indicator bacteria concentrations and loads are reported as *E. coli* unless otherwise indicated.

Discharge data were used from the USGS gage stations shown in Table 2-2 and Figure 2-3. Figure 3-3 shows 17 monitoring sites where flow and water quality data are currently available.

3.4. Interpretation of Watershed Wide Data

Iowa WQS designate all perennial streams as Class A1; the applicable criterion for a primary contact recreation Class A1 stream in Iowa is a maximum concentration value of 235 *E. coli* cfu/100 ml. An analysis of the data indicates that approximately 50 percent of the samples taken during the recreational season (March 15 through November 15) in the Cedar River Watershed on perennial streams exceed 235 *E. coli* cfu/100 ml (Figure 3-4). The magnitude and spatial distribution (see Figure 3-5) of these exceedances indicates that this is a watershed wide problem.

Figure 3-6 presents boxplots of concentration data grouped by the flow range (high, mid, and low) recorded at the time of sampling for the 17 gages where flow and water quality were concurrently collected. From this plot, it is evident that there are exceedances for all flow ranges; however, there is a clear trend of more exceedances that occur during larger flows, such as during runoff events. This indicates that indirect or nonpoint sources are a predominant cause of exceedances within the watershed. However, exceedances at lower range flows are prevalent and are likely caused by direct sources, such as WWTPs not using disinfection practices. Table 3-2 presents descriptive statistics for both fecal coliform and *E. coli* for all available data.

Figures 3-7 and 3-8 present boxplots of the concentrations recorded throughout the watershed by month and season, respectively. The seasons were set as follows: spring – April through June, summer – July through September, fall – October through November, and winter – December through March. In general, the concentrations are higher during the months and seasons with larger runoff and the impact of seasonality on critical conditions are encapsulated within the flow regime. Table 3-3 summarizes the median concentrations measured by flow regime and season. Boxplots and statistical summaries for all stations with water quality and flow data are in Appendix C.

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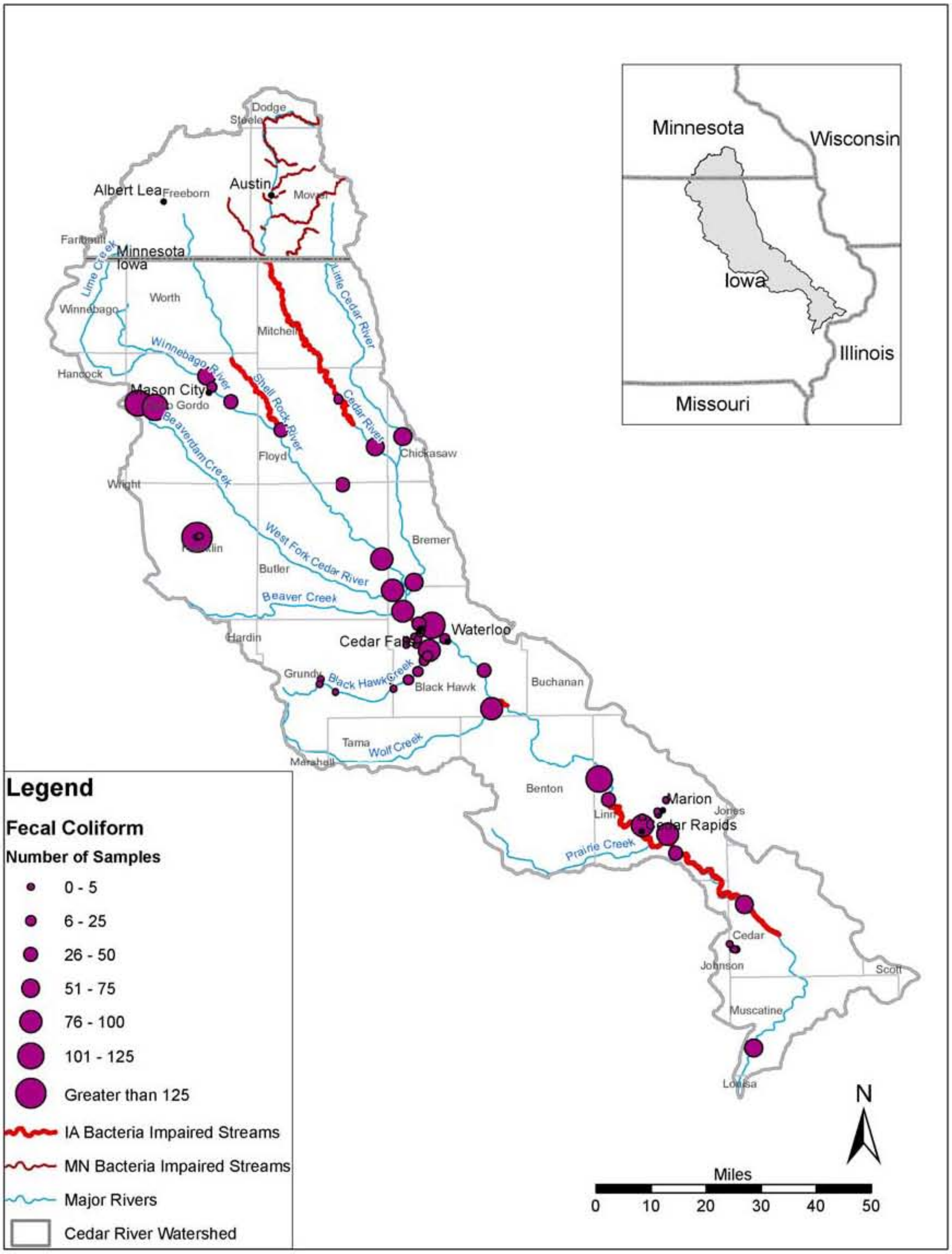

Figure 3-1. Bacteria Monitoring Stations with Fecal Coliform Samples.

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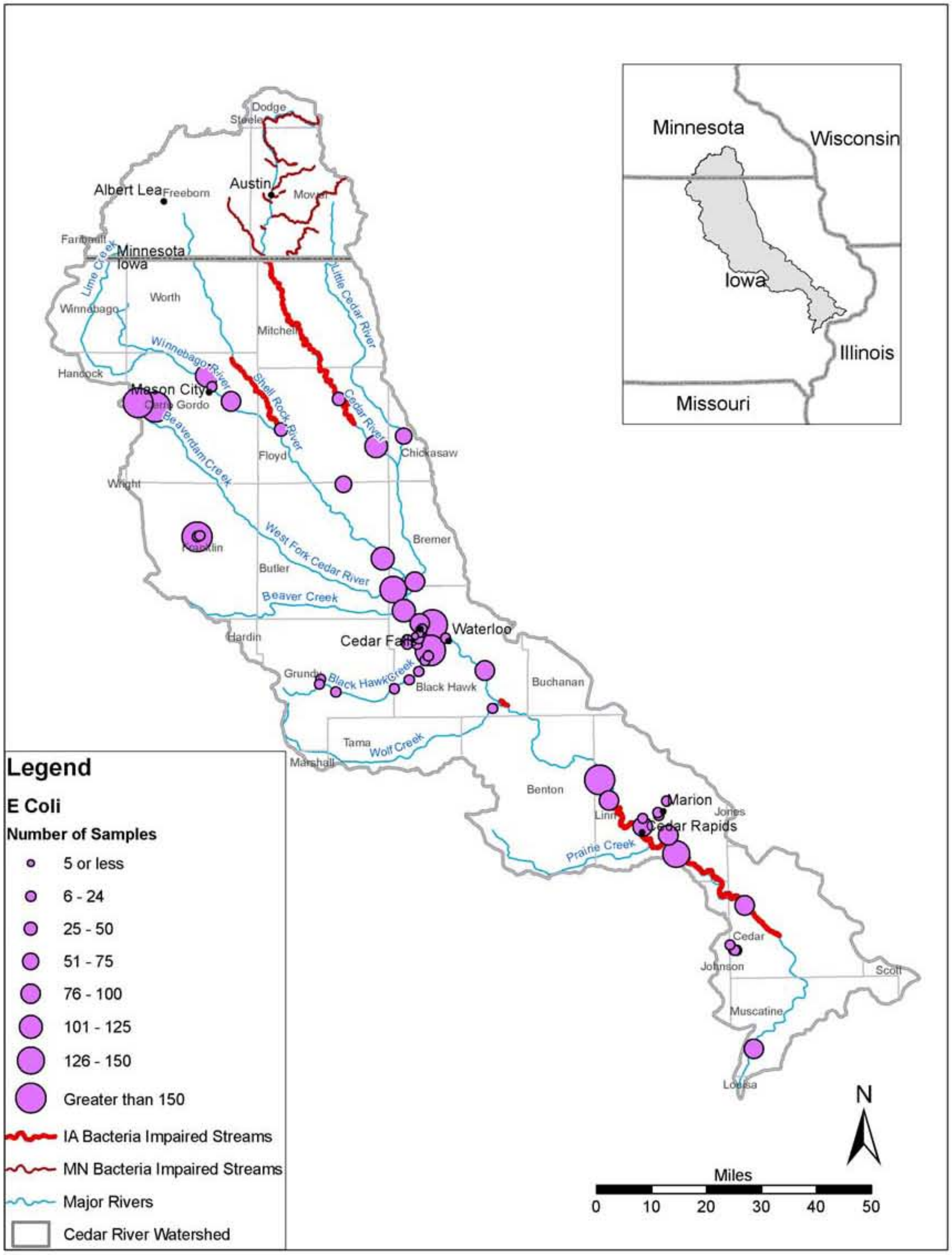

Figure 3-2. Bacteria Monitoring Stations with *E. coli* Samples.

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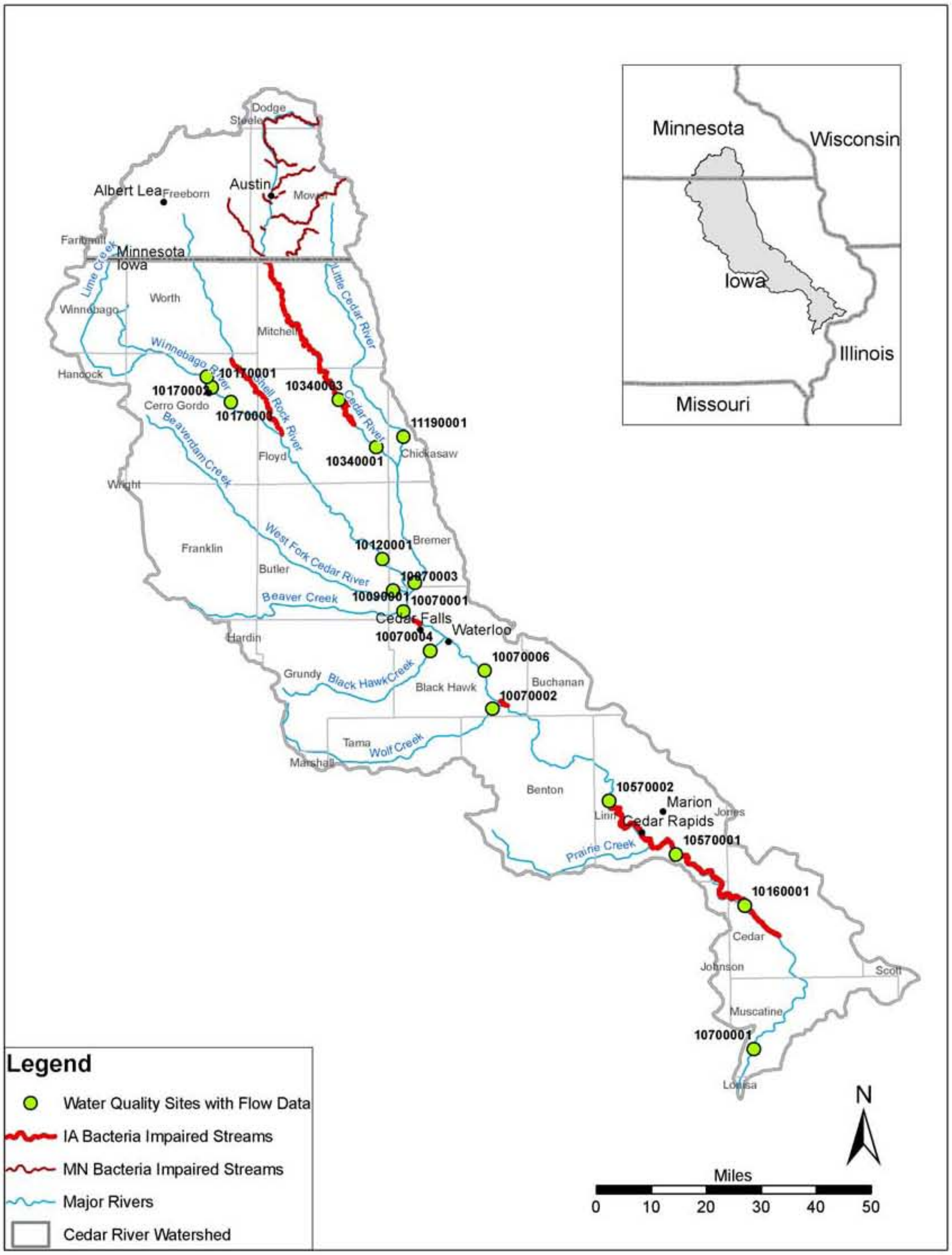

Figure 3-3. Paired Water Quality and Flow Monitoring Sites.

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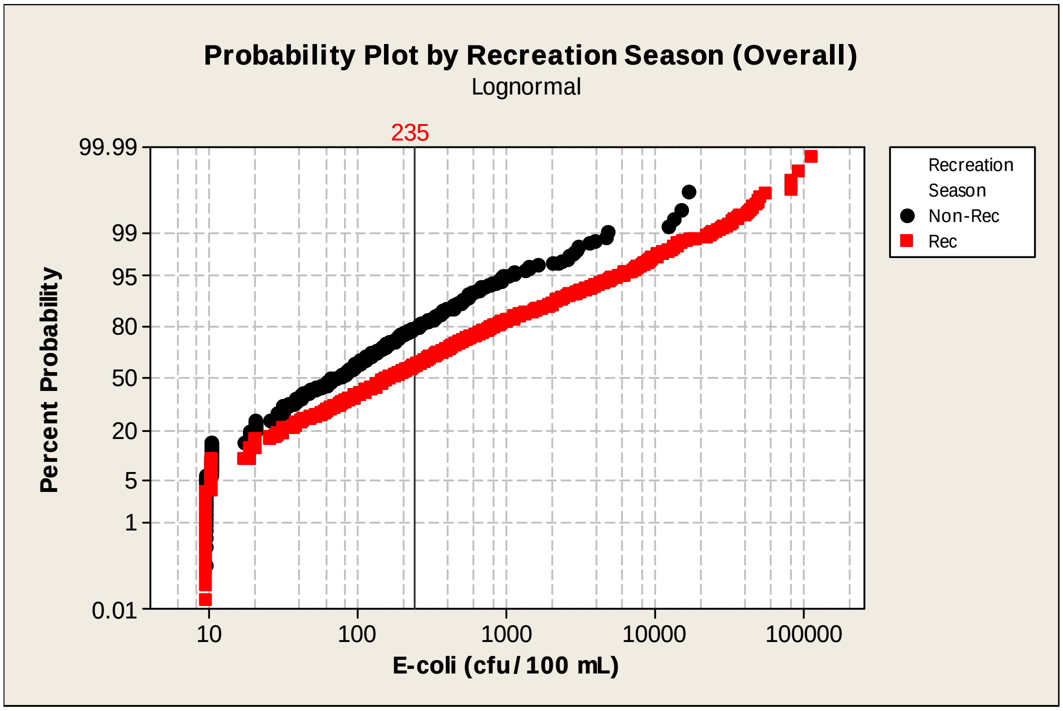

Figure 3-4. Percent of Watershed Wide Data Exceeding 235 cfu/100 ml.

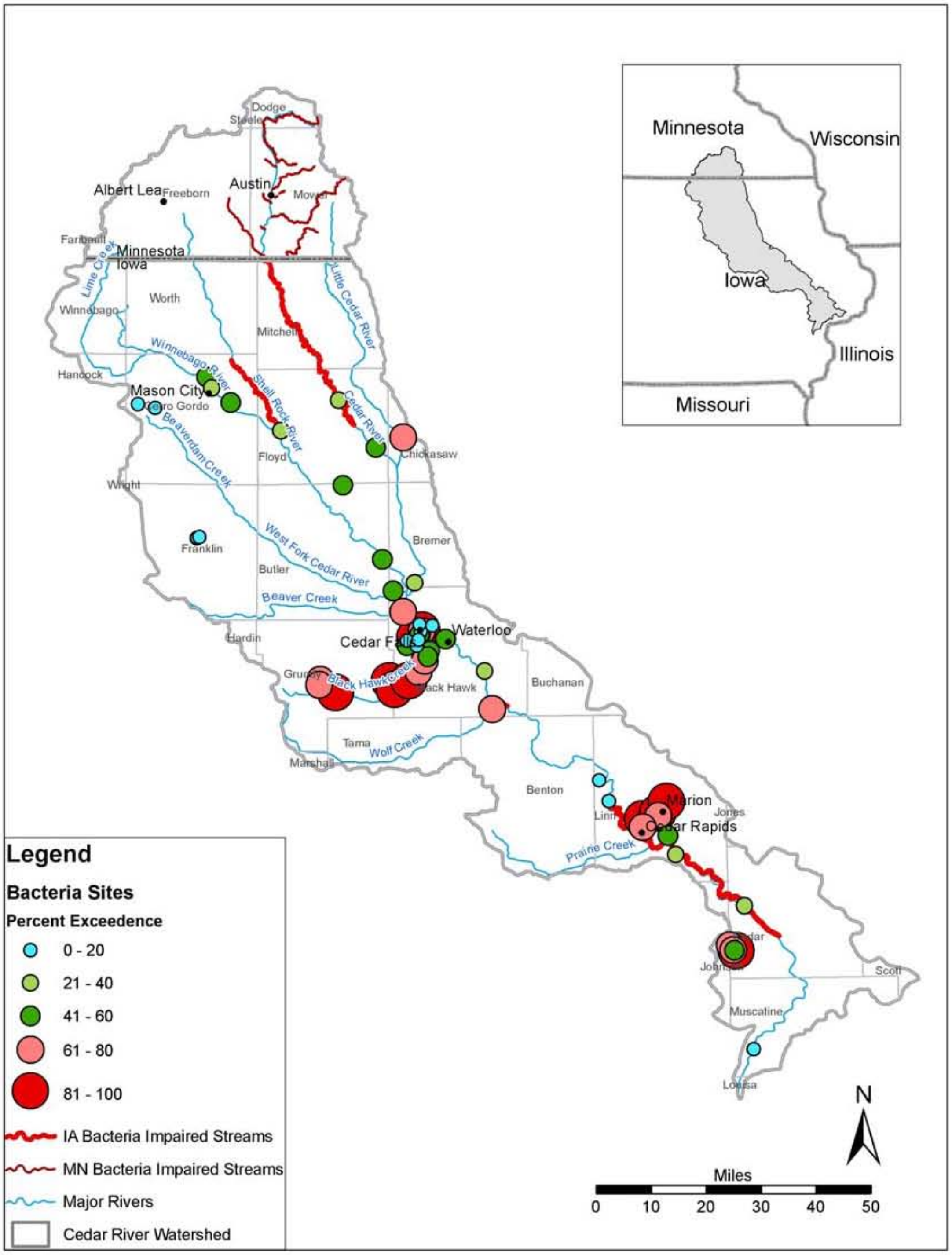

Figure 3-5. Spatial Distribution of Watershed Wide Data Exceeding 235 cfu/100 ml.

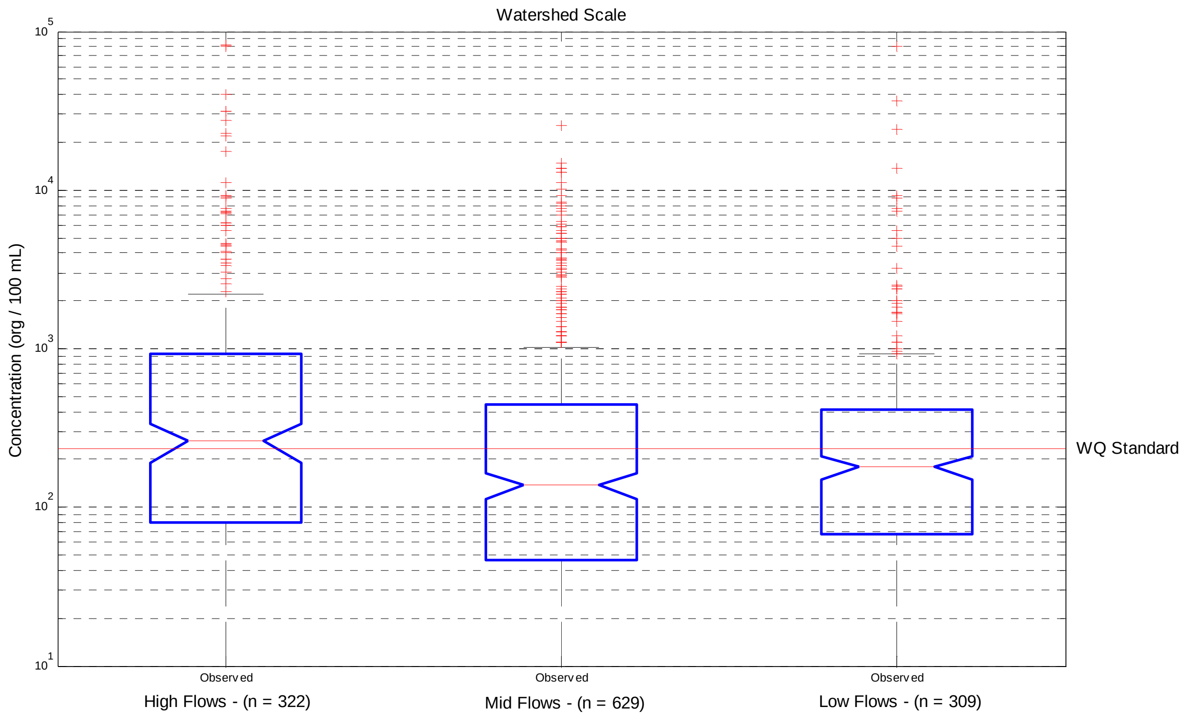

Figure 3-6. Boxplots for Watershed Wide Concentrations by Flow Range.

Table 3-2. Watershed wide descriptive statistics.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	3,204	794.2	3,624.5	10.0	18	91.0	357.5	90,000
Fecal	1,909	1,293	5,467	9	18	92	460	110,400

3.5. Identification of Watershed Pollutant Sources

In the absence of an NPDES permit, the discharges associated with sources were applied to the LA, as opposed to the WLA **for purposes of this TMDL**. The decision to allocate these sources to the LA does not reflect any determination by EPA as to whether these discharges are, in fact, unpermitted point source discharges within this watershed. In addition, by establishing these TMDLs with some sources treated as LAs, EPA is not determining that these discharges are exempt from NPDES permitting requirements. If sources of the allocated pollutant in this TMDL are found to be, or become, **NPDES**-regulated **discharges**, their loads must be considered as part of the calculated ∑WLA in this TMDL. WLA in addition to that allocated here is not available.

A comprehensive accounting of all potential bacterial sources within the Cedar River Watershed was conducted. Bacteria sources include WWTP and urban storm sewer discharges, failed septic systems, wildlife, pastured livestock, runoff from fields where manure has been applied and open feedlots. These sources can be categorized as indirect or direct. Indirect sources of bacteria are associated with runoff events; whereas, direct sources of bacteria, such as WWTPs, usually discharge continuously (Figure 3-9). These sources can be further broken down into point and nonpoint sources.

In 2004, the IDNR converted from fecal coliform to *E. coli* bacteria as the indicator for primary contact recreation assessment. Even though *E. coli* may be a better indicator of human health issues for primary contact recreation assessment, historical data consisted only of fecal coliform data and most of the pollutant source reference material, particularly for the EPA's **Bacteria Indicator Tool** (**BIT**) spreadsheet, used fecal coliform as the pathogen indicator. **BIT** (EPA, 2000) was used in conjunction with the **HSPF** (Bicknell et al., 2001) to estimate pollutant source loading. The fecal coliform was multiplied by 0.92 to obtain an estimate of *E. coli* using the relationship developed between *E. coli* and fecal coliform.

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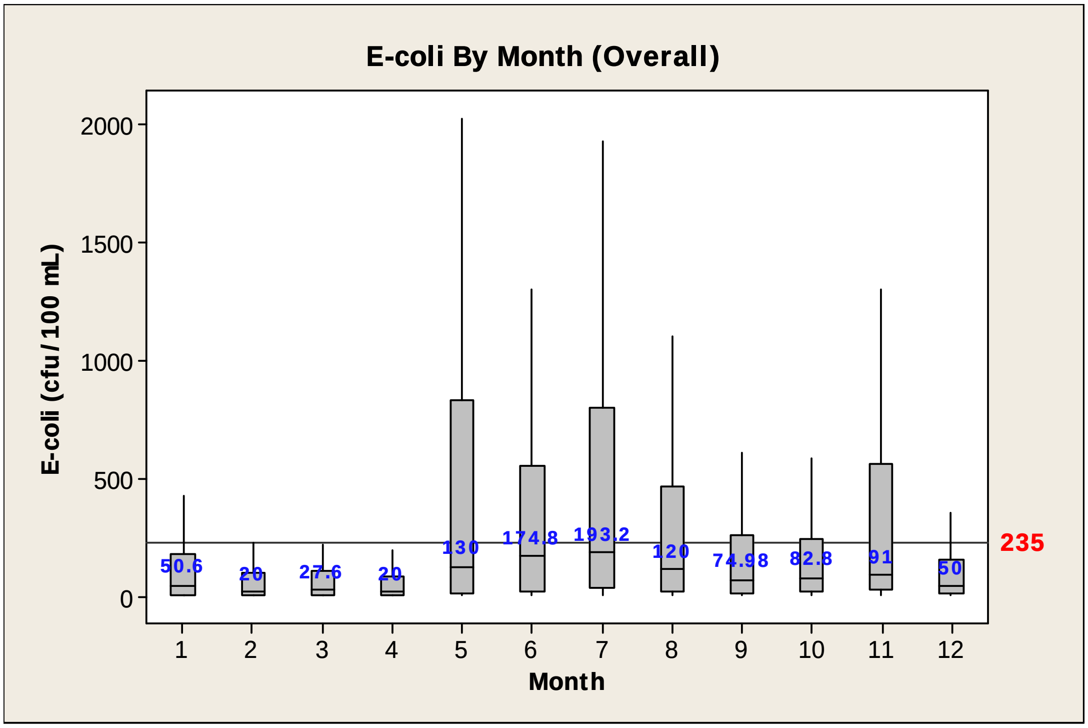

Figure 3-7. Boxplots of Watershed Wide Monthly Concentration.

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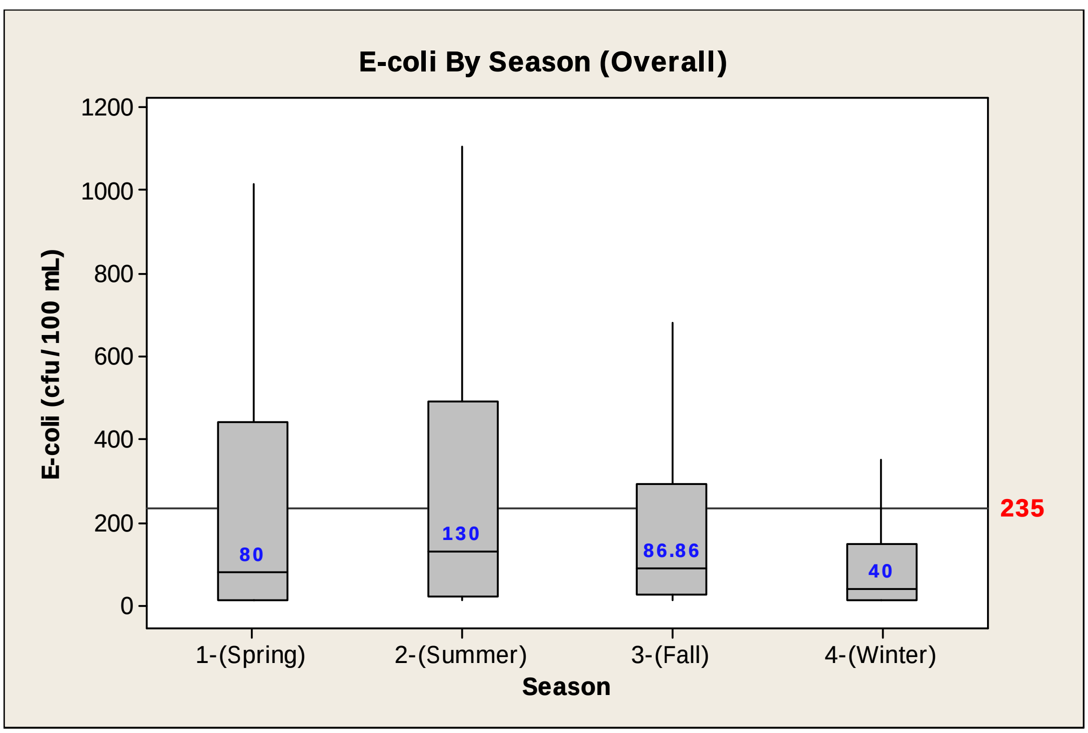

Figure 3-8. Boxplots of Watershed Wide Seasonal Concentrations

Table 3-3. Watershed scale descriptive concentration (cfu/100 ml) statistics by flow and season.

Season	Metric	Low flow	Mid flow	High flow	All flows
Spring	Median (cfu/100 ml)	9	55	320	180
	Count (n)	8	206	252	466
Summer	Median (cfu/100 ml)	135	197	890	240
	Count (n)	74	276	125	475
Fall	Median (cfu/100 ml)	60	129	810	100
	Count (n)	127	171	21	319
Winter	Median (cfu/100 ml)	18	20	70	28
	Count (n)	33	64	13	110
All season	Median (cfu/100 ml)	74	129	432	150
	Count (n)	242	717	411	1,370

3.5.1. Direct Sources

The direct sources category captures bacteria loadings that are discharged to waterbodies on a continuous basis, not associated with rainfall runoff. Information was used to estimate historical loadings that originate from these direct sources. Sources with defined outfalls were represented as point sources (e.g., WWTP), while less localized sources were distributed along the length of the waterbodies (e.g., direct defecation).

Permitted Bacteria Dischargers. The point source dischargers with NPDES permits that discharge bacteria are shown in Tables D-1 and D-2 in Appendix D. There are 144 permitted dischargers in the Cedar River Watershed, 122 facilities in Iowa (5 facilities have two separate discharges with the same permit ID) and 22 facilities in Minnesota (Figure 3-10). Most facilities are municipal wastewater treatment plants or sanitary districts. Information was obtained from IDNR and the Minnesota Pollution Control Agency (MPCA) regarding bacteria concentrations and flows.

There are two different types of discharges from WWTP – continuous and controlled. For a continuous discharge WWTP, the discharge occurs on a continuous basis in both Iowa and Minnesota. For controlled discharge facilities in Iowa, discharges are conducted in April and October for approximately three weeks at a time. In Minnesota, controlled discharges can occur at any time. Since controlled discharges from facilities in Minnesota occur throughout the year, these facilities were treated like continuous discharges.

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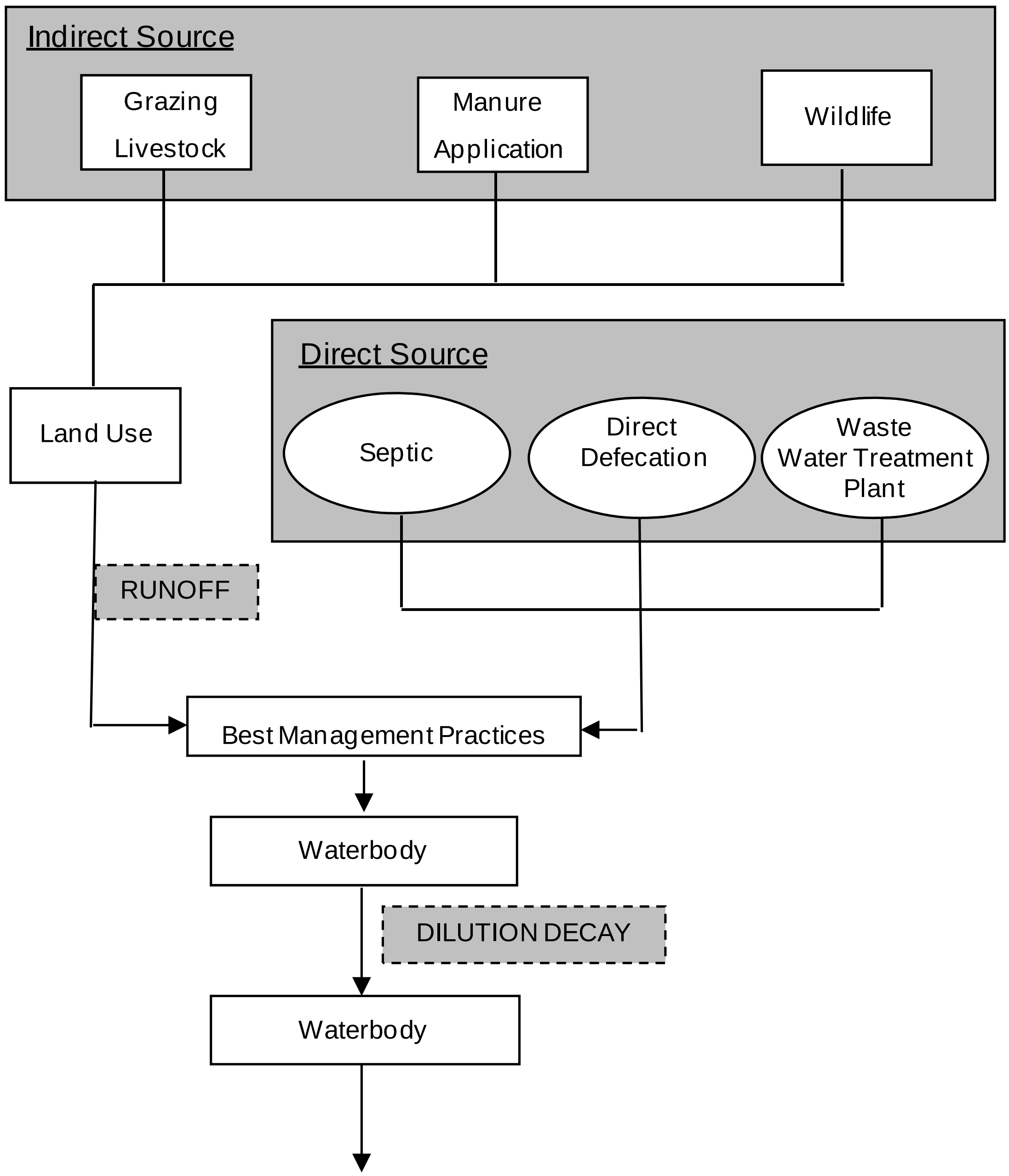

Figure 3-9. Sources of Bacteria.

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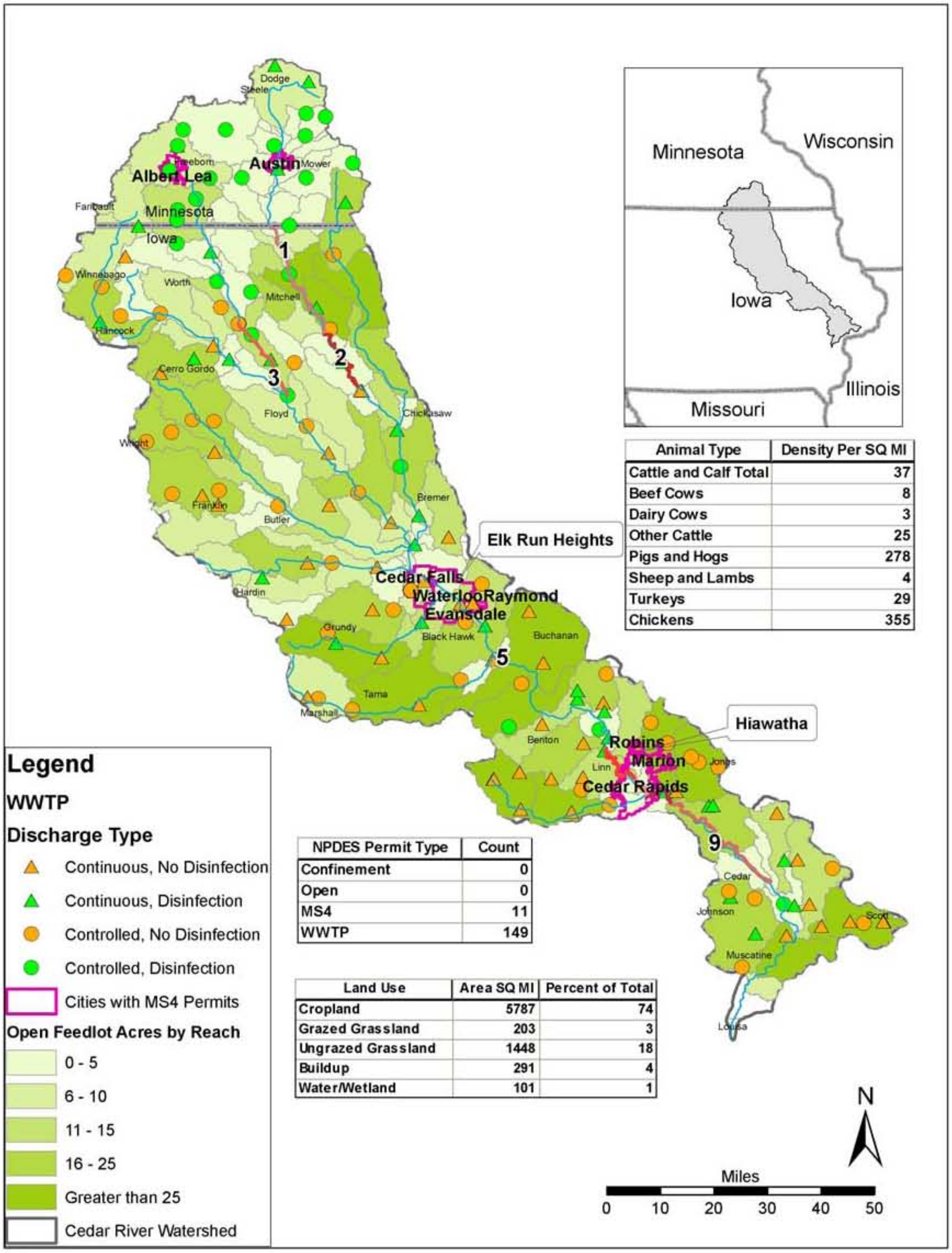

Figure 3-10. Watershed Wide Pollutant Sources.

Facility-specific discharge data were not available for the majority of WWTPs in Iowa. Discharge for continuous discharge facilities was estimated as the average wet weather (AWW) design flow. For controlled discharge facilities, the flow was estimated as 10 times the AWW design flow. Discharge flow data were available for continuous discharge facilities in Minnesota. The daily flow was estimated as an annual average. For controlled discharge facilities, the flow was estimated as the AWW design flow.

In Iowa, some WWTPs disinfect during the recreation season while others do not (Table D-1, Appendix D). In Minnesota, all WWTPs disinfect during the recreation season. In Iowa where disinfection is conducted, the load is calculated as the flow times the *E. coli* criterion of 235 cfu/100 ml. If no disinfection occurs, the load is estimated as the flow times 10 percent of the influent load (based on per capita bacteria generation) into the facility. For continuous WWTPs in Minnesota, the load was estimated as the flow times the annual average load concentration. For controlled discharge WWTPs in Minnesota, the load was estimated as the flow times the *E. coli* WQS criterion. The spatial location of the WWTPs is shown on Figure 3-10. The estimated WLA for each WWTP is shown in Table D-1 in Appendix D.

There are 11 municipalities in the watershed that are large enough to need a MS4 NPDES permit (Figure 3-10). Table 3-4 lists the 11 MS4s. This TMDL assigns numeric WLAs to MS4s by basin. However, as recommended by the EPA, the WLA for urban stormwater point sources in the watershed will be implemented through the NPDES MS4 permits and will use BMPs in lieu of numeric limits.

Table 3-4. Cities within the watershed with MS4 permits.

MS4 cities		
Austin	Evansdale	Raymond
Albert Lea	Robins	Cedar Rapids
Cedar Falls	Hiawatha	Waterloo
Elk Run Heights	Marion	

Generally, animal-feeding operations with 1,000 animal units or more are required to obtain an NPDES permit. For medium sized animal-feeding operations regulation depends on factors such as technology in place on the site. Currently, there are no NPDES-permitted animal-feeding operations in the watershed.

Failing Septic Systems. Septic systems deliver bacteria to nearby waterbodies from malfunctions, undetected system failures or directly through piped discharges. A large portion of the Cedar River Watershed is considered rural where the residents would not have access to a WWTP. Although the exact number of septic systems is unknown, the number was estimated from the number of septic systems in the 1990 U. S. Census (U. S. Census Bureau, 1990). This information was not collected in the 2000 Census but IDNR staff indicated the 1990 Census data were representative of the current rural septic systems since most of the growth occurred in urban areas where there is generally access to WWTPs (Olsen, 2007). The U. S. Census data are presented by census block group. The septic systems were estimated by reducing the number of septic systems by the percent of the subwatershed within the census block group (Figure 3-11). There are approximately 43,000 septic systems within the Cedar River Watershed. Although there is no specific information regarding the failure rate, IDNR staff estimated that approximately 50 percent of the septic systems are failing throughout the watershed (Olsen, 2007).

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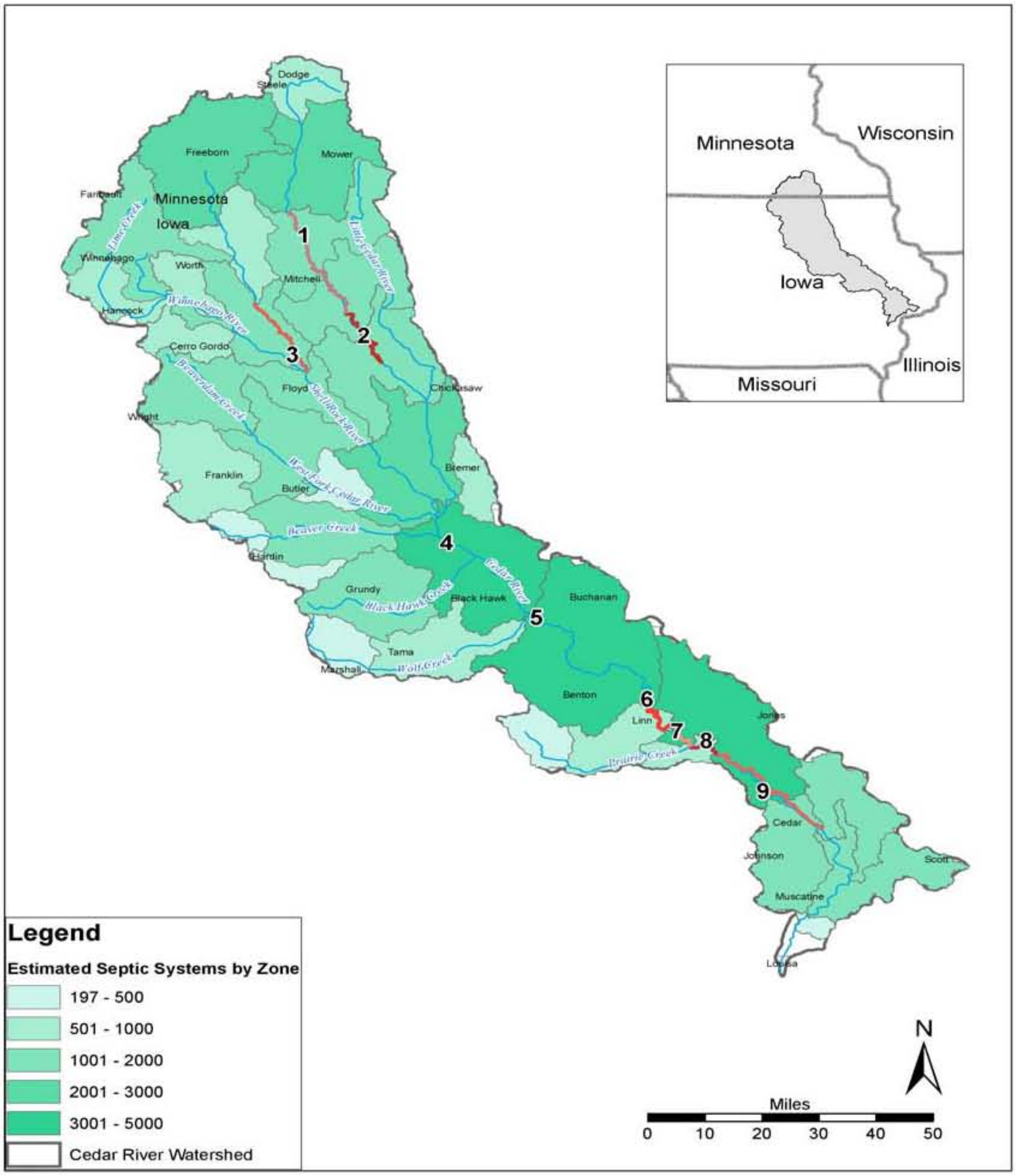

Figure 3-11. Watershed Wide Distribution of Septic System.

Direct Defecation. Livestock spend some time directly in waterbodies, depending on the time of the year. Therefore, there is potential for direct defecation from livestock into waterbodies. The amount of time cattle spend in the waterbodies depends on the availability of access, the availability of off-stream watering facilities, the time of year and the associated temperature. Grazing season is from April to November, but the time spent in the streams varies as the temperature varies. For modeling purposes only beef cattle that are not in confinement operations have access to the streams. In this watershed, approximately 70 percent of the beef cattle are in confinement operations most of the year and do not have access to streams (Loy, 2007). The beef cattle that have access to the streams typically spend between zero to five percent of their time directly in streams (Russell, 2007).

Even with estimating that only 30 percent of the beef cattle have access to the streams for direct defecation, the LA would be very large. However, all grazing beef cattle do not have access to the streams. To obtain a better estimate of access to the streams, perennial streams were buffered by one mile and it was assumed the beef cattle grazed only on pastureland. The amount of grazed pastureland within the buffered area was then calculated. Finally, the number of beef cattle that have access to streams was reduced by the percent of the total area of grazed pastureland within the buffered region.

3.5.2. Indirect Sources

Indirect sources of bacteria include runoff generated from rainfall events from open feedlots, agriculture and other lands that receive contributions of bacteria from manure application, grazing livestock, and wildlife.

Open Feedlots. Open feedlots are unroofed or partially roofed animal-feeding operations. Crop, vegetation, forage growth or residue cover is not maintained during the period the animals are confined in the operation. Runoff from open feedlots can transport bacteria to waterbodies by precipitation. If a discharge occurs, it must be reported to the IDNR. Generally, open feedlots with more than 1,000 animal units are required to have an NPDES permit but smaller facilities are regulated under certain conditions. For NPDES-regulated facilities, all manure must be retained to prevent any discharge that results from less than a 25-year, 24-hour, precipitation event (IDNR, 2007b). There are no NPDES-permitted facilities in the watershed. However, there are numerous presently unpermitted small open feedlots throughout the watershed. The amounts of bacteria that are transported to nearby waterbodies are dependent on the size of operation, type of animals and manure management practices.

Any CAFO that does not obtain an NPDES permit must operate as a no discharge operation. Any discharge from an unpermitted CAFO is a violation of Section 301. It is EPA's position that all CAFOs should obtain an NPDES permit because it provides clarity of compliance requirements, authorization to discharge when the discharges are the result of large precipitation events (e.g., in excess of 25-year and 24-hour frequency/duration) or are from a man-made conveyance. However, many large CAFOs (mostly the poultry and swine sectors) contend that they do not discharge nor propose to discharge therefore are not required to obtain an NPDES permit. It is EPA's opinion that many of the "no discharge" CAFOs do not have adequate land application area to ensure the agronomic uptake of land applied waste. Furthermore, there are many AFOs that meet the definition of a medium CAFO (i.e., discharge via a man-made conveyance) but are unpermitted and have not limited their impact on waters by applying Best Professional Judgment to effluent reductions.

Permitted CAFOs identified in this TMDL are part of the assigned WLA. AFOs and unpermitted CAFOs are considered under the LA because we do not currently have enough detailed information to know whether these facilities are required to obtain NPDES permits. This TMDL does not reflect a determination by EPA that any such facility does not meet the definition of a CAFO nor that the facility does not need to obtain a permit. To the contrary, a CAFO that discharges or proposes to discharge has a duty to obtain a permit. If it is determined that any such operation is an AFO or CAFO that discharges, any future WLA assigned to the facility must not result in an exceedance of the sum of the WLAs in this TMDL as approved.

Although, Iowa has a voluntary facility registration program, only a small fraction of the open feedlots have registered. The IDNR used aerial photographs to estimate the size and location of open feedlots throughout the watershed. There are approximately 1,390 open feedlots that cover approximately 1,290 acres. It is possible that some of these facilities are subject to regulation.

Minnesota requires that all feedlots with more than 50 animal units register their facility. There are approximately 125 open feedlots that cover nearly 37 acres. The area of the open feedlots was estimated based on 100 square feet per animal (Loy, 2007).

The generation of bacteria was once again developed within the framework of **BIT** using the available livestock data. The fate and transport of bacteria was then predicted by **HSPF**. According to IDNR, most open feedlots have some degree of manure runoff controls; e.g., silt fences or detention ponds. Thus the model was parameterized to mimic the anticipated hydrology (e.g., high surface runoff) and to provide some capture of the simulated bacteria runoff. Specifically, within the model, the open feedlots were connected to a detention structure with enough storage to capture one inch of runoff before discharging to the local stream. Subsequent storms would result in the detention structures having less storage until the detention structure was drained through losses; i.e., evaporation. This provided a reasonable means to account for some level of existing BMPs.

Manure Application. Livestock numbers for the Cedar River Watershed were estimated using the Census of Agriculture (Ag Census) (U.S. Department of Agriculture National Agricultural Statistics Service, 2002) for beef and dairy cattle, hogs and sheep. The Ag Census data are available by county. The subwatershed livestock population was estimated by reducing county livestock population by the percent of subwatershed within the county. The poultry numbers were obtained from the IDNR Animal Feeding Operations Division (Tinker, 2007).

All animal-feeding operations (confinements and open feedlots) in Iowa, regardless of size, are required to control manure to prevent discharge to waterbodies. While the manure is on site, it is stored in concrete or earthen structures. The manure generated is then land-applied in either solid or liquid form. Manure disposal is prohibited within 200 feet of a well, agriculture drainage well, cistern, surface water inlet or water source, or within 800 feet of high-quality water source (IDNR, 2007c). Manure application typically occurs in April and early May and again in October and November. Manure application occurs only on cropland within the watershed (Morrical, 2007). The **BIT** spreadsheet was modified with watershed-specific application rates and application to pastureland was removed. With no permitted and very few registered facilities, it is uncertain how well the regulations are followed.

Grazing Livestock. Staff from the Iowa Beef Center (IBC) at Iowa State University were contacted regarding the time livestock spend grazing pastureland and the types of beef cows that are typically confined. The IBC staff indicated that the "Cattle Other" and "Dairy Cows" categories in the Ag Census were typically beef and dairy cows in confinement operations. The "Beef Cows" category is livestock that is typically allowed to graze during the grazing season (Loy, 2007).

The subwatershed livestock population was estimated by reducing county livestock population by the percent of subwatershed within the county. Typically, beef cattle and sheep graze (and defecate) on pastureland during the grazing season, which is from April to November. Precipitation events then transport bacteria to nearby waterbodies. The beef cattle (nonconfined) graze approximately 20 percent of the time from January to March, nearly 100 percent from April to October and approximately 80 percent of the time in November and December (Russell, 2007). Because 70 percent of the beef cattle are typically confined, the **BIT** spreadsheet was modified to calculate manure accumulation based on the beef cattle that are allowed to graze instead of assuming all beef cattle graze within the watershed.

Sheep graze nearly 100 percent of the time from April to October and are confined from November through March (Morrical, 2007). The 2002 Iowa Land Cover Grid was used to determine where the grazed pastureland is located throughout the subwatershed.

Wildlife. The **BIT** spreadsheet addresses ducks, geese, deer, beaver and raccoons. IDNR wildlife biologists indicated there is not sufficient data on beavers within the watershed and there are no other significant quantities of other wildlife to be included (Andrews, 2007). Wildlife is generally present on cropland, pastureland and forestland. The manure generated by the wildlife can be transported to nearby waterbodies through precipitation events.

The wildlife population density estimates were obtained from IDNR wildlife biologists. Duck density is approximately four animals per square mile while the geese density ranges from two to three animals per square mile (Zenner, 2007). Ducks and geese are not typically found on pastureland (Zenner, 2007). Deer density is approximately five animals per square mile (Suchy, 7007). The raccoon density varies seasonally but the average density is approximately 21 animals per square mile (Andrews, 2007). The daily per-acre bacteria loading rate for each animal was calculated using literature values.

Urban Development. Bacteria from urban development include stormwater runoff and illicit discharge of sanitary wastes. The urban areas were categorized as build-up which consists of commercial/industrial, residential and roads. These land use areas were quantified from the 2002 Iowa Land Cover Grid. The daily per acre bacteria loading rate was calculated using literature values. A weighted average accumulation rate was calculated for each subwatershed based on the land use categories present and the corresponding accumulation rates. Although there are several large urbanized areas within the watershed, the build-up consists of only four percent of the area within the watershed.

3.6. TMDL Development Methodology

This section provides an explanation of the components included in each of the nine individual TMDLs to follow in Chapters 4 through 12.

I. **Problem Identification.** This component focuses on analyzing the flow and bacteria data that are available within the vicinity of the reach segment to understand the magnitude and mechanisms of the impairment.

   a. Problem Statement. The problem statement indicates the number of samples exceeding the WQS for the segment. The frequency of data sampling does not typically support validating the compliance of a geometric mean standard; thus, exceedance analyses focus on the single-sample maximum standard.

   b. Data Interpretation. The variability of concentration with respect to time and flow is presented in a series of figures and tables. This analysis provides insight to the environmental conditions associated with the impairment.

II. **Pollution Source Assessment.** This component presents an assessment of all potential bacteria pollution sources that are hydrologically connected to the impaired reach.

   a. Identification of Pollution Sources. A figure is presented that displays the contributing drainage area (CDA) to the segment endpoint and summarizes the distribution of land use, NPDES permits, animal and open feedlot density and locations of WWTPs within the CDA.

III. **Flow Variable TMDL Approach and Target.** This component specifies the TMDL. The TMDL is the maximum amount of pollutant that the reach can receive and still meet WQS and/or designated uses. The TMDL is developed according to the following equation:

$$TMDL = \sum WLA + \sum LA + MOS \qquad (3.1)$$

where:

TMDL = Total Maximum Daily Load
∑WLA = Sum of Waste Load Allocations (point sources)
∑LA = Sum of Load Allocations (nonpoint sources)
MOS = Margin of Safety (implicit and/or explicit)

Based on a review of the flow and water quality data available throughout the watershed, it was determined that bacterial concentrations were primarily a function of flow. EPA recommends using a flow variable expression for the TMDL when critical conditions are associated with precipitation/runoff events and sources include multiple-source types (EPA, 2007a). Thus a flow-variable daily load was selected to represent the TMDL.

A combination of the LDC modeling approach and a dynamic watershed model (**HSPF**) was used to develop the flow-variable daily load expressions. The LDC method involves developing a flow duration curve or a representation of the percentage of days when a given instream flow occurs. Figure 3-12 shows an example of a LDC. A lower percentile rank of flow exceedance indicates periods when flow volumes rarely occur and typically represent high-flow periods (runoff events); whereas, a high percentile rank of flow exceedance indicates periods when flows are exceeded most of the time (low flow periods). The allowable pollutant load curve (solid blue line in Figure 3-12) is calculated using the flow duration curve and multiplying the flow values to the applicable TMDL target. The curve represents a dynamic expression of the allowable daily load as a function of the measured flow for the respective day. Alternatively, separate daily loads can be identified for select flow conditions. For this TMDL, flows are grouped into quartiles and for each of these flow categories, a daily maximum load and a daily average load were identified as the daily load expression. The daily maximum allows for infrequent high-concentration inputs while the daily average represents the desired persistent loading conditions. LDC for all stations that have water quality data and flow are presented in Appendix C.

The observed pollutant loads in the river for the local sampling point are plotted on the LDC to show the departure, or lack thereof, from WQS for existing conditions. The points that fall above the allowable load curve indicate exceedances while the points that fall below the curve indicate acceptable loads. The observed pollutant loads are also symbolized by season to provide a temporal aspect to the analysis. Calibrated **HSPF**-predicted flows were used for the LDCs when measured flows were not concurrently collected with water quality samples and/or not available at a TMDL endpoint.

The estimated waste load component of the TMDL is also shown on the LDCs for the existing and post-TMDL implementation conditions. The **HSPF** application for the Cedar River was used to estimate the WLA that was delivered to each TMDL endpoint. This estimation was done by limiting the sources of bacteria within the model application to the WLA sources (e.g., NPDES facility loads) and allowing the model to predict the transport and fate of these loads. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period, which was from 1995 to 2005.

a. Existing Load and Departure From Load Capacity. Summary statements about the LDC are presented along with exceedance predictions from **HSPF**.

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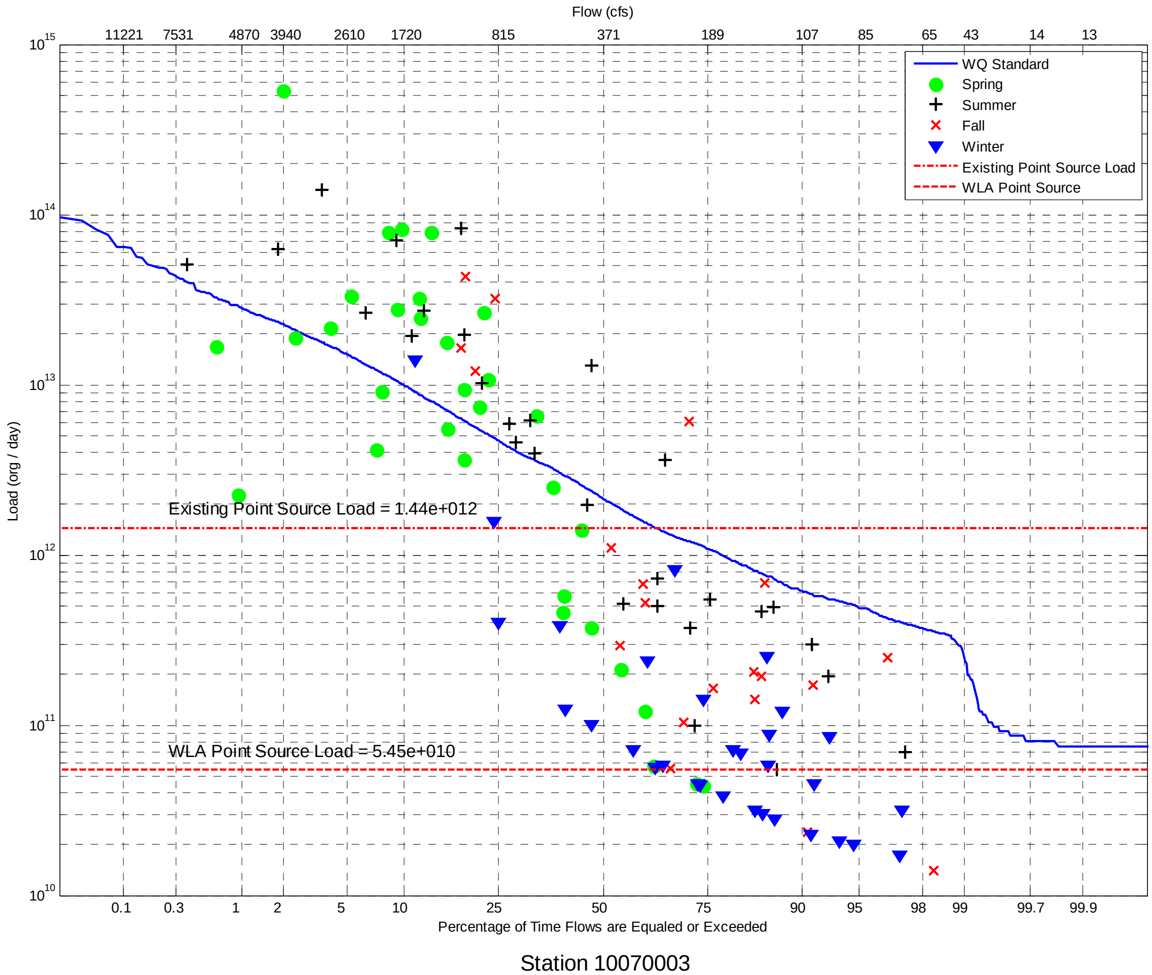

Figure 3-12. Load Duration Curve for *E. coli* Measured at Station 10070003.

b. Flow Variable TMDL Targets for Daily Loads. A dual target was established using the 95th percentile load as the daily maximum value using the single sample maximum criterion to address variability in instantaneous concentrations and the 50th percentile load using the geometric mean criterion as the allowable daily median to represent long-term loading goals. This effectively sets a bounding range of loads that can occur for each of the four flow ranges which will result in compliance with the WQS.

IV. **Pollutant Allocation.** This component presents the source allocation of all potential sources of bacteria. These estimates are based on a combination of **HSPF** predictions and available data within the immediate vicinity of the TMDL endpoints; the predictions represent the combined processes of generation and transport and fate.

a. Source Allocation. The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application are summarized. These sources include the following:

- Indirect Sources
  - Forest
  - Crop
  - Ungrazed Pasture
  - Grazed Pasture
  - Built-Up Areas (Pervious and Effectively Impervious)
  - Open Feedlots
  - MS4s (defined as a point source)
- Direct Sources
  - Septics (defined as a nonpoint source)
  - Point Sources
  - Cattle in Streams (defined as a nonpoint source)

b. Waste Load Allocation. The WLA includes contribution from all upstream NPDES regulated point sources, including WWTPs, MS4s, and WLA reserve (not regulated but quantified for future permits).

With the change in Iowa's WQS for indicator bacteria (now *E. coli*) such that all perennial rivers and streams are subject to Class A1 standards (see Section 3.2 for more details) during the recreation season (March 15 to November 15), all perennial rivers and streams will have the WQS of 126 cfu/100 ml (geometric mean of multiple samples) and 235 cfu/100 ml (single sample maximum). For the purpose of this TMDL the WLA are based on the Class A1 standards. Thus if a WWTP or other point source discharges to a perennial river or stream with effluent concentrations higher than 235 cfu/100 ml, they would be in violation of the WQS. Considering that all the permitted WWTPs and other point source dischargers in the Cedar River Watershed discharge to a perennial stream, the daily WLA for all point sources in the watershed is established, by rule, to be based on a concentration standard of 235 cfu/100 ml (single sample maximum). Individual WLAs for each of the permitted point sources in the watershed are presented in Table D-1 in Appendix D.

The WLA for urban stormwater point sources in the watershed will be implemented through the NPDES MS4 permits, basin numeric limits are allocated in segment specific tables.

The total waste load allocated for NPDES-regulated livestock animal-feeding operations in the Cedar River Watershed is zero in accordance with Iowa Administration Code (IAC) Chapter 65. Note that there are no permitted feeding operations listed in the watershed.

As previously discussed, the cumulative waste load component of the TMDL is shown on the LDCs for the existing and post-TMDL implementation conditions. For most basins this load represents a flow independent or static load which was predicted to be delivered to the TMDL endpoint, and was based on transport and fate model simulations spanning a wide range of hydrologic conditions occurring from 1995 to 2005. For segments with MS4 permitted municipalities located within their drainage the WLA increases with higher flows as the MS4 WLAs are not static. This increase in WLA is not represented in the LDC but is quantified in tabular form for each segment containing a MS4 entity.

c. Load Allocation. The LA includes contribution from all nonpoint sources as well as animal-feeding operations without an NPDES permit.

   The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - MOS - \sum WLA \qquad (3\text{-}2)$$

   The TMDL LA for bacteria in the LDCs is illustrated graphically as the region between the red WLA line and the solid blue line representing the daily bacteria load at 235 cfu/100 ml. Note that this does not include any explicit MOS.

d. Margin of Safety. The MOS will be set explicitly at 35 *E. coli* cfu×flow for daily maximum load and 19 *E. coli* cfu×flow for geometric mean load, or 15 percent when expressed as a percentage of the TMDL. This is consistent with *E. coli* TMDLs developed within Iowa by the IDNR and is used to account for uncertainties in modeling.

4. Indicator Bacteria Impairment for Cedar River from Rock Creek to Iowa/Minnesota Border (IA 02-CED-0110_3)

The drainage area of the 30-mile river segment, at its endpoint, is approximately 900 square miles, the majority of which lies within Minnesota (shown as Segment 1 on the figures). The nearest water quality station with a significant number of samples for this reach is 10340003; the station is located approximately 10 miles downstream of the segment's endpoint. Concurrent flow estimates are provided at the segment endpoint by **HSPF** Reach 110.

4.1. Problem Identification

4.1.1. Problem Statement

Of the 42 bacteria samples collected at Water Quality Station 10340003 during the recreation season, 31 percent (or 13 samples) exceeded the WQS. Of the 12 bacteria samples collected at Water Quality Station 10340003 during the nonrecreation season, no concentrations exceeded the WQS. Table 4-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 4-1. Descriptive statistics for Water Quality Station 10340003.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	41	846	3,650	10	10	64	205	23,000
Fecal	13	2,603	7,631	9	10	51	478	27,600

4.1.2. Data Interpretation

Figure 4-1 presents a boxplot of concentration data grouped by flow range (high, mid, and low). There were 21 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are exceedances for all flow ranges; however, the amount of data within the high and low flow ranges allows limited interpretation.

Table 4-2 presents descriptive statistics for Water Quality Station 10340003 by season. For all seasons classified as recreational (i.e., spring, summer, fall), the upper quartile exceeds the WQS. Figure 4-2 shows this graphically by the four seasons and Figure 4-3 shows this by recreational season.

4.2. Pollution Source Assessment

4.2.1. Identification of Pollutant Sources

Figure 4-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0110_3. The upstream watershed's indirect sources are predominately cropland (approximately 80 percent of the area) and a relatively large density of runoff from manure application on open feedlots local to the impaired reach. This area also contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 15 NPDES-permitted WWTPs and 1 MS4 (Minnesota) permit within the watershed. Of the 15 permitted WWTPs, 14 facilities use disinfection during the recreation season. The one facility that does not disinfect is a controlled-discharge facility in Iowa. Because discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

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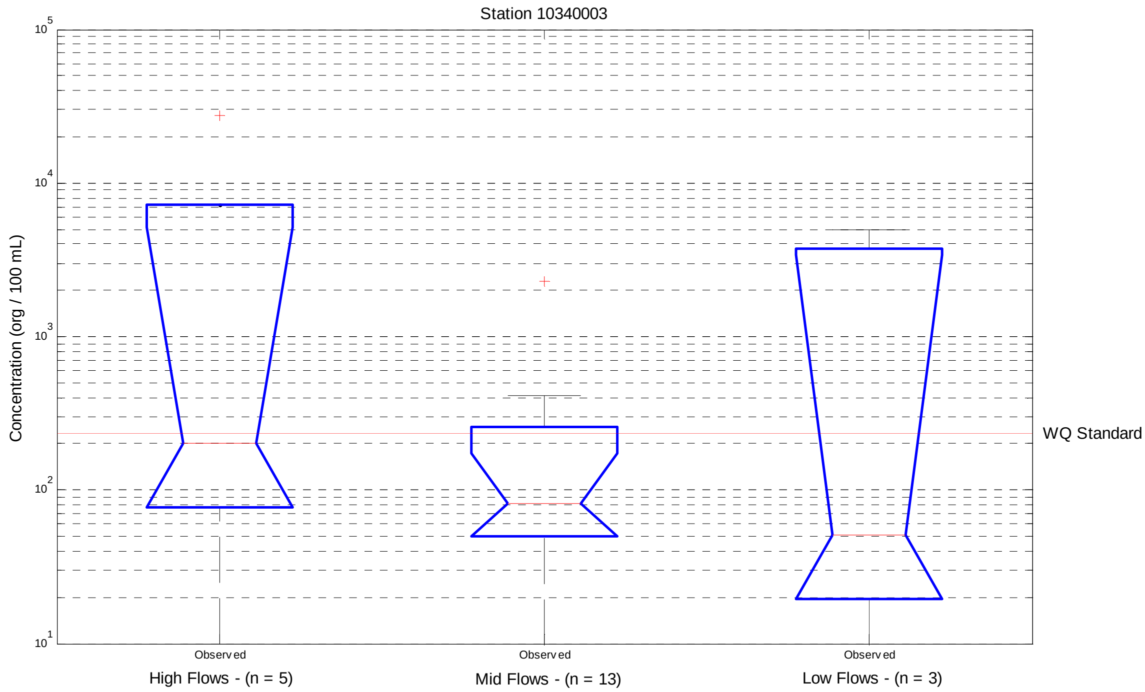

Figure 4-1. Boxplots for Water Quality Station 10340003 by Flow Range.

Table 4-2. Descriptive statistics for Water Quality Station 10340003 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	16	148.1	178.9	10	10	82	285	588.8
Summer	16	3,434	8,594	51	77	165	373	27,600
Fall	10	1,080	2,114	9	10	60	1,550	5,200
Winter	12	34	52	9.2	10	10	42.5	190

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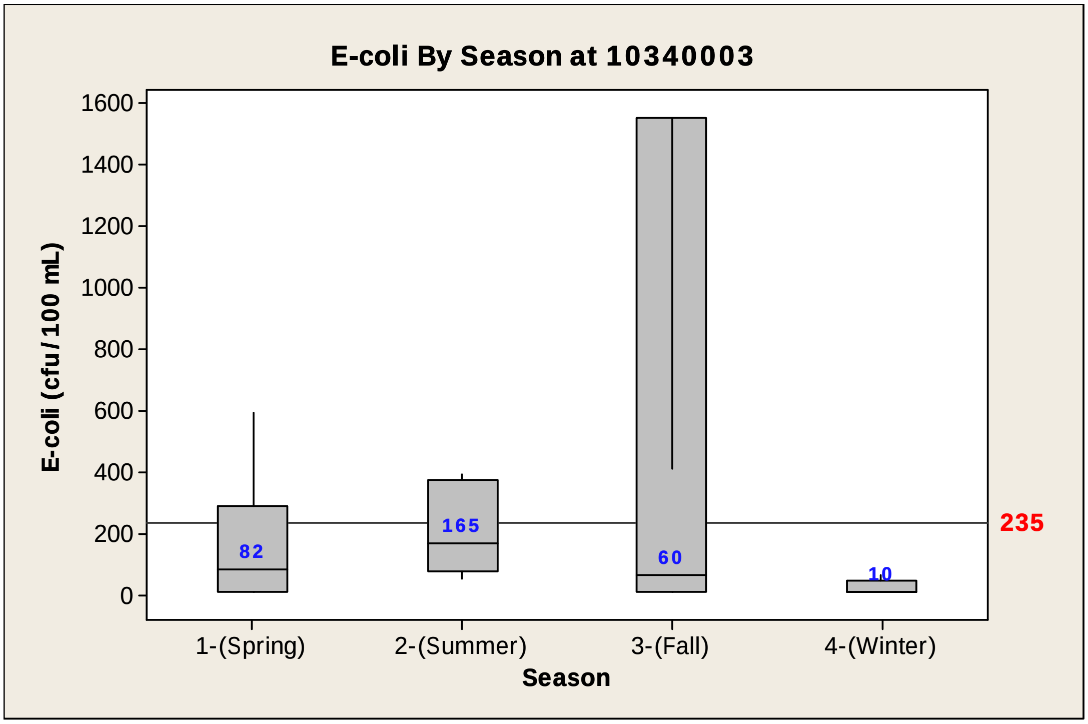

Figure 4-2. Boxplots for Water Quality Station 10340003 by Season.

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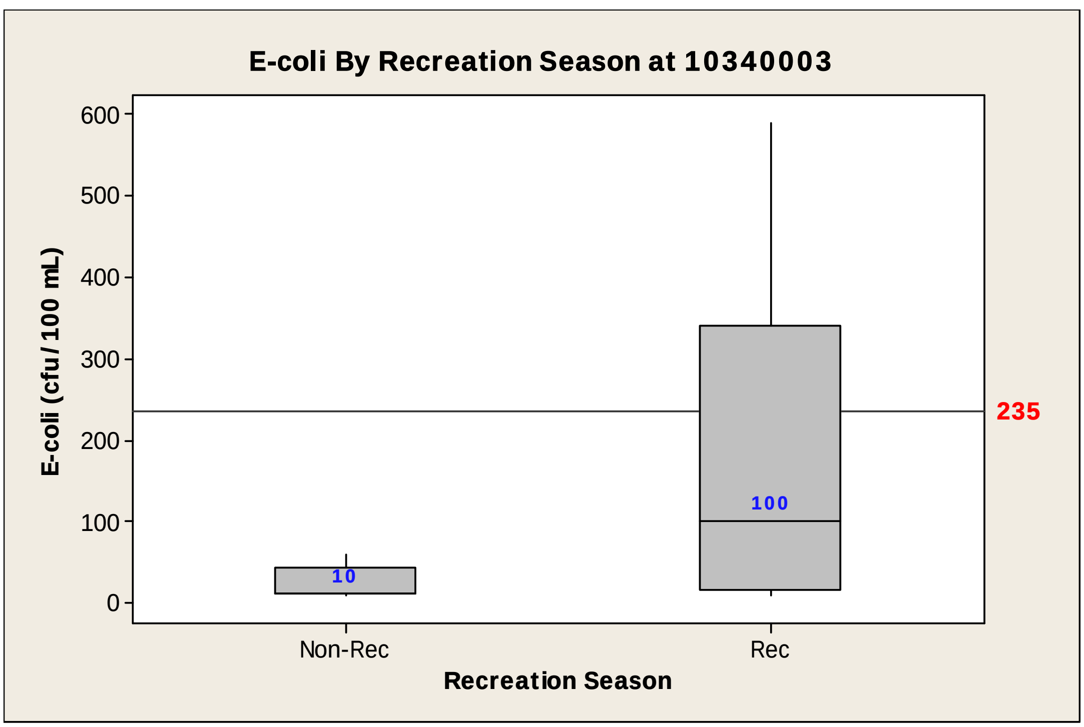
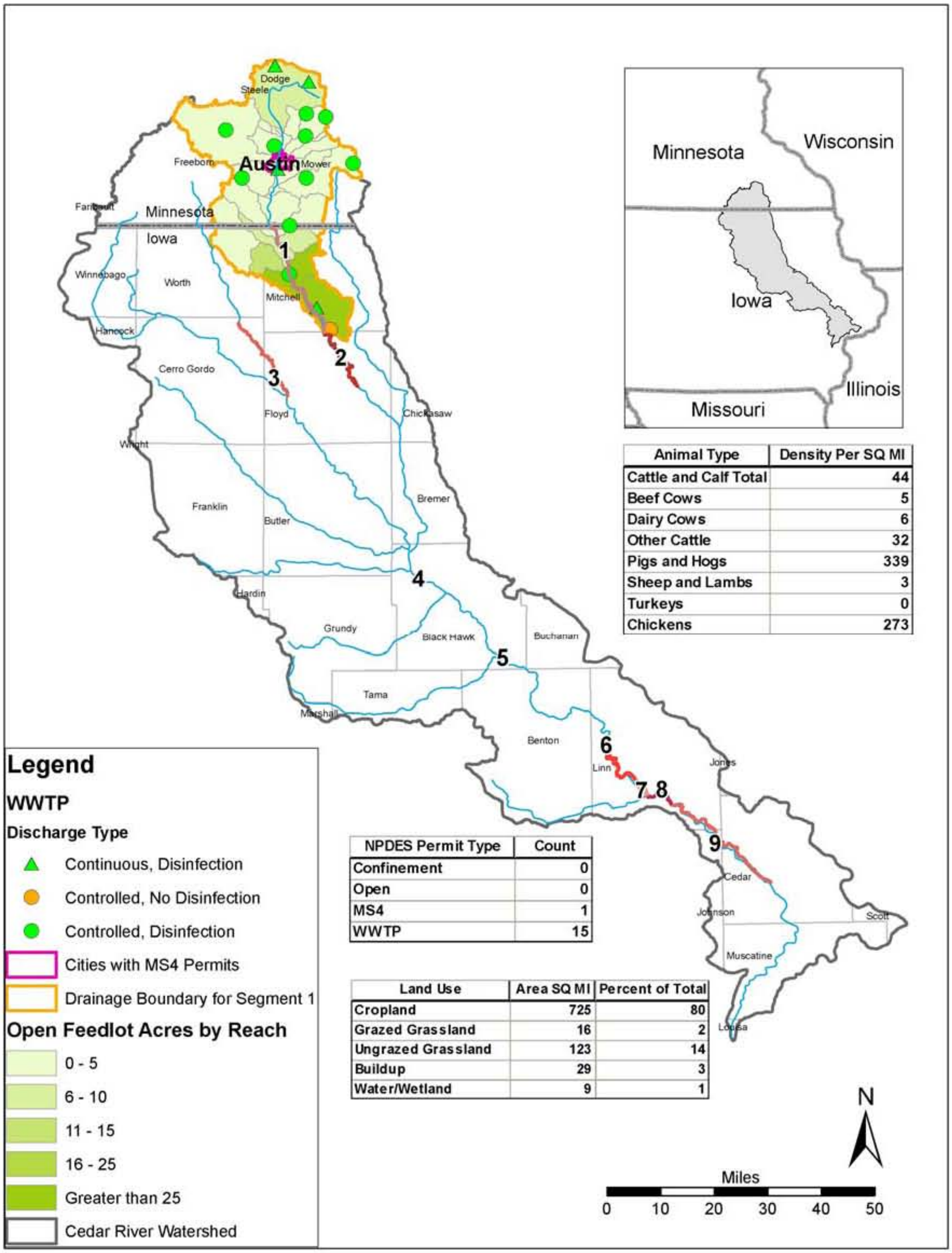


Figure 4-3. Boxplots for Water Quality Station 1034003 by Recreation Season.



Animal Type	Density Per SQ MI
Cattle and Calf Total	44
Beef Cows	5
Dairy Cows	6
Other Cattle	32
Pigs and Hogs	339
Sheep and Lambs	3
Turkeys	0
Chickens	273

NPDES Permit Type	Count
Confinement	0
Open	0
MS4	1
WWTP	15

Land Use	Area SQ MI	Percent of Total
Cropland	725	80
Grazed Grassland	16	2
Ungrazed Grassland	123	14
Buildup	29	3
Water/Wetland	9	1

Figure 4-4. Pollutant Sources for Cedar River Segment IA 02-CED-0110_3.

4.3. Flow Variable TMDL Approach and Target

4.3.1. Existing Load and Departure From Load Capacity

Figure 4-5 presents the LDC for IA 02-CED-0110_3. This curve presents a dynamic expression of the maximum daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 42 bacteria samples collected at Water Quality Station 10340003 during the recreation season, 31 percent (or 13 samples) exceeded the WQS. Of these 42 samples, flow estimates are available for 21 samples during the recreational season. Spring, summer and fall were defined to be within the recreation season. These 21 pollutant loads are plotted on the curve and symbolized by season. Table 4-3 summarizes the exceedances by quartile flow regime for these data.

RSI-1748-08-026

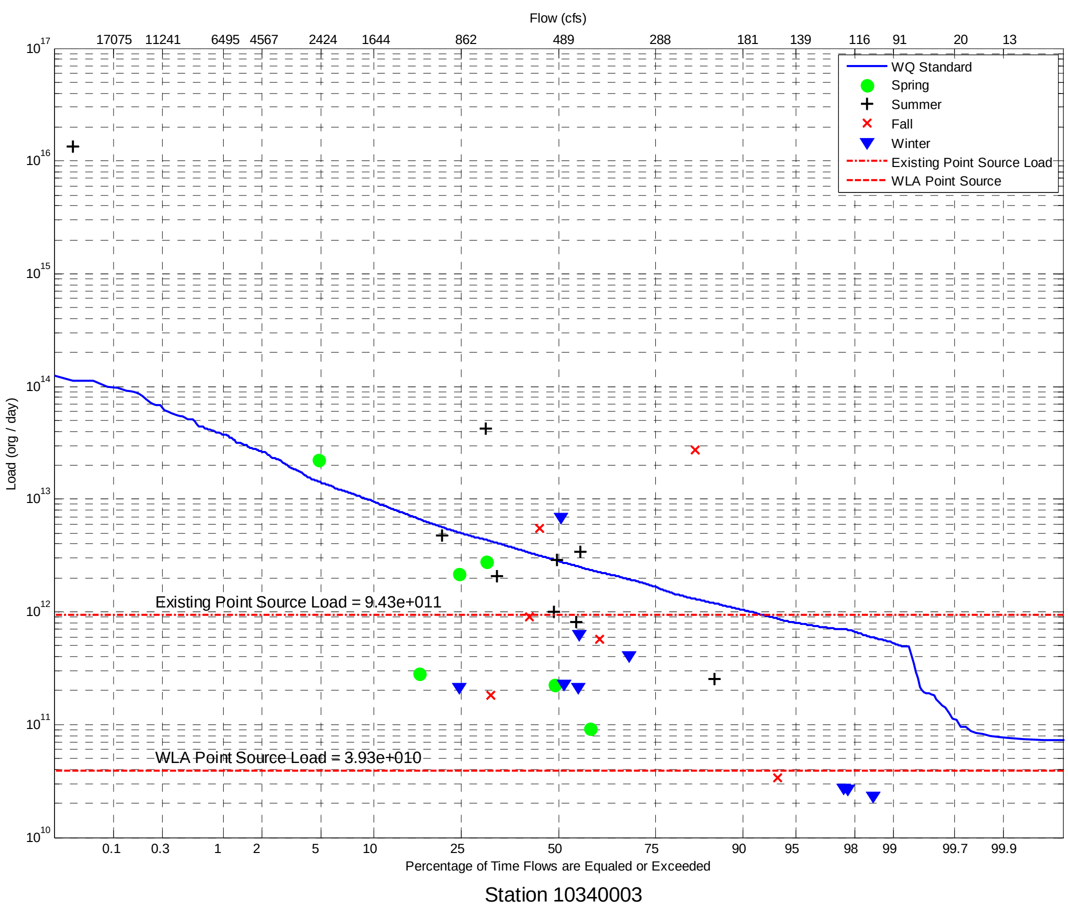


Figure 4-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10340003.

Table 4-3. Departure from load capacity for IA 02-CED-0110_3 by flow regime.

Flow Range[1]	# samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	3	33.3	95.3	95.3
0.25–0.50	7	28.6	14.9	26.6
0.50–0.75	6	33.3	83.2	89.8
0.75–1.00	5	40.0	99.1	99.1

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 4-4 provides an analysis of the HSPF-predicted daily concentrations for Reach 110 for the time period of 1995-2005 under existing conditions. These predictions show similar results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 4-4. HSPF-Predicted departure from load capacity for IA 02-CED-0110_3.

Q1 percentile (cfu/100 ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100 ml)	% Exceed max-standard	% Exceed geom-standard
29	111	308	31	48

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

4.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 4-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 4-5. The loads in Table 4-5 include a 15 percent MOS.

Table 4-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_3.

TMDL	Flow quartile (low to high flows)			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	5.02E+11	1.00E+12	1.70E+12	3.75E+12
Daily median flow (cfs)	163	325	550	1,216
Daily maximum load (cfu/day)	1.33E+12	2.35E+12	4.11E+12	2.89E+13
Daily maximum flow (cfs)	231	408	714	5,035

4.4. Pollutant Allocation

4.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 4-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland.

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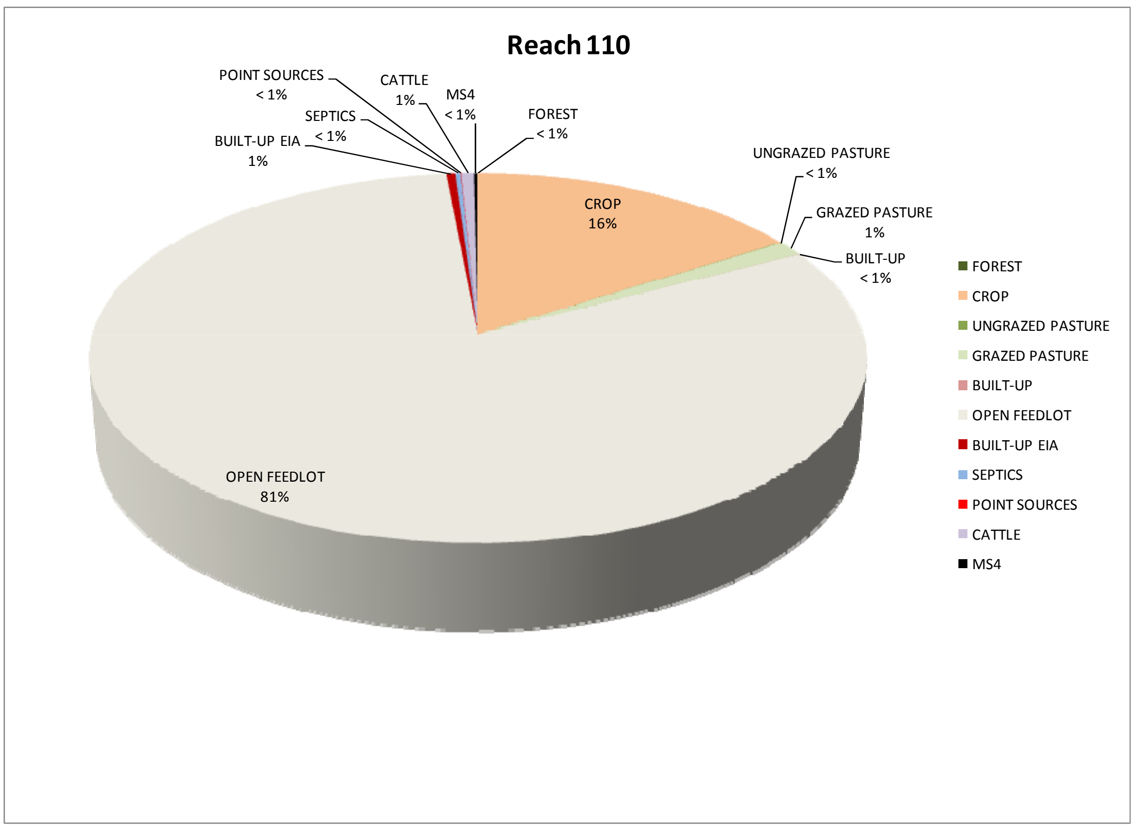


Figure 4-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0110_3.

4.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, the WLA is expressed as a static load. The WLA component of the TMDL is shown in Figure 4-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0110_3, the WLA was calculated to be 3.93E+10 *E. coli* cfu/day, this includes a reserve WLA of 3.48E+08 *E. coli* cfu/day for unsewered communities in the basin. The existing point source load is 9.43E+11 *E. coli* cfu/day. To obtain the WLA, the existing point source load needs to be reduced by 96 percent.

4.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (4\text{-}1)$$

Table 4-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 4-5.

Table 4-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load IA 02-CED-0110_3.

LA	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	3.88E+11	8.12E+11	1.40E+12	3.15E+12
Daily maximum load (cfu/day)	1.09E+12	1.95E+12	3.45E+12	2.46E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

4.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for daily maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 4-7. Flow variable MOS (cfu/day) for daily maximum load and daily median load IA 02-CED-0110_3.

MOS	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	7.54E+10	1.50E+11	2.54E+11	5.62E+11
Daily maximum load (cfu/day)	1.99E+11	3.52E+11	6.16E+11	4.34E+12

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

5. Indicator Bacteria Impairment for Cedar River from Charles City Dam No. 2 to Confluence with Rock Creek (IA 02-CED-0110_2)

The drainage area of the 19-mile river segment, at its endpoint, is approximately 1,070 square miles, with approximately one-half of the area within Minnesota (shown as Segment 2 on the figures). This reach segment is directly downstream of impaired Reach IA 02-CED-0110_3. The water quality station with a significant number of samples and within closest proximity to this reach outlet is 10340001; the station is located approximately 5 miles downstream of the segment endpoint. Concurrent flow estimates are provided at the segment endpoint by **HSPF** Reach 130.

5.1. Problem Identification

5.1.1. Problem Statement

Of the 138 bacteria samples collected at Water Quality Station 10340001 during the recreation season, 51 percent (or 70 samples) exceeded the WQS. Of the 39 bacteria samples collected at Water Quality Station 10340001 during the non-recreation season, 56 percent (or 22 samples) exceeded the WQS. Table 5-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 5-1. Descriptive Statistics for Water Quality Station 10340001.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	105	730	3,245	10	91	230	450	33,000
Fecal	72	985	4,740	9	156	313	529	40,480

5.1.2. Data Interpretation

Figure 5-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 50 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are exceedances for all flow ranges. Over one-half of the samples taken during high and low flows exceed the WQS. An additional approximate 25 percent exceed the standard during the other midrange flows. These low flow exceedances indicate indirect sources are contributing highly concentrated loads. It is apparent that both indirect and direct sources contribute to the impairment.

Table 5-2 presents descriptive statistics for Water Quality Station 10340001 by season. For all seasons classified as recreational (i.e., spring, summer, fall), the upper quartile exceeds the WQS. Figure 5-2 shows this graphically by the four seasons and Figure 5-3 shows this by recreational season.

RSI-1748-08-028

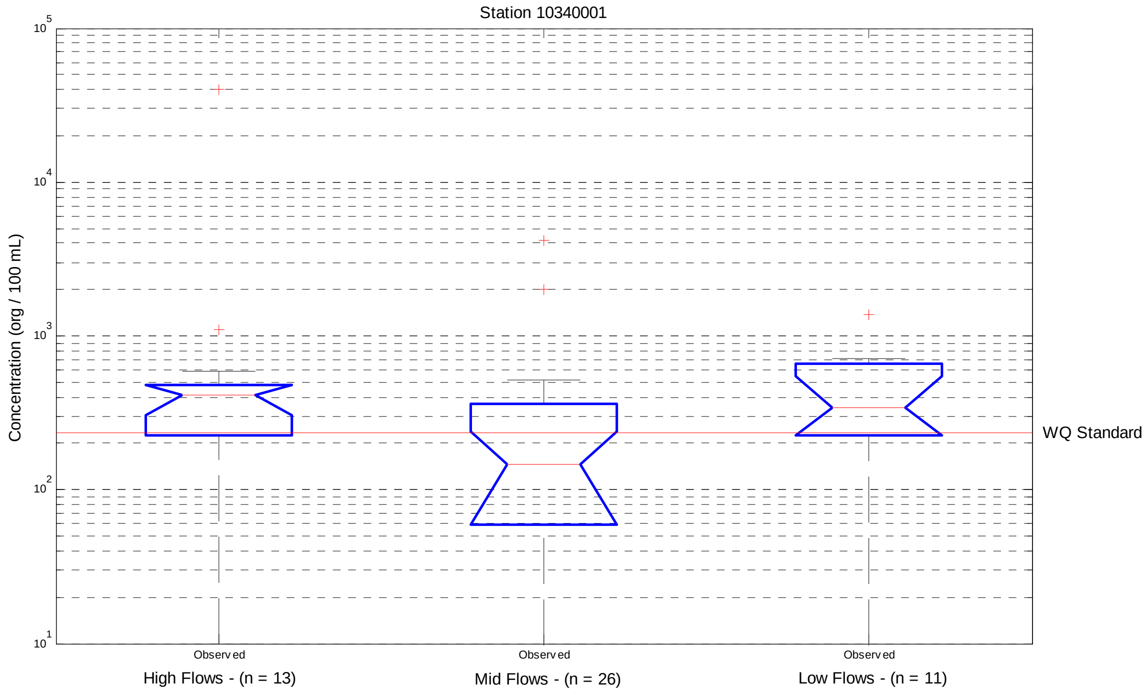


Figure 5-1. Boxplots for Water Quality Station 10340001 by Flow Range.

Table 5-2. Descriptive statistics for Water Quality Station 10340001 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	60	171.8	147.4	9.2	45.3	140	277.5	480
Summer	46	2,309	7519	60	174	360	1,127	40,480
Fall	32	516.7	442.6	50	254.2	375	631.8	2,024
Winter	39	373.3	294.6	10	170	320	533.6	1,380

5.2. Pollution Source Assessment

5.2.1. Identification of Pollutant Sources

Figure 5-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0110_2. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 80 percent of the area) and a relatively large density of open feedlots local to the impaired reach. This area also contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 16 NPDES-permitted WWTPs and one MS4 permit within the watershed. Of the 16 permitted WWTPs, 15 use disinfection during the recreation season. The one facility that does not disinfect is a controlled discharge facility in Iowa. Because discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

RSI-1748-08-029

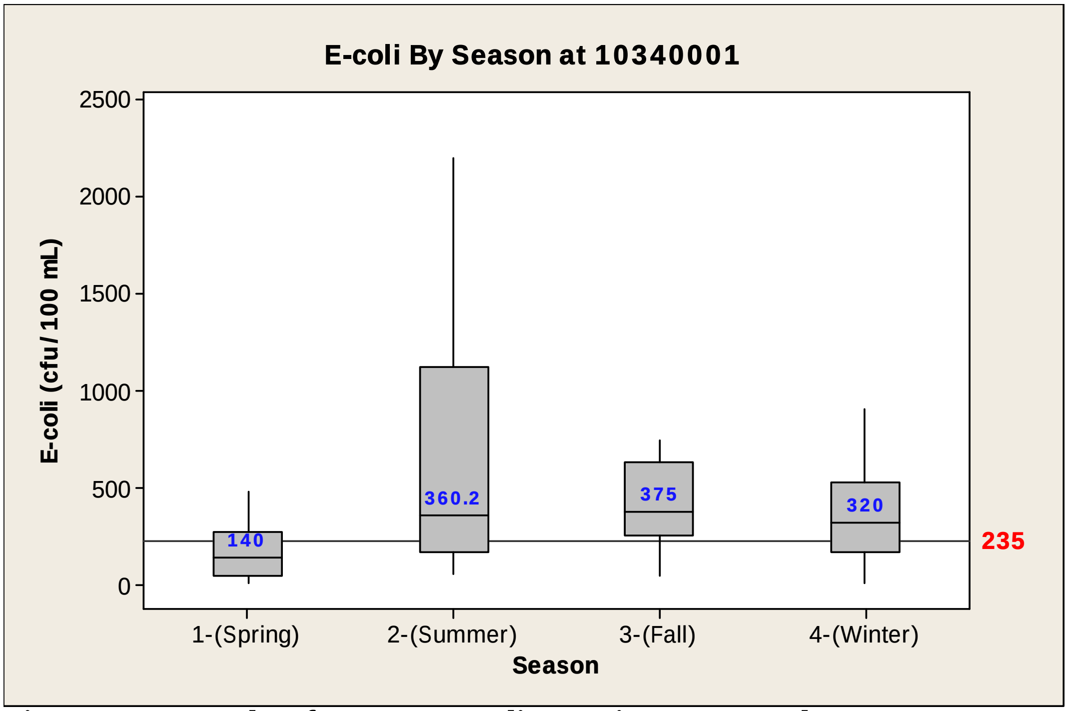


Figure 5-2. Boxplots for Water Quality Station 10340001 by Season.

RSI-1748-08-030

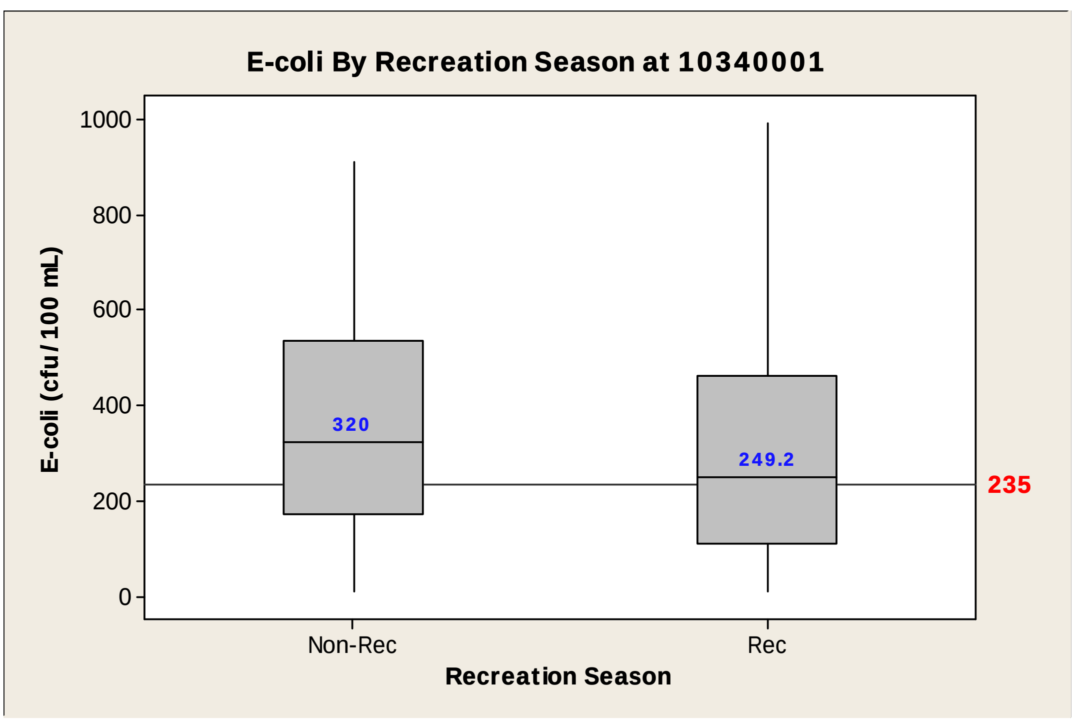
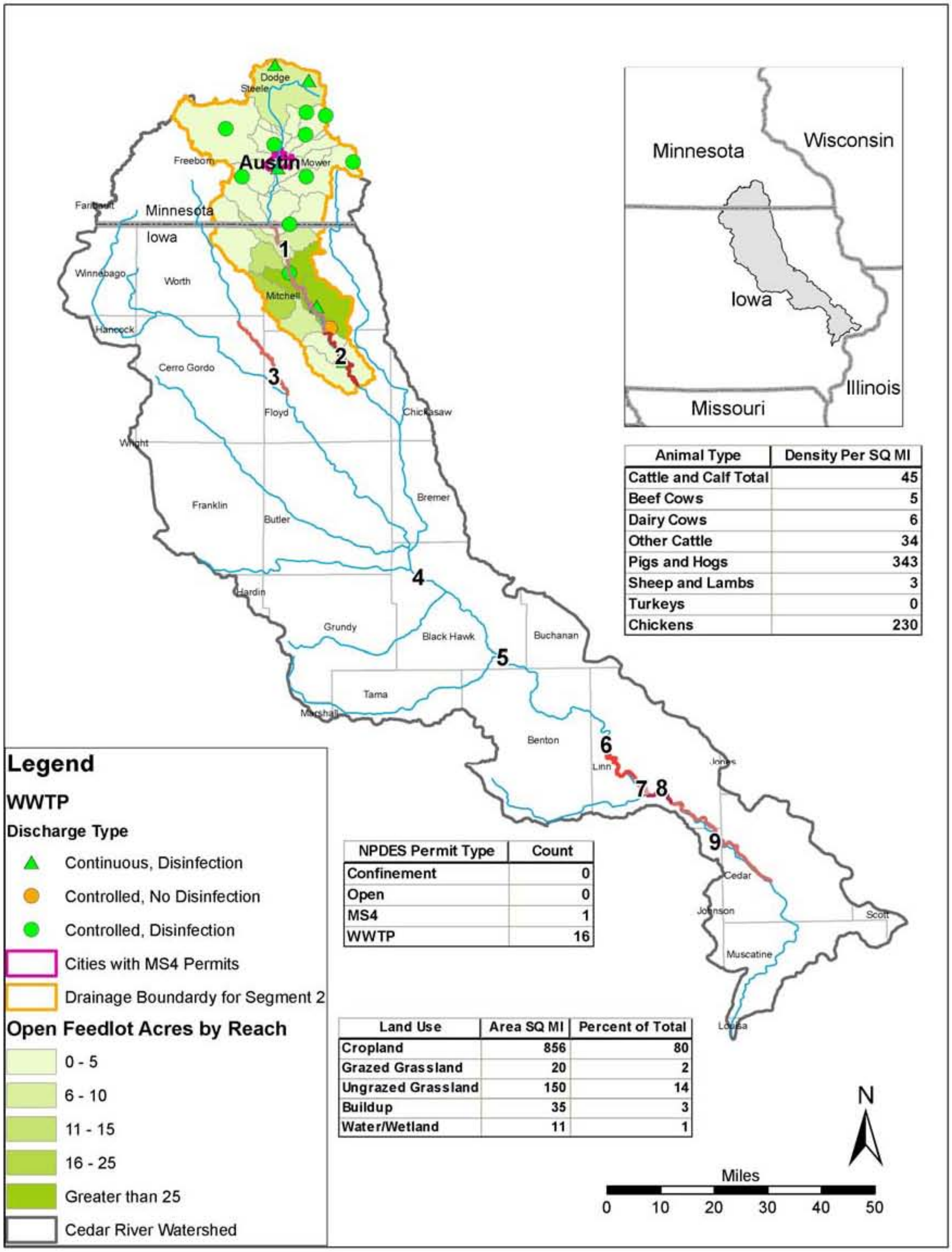


Figure 5-3. Boxplots of Water Quality Station 10340001 by Recreation Season.



Animal Type	Density Per SQ MI
Cattle and Calf Total	45
Beef Cows	5
Dairy Cows	6
Other Cattle	34
Pigs and Hogs	343
Sheep and Lambs	3
Turkeys	0
Chickens	230

NPDES Permit Type	Count
Confinement	0
Open	0
MS4	1
WWTP	16

Land Use	Area SQ MI	Percent of Total
Cropland	856	80
Grazed Grassland	20	2
Ungrazed Grassland	150	14
Buildup	35	3
Water/Wetland	11	1

Figure 5-4. Pollutant Sources for Cedar River Segment IA 02-CED-0110_2.

5.3. Flow Variable TMDL Approach and Target

5.3.1. Existing Load and Departure From Load Capacity

Figure 5-5 presents the LDC for IA 02-CED-0110_2. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 138 bacteria samples collected at Water Quality Station 10340001 during the non-recreation season, 51 percent (or 70 samples) exceeded the WQS. Of these 138 samples, flow estimates are available for 50 samples during the recreational season. Spring, summer and fall were defined to be within the recreation season. These 50 pollutant loads are plotted on the curve and symbolized by season. Table 5-3 summarizes the exceedances by quartile flow regime for these data.

RSI-1748-08-032

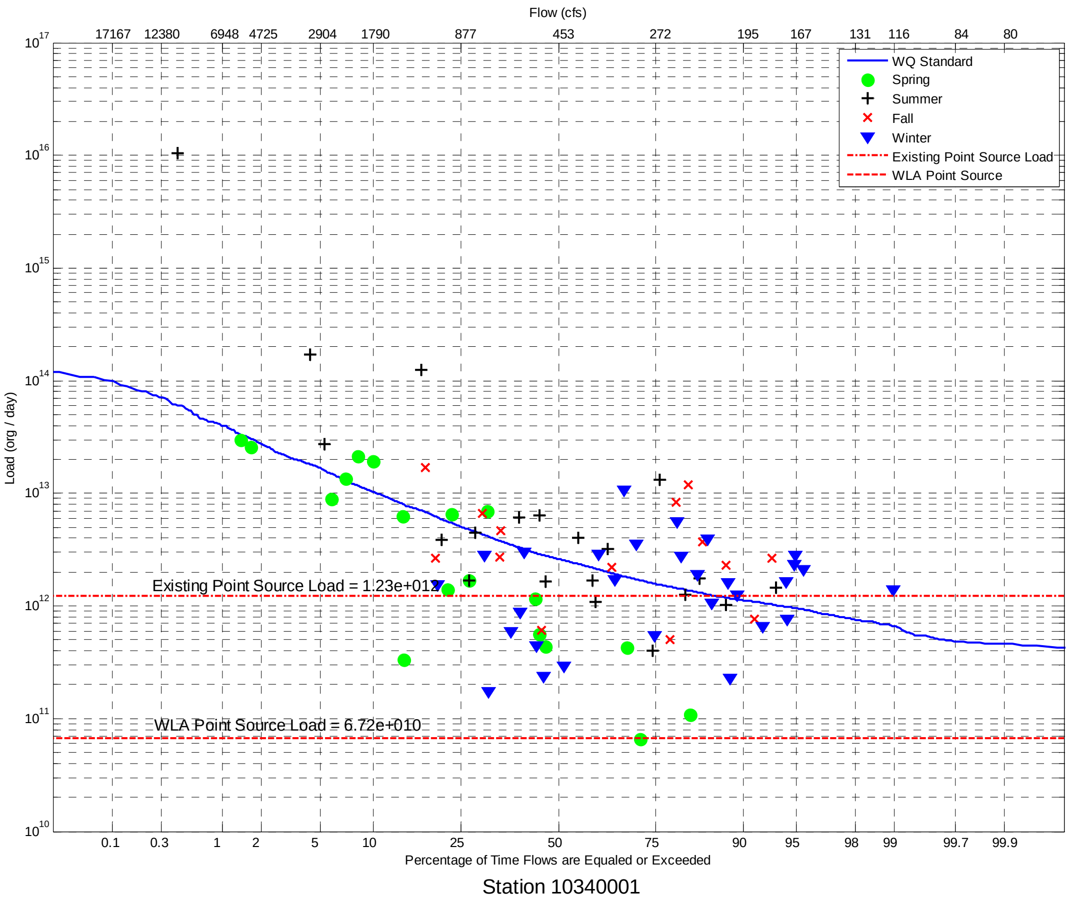


Figure 5-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10340001.

Table 5-3. Departure from load capacity for IA 02-CED-0110_2 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	11	72.7	41.0	83.0
0.25–0.50	10	40.0	81.5	88.4
0.50–0.75	16	31.3	34.7	94.4
0.75–1.00	13	69.2	43.2	99.4

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 5-4 provides an analysis of the **HSPF**-predicted daily concentrations for Reach 130 for the time period of 1995-2005 under existing conditions. These predictions show similar (slightly lower) results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 5-4. HSPF-Predicted departure from load capacity for IA 02-CED-0110_2.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
37	97	262	27	48

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection. Based on the number of exceedances at low flows, it is clear that these point source loadings and other indirect sources require reductions.

5.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 5-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 5-5. The loads in Table 5-5 include a 15 percent MOS.

Table 5-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_2.

TMDL	Flow quartile (low to high flows)			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	6.07E+11	1.18E+12	1.99E+12	4.35E+12
Daily median flow (cfs)	197	383	646	1,410
Daily maximum load (cfu/day)	1.58E+12	2.74E+12	4.84E+12	3.25E+13
Daily maximum flow (cfs)	274	477	841	5,653

5.4. Pollutant Allocation

5.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 5-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland.

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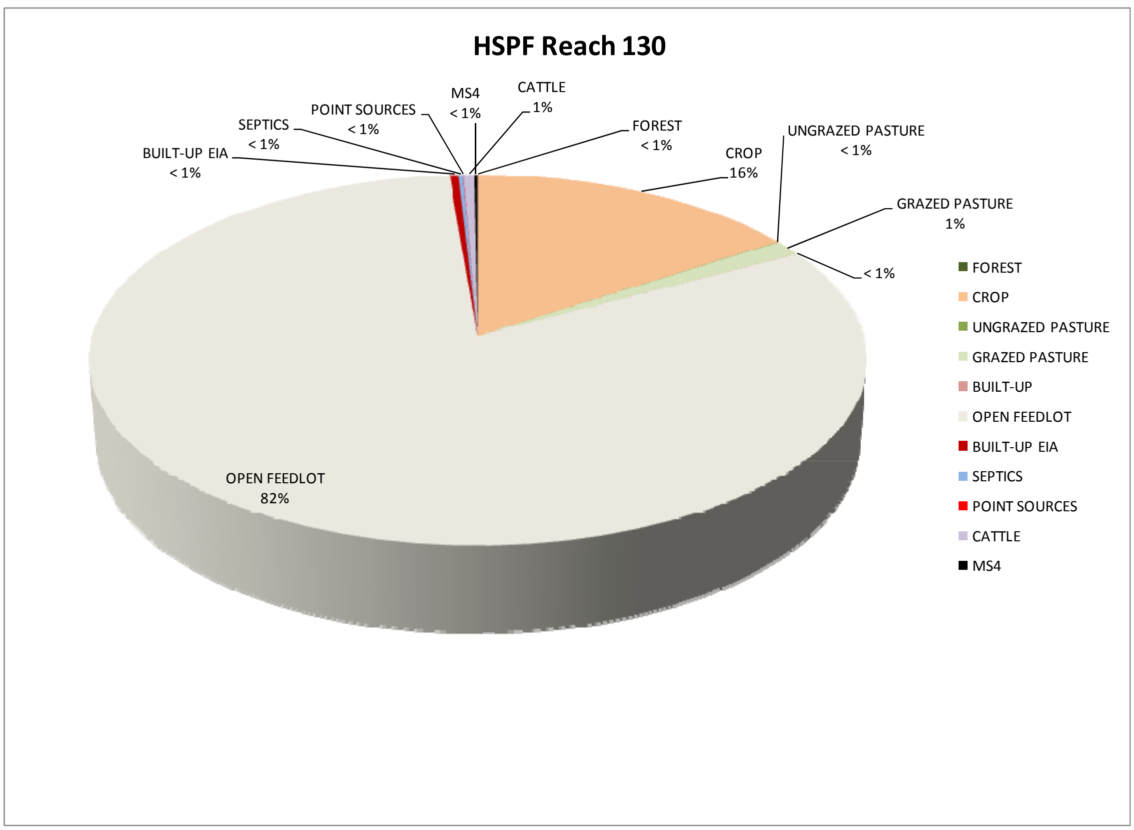

Figure 5-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0110_2.

5.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, the WLA is expressed as a static load. The estimated WLA component of the TMDL is shown in Figure 5-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0110_2, the WLA was calculated to be 6.72E+10 *E. coli* cfu/day; this includes a reserve WLA of 1.48E+08 *E. coli* cfu/day for unsewered communities in the basin. The existing point source load is 1.23E+12 *E. coli* cfu/day. To obtain the WLA, the existing point source load needs to be reduced by 95 percent.

5.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (5\text{-}1)$$

Table 5-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 5-5.

Table 5-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_2.

LA	Flow quartile (low to high flows)[1]			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	4.49E+11	9.36E+11	1.63E+12	3.63E+12
Daily maximum load (cfu/day)	1.27E+12	2.26E+12	4.04E+12	2.76E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

5.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 5-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0110_2.

MOS	Flow quartile (low to high flows)[1]			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	9.11E+10	1.77E+11	2.99E+11	6.52E+11
Daily maximum load (cfu/day)	2.36E+11	4.11E+11	7.25E+11	4.88E+12

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

6. Indicator Bacteria Impairment for Shell Rock River from Confluence with the Winnebago River to Confluence with Rose Creek (IA 02-SHL-0020_1)

The drainage area of the 22-mile river segment, at its endpoint, is approximately 1,200 square miles, with approximately one-third of the area within Minnesota (shown as Segment 3 on the figures). The nearest water quality station for this reach with a significant number of samples is 11340001; the station is located at the segment endpoint. Concurrent flow estimates are provided at the segment endpoint by **HSPF** Reach 196.

6.1. Problem Identification

6.1.1. Problem Statement

Of the 66 bacteria samples collected at Water Quality Station 11340001 during the recreation season, 23 percent (or 15 samples) exceeded the WQS. Of the 14 bacteria samples collected at Water Quality Station 11340001 during the nonrecreation season, 21 percent (or three samples) exceeded the WQS. Table 6-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 6-1. Descriptive statistics for Water Quality Station 11340001.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	40	237.2	599.3	10	20	91	207.5	3,700
Fecal	40	281	671	9	18	88	265	4,048

6.1.2. Data Interpretation

Figure 6-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 31 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that exceedances primarily occur during larger runoff events, with over 50 percent of high flow samples exceeding the WQS.

Table 6-2 presents descriptive statistics for Water Quality Station 11340001 by season. For the summer recreation season and during the winter (nonrecreation) season, the upper quartile exceeds the WQS. Figure 6-2 shows this graphically by the four seasons and Figure 6-3 shows this by recreational season. It is evident from these tables and figures that larger concentrations are measured during the summer and under high flow conditions.

6.2. Pollution Source Assessment

6.2.1. Identification of Pollutant Sources

Figure 6-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-SHL-0020_1. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 72 percent of the area) and open feedlots upstream of the impaired reach. This area also contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources.

There are 28 NPDES-permitted WWTPs and 1 MS4 permit within the watershed. Of the 28 permitted WWTPs, 19 use disinfection during the recreation season. There are nine discharge locations where no disinfection occurs; of these, seven are controlled discharges. Because controlled discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. There are two continuous discharge locations where no disinfection occurs. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

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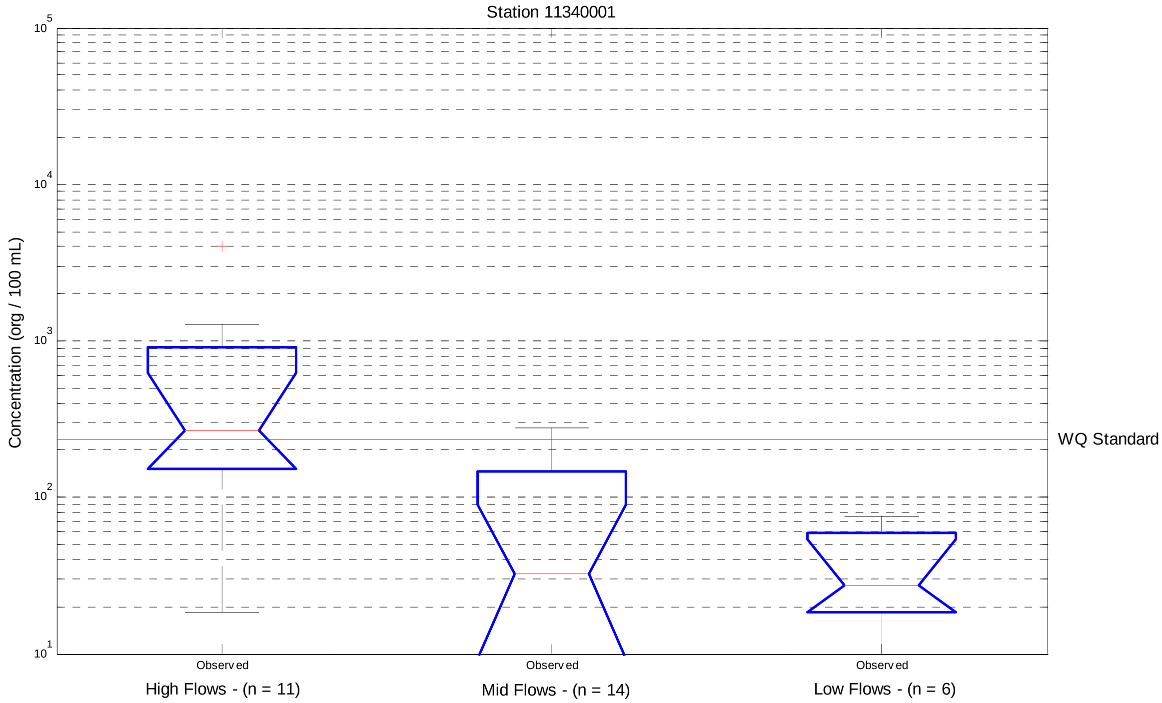

Figure 6-1. Boxplots for Water Quality Station 11340001 by Flow Range.

Table 6-2. Descriptive statistics for Water Quality Station 11340001 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	26	171.8	268.8	9.2	10	59.4	215	1,104
Summer	24	544	1,065	18	113	170	274	4,048
Fall	16	58.5	93.3	9.2	10	14.2	55.2	312.8
Winter	14	162.5	232	18.4	25.3	35.7	239.7	763.6

RSI-1748-08-035

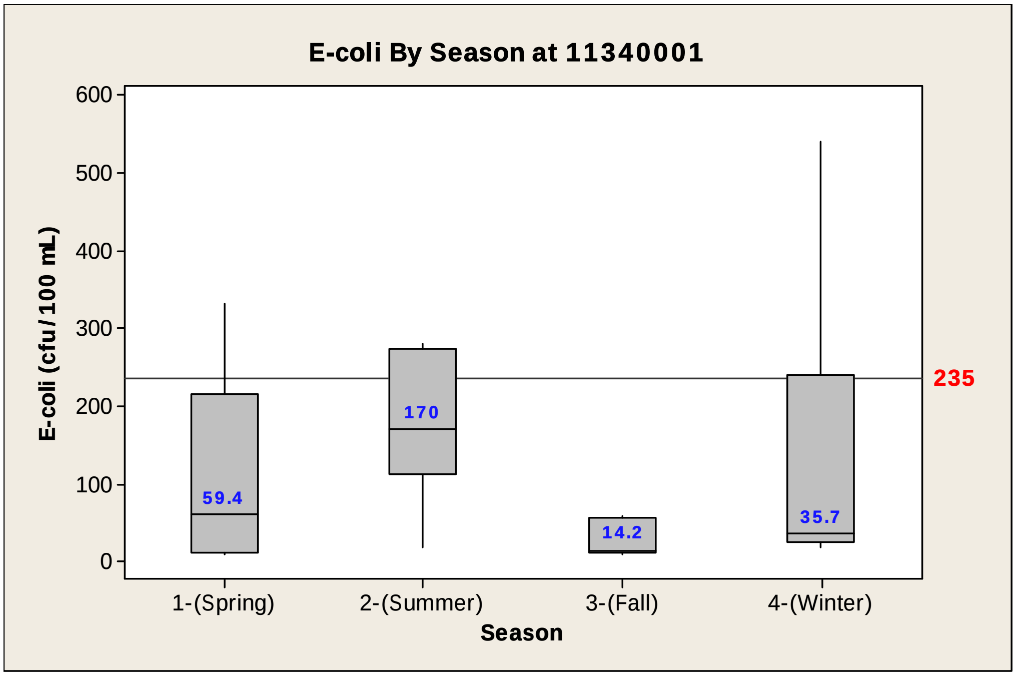

Figure 6-2. Boxplots for Water Quality Station 11340001 by Season

RSI-1748-08-036

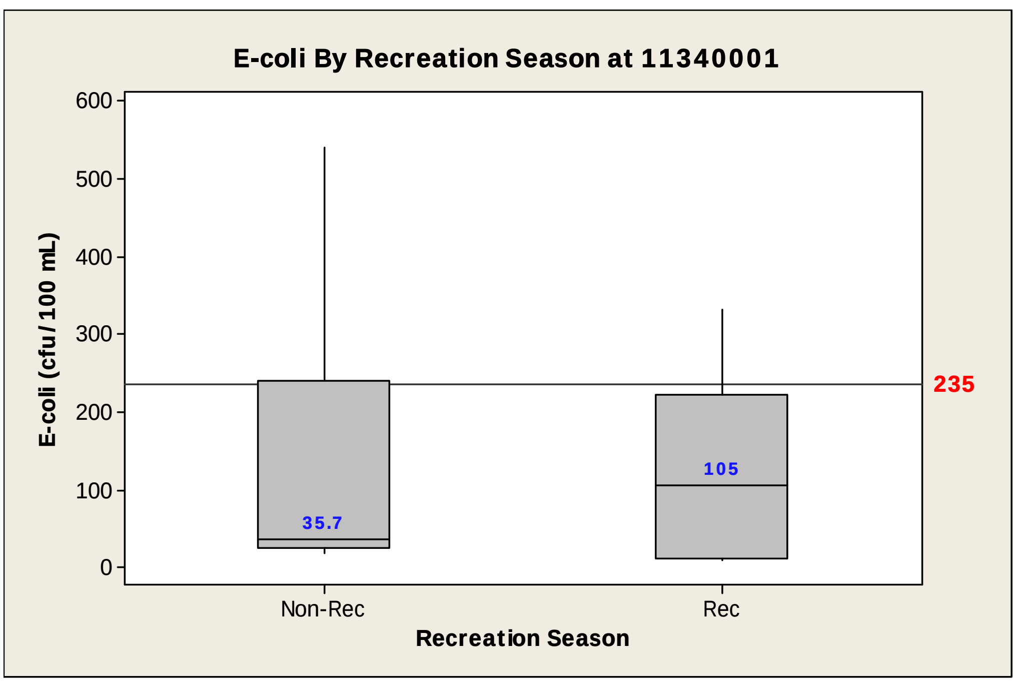

Figure 6-3. Boxplots for Water Quality Station 11340001 by Recreation Season

RSI-1748-08-037

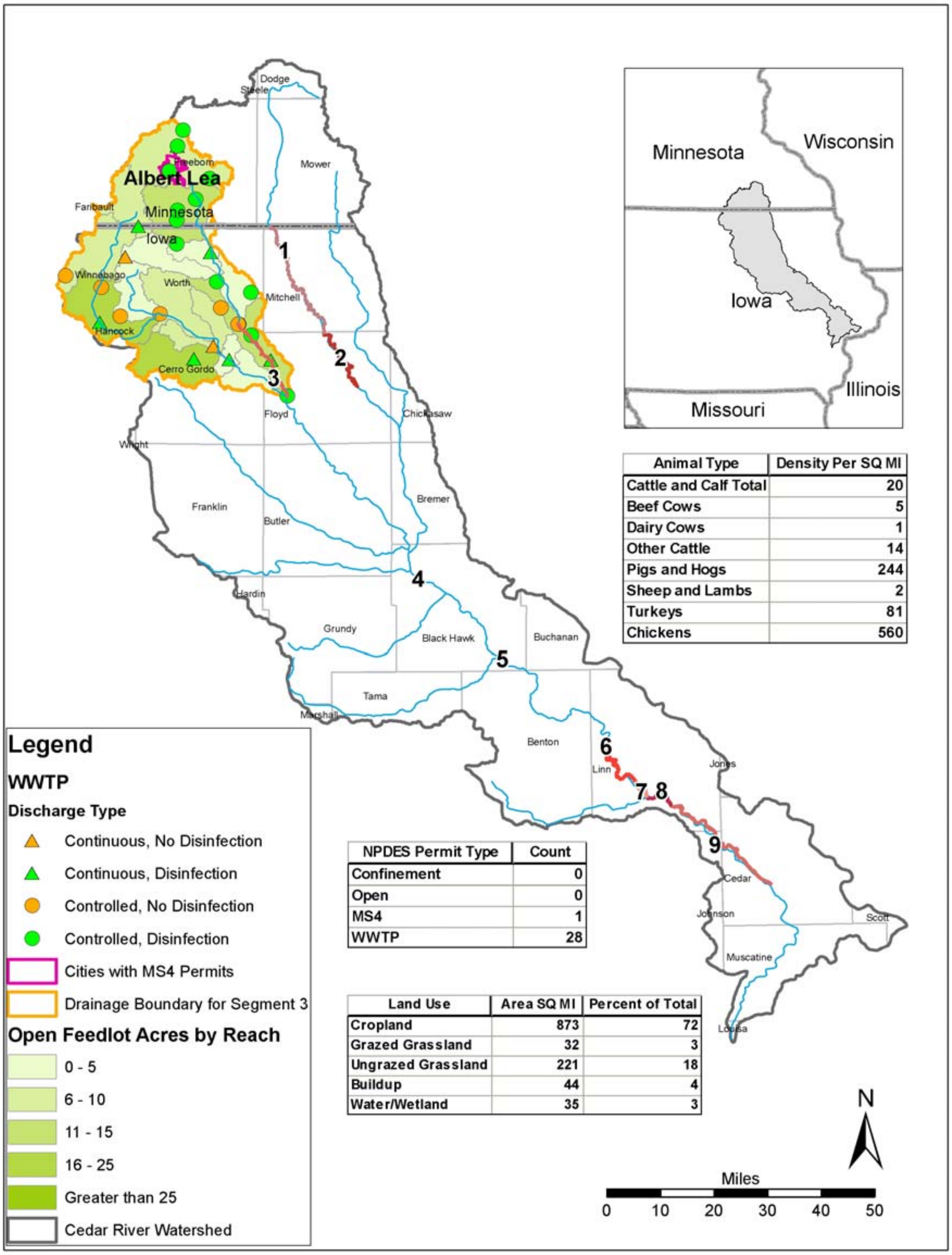

Figure 6-4. Pollutant Sources for Shell Rock River Segment IA 02-SHL-0020_1

6.3. Flow Variable TMDL Approach and Target

6.3.1. Existing Load and Departure From Load Capacity

Figure 6-5 presents the LDC for IA 02-SHL-0020_1. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 66 bacteria samples collected at Water Quality Station 11340001 during the recreation season, 23 percent (or 15 samples) exceeded the WQS. Of these 66 samples, flow estimates are available for 31 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 31 pollutant loads are plotted on the curve and symbolized by season. Table 6-3 summarizes the exceedances by quartile flow regime for these data.

RSI-1748-08-038

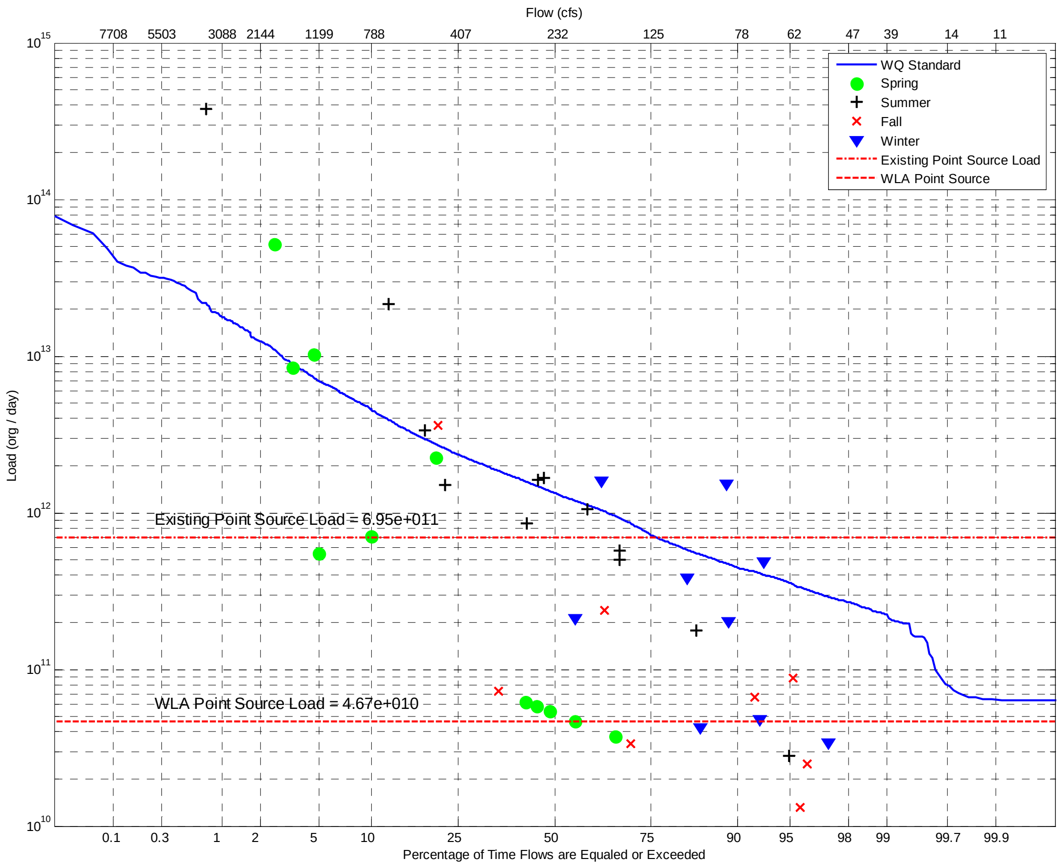

Figure 6-5. Load Duration Curve for E. coli Measured at Water Quality Station 1134001.

Table 6-3. Departure from load capacity for IA 02-SHL-0020_1 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	6	0	0	0
0.25–0.50	7	0	0	0
0.50–0.75	7	28.6	11.9	14.9
0.75–1.00	11	54.5	64.7	94.2

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 6-4 provides an analysis of the **HSPF**-predicted daily concentrations for Reach 196 for the time period of 1995-2005 under existing conditions. These predictions show similar results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 6-4. HSPF-Predicted departure from load capacity for IA 02-SHL-0020_1.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
16	38	134	18	22

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 25 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

6.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 6-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 6-5. The loads in Table 6-5 include a 15 percent MOS.

Table 6-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-SHL-0020_1.

TMDL	Flow quartile (low to high flows)			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	2.62E+11	5.61E+11	9.31E+11	2.08E+12
Daily median flow (cfs)	85	182	302	674
Daily maximum load (cfu/day)	6.96E+11	1.30E+12	2.28E+12	1.62E+13
Daily maximum flow (cfs)	121	226	396	2,814

6.4. Pollutant Allocation

6.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 6-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland.

RSI-1748-08-039

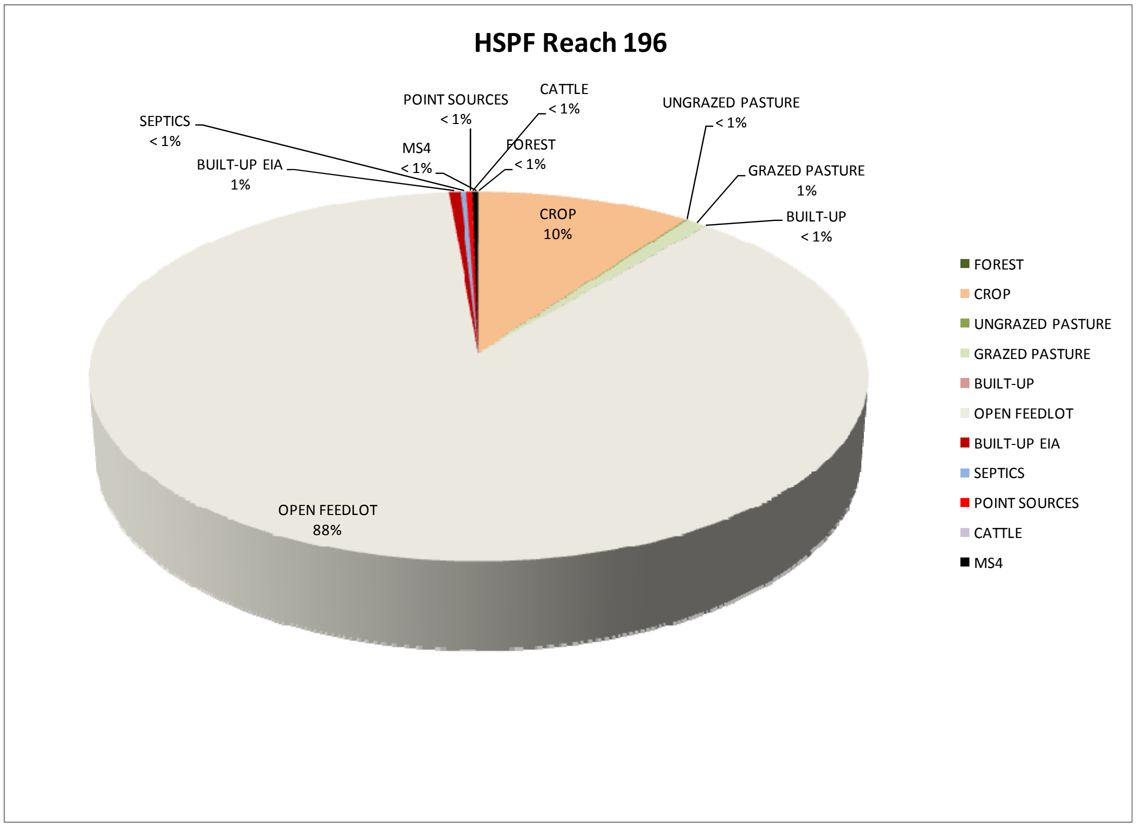

Figure 6-6. HSPF Source Allocation for Shell Rock River Segment IA 02-SHL-0020_1.

6.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, the WLA is expressed as a static load. The estimated WLA component of the TMDL is shown in Figure 6-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-SHL-0020_1, the WLA was calculated to be 4.67E+10 *E. coli* cfu/day; this includes a reserve WLA of 8.26E+08 *E. coli* cfu/day for unsewered communities in the basin. The existing point source load is 6.95E+11 *E. coli* cfu/day. To obtain the WLA, the existing point source load needs to be reduced by 93 percent.

6.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (6\text{-}1)$$

Table 6-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 6-5.

Table 6-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-SHL-0020_1.

LA	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	1.76E+11	4.30E+11	7.45E+11	1.72E+12
Daily maximum load (cfu/day)	5.45E+11	1.06E+12	1.89E+12	1.37E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

6.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 6-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-SHL-0020_1.

MOS	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	3.93E+10	8.42E+10	1.40E+11	3.12E+11
Daily maximum load (cfu/day)	1.04E+11	1.95E+11	3.42E+11	2.43E+12

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

7. Indicator Bacteria Impairment for Cedar River from the Dam of Cedar Falls Impoundment to the Upper End of the Impoundment (IA 02-CED-0050-L_0)

The drainage area of the 1.5-mile river segment, at its endpoint, is approximately 4,700 square miles, with the northern portion of the area extending into Minnesota (shown as Segment 4 on the figures). The nearest water quality station for this reach with a significant number of samples is 10070005; the station is located near the segment endpoint. Concurrent flow estimates are provided at the segment endpoint by **HSPF** Reach 230.

7.1. Problem Identification

7.1.1. Problem Statement

Of the 94 bacteria samples collected at Water Quality Station 10070005 during the recreation season, 17 percent (or 16 samples) exceeded the WQS. Of the 33 bacteria samples collected at Water Quality Station 10070005 during the nonrecreation season, 6 percent (or two samples) exceeded the WQS. Table 7-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 7-1. Descriptive statistics for Water Quality Station 10070005.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	79	134.8	326.3	10	18	36	120	2,300
Fecal	48	158.7	373	9.2	18.4	39.1	170.2	2,116

7.1.2. Data Interpretation

Figure 7-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 44 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that exceedances primarily occur during large runoff events.

Table 7-2 presents descriptive statistics for Water Quality Station 10070005 by season. For all seasons classified as recreational (i.e., spring, summer, fall), the upper quartile is below the WQS. Figure 7-2 shows this graphically by the four seasons and Figure 7-3 shows this by recreational season. It is evident from these tables and figures that the majority of these data indicate compliance with the WQS. However, exceedances tend to occur during large spring and summer runoff events.

7.2. Pollution Source Assessment

7.2.1. Identification of Pollutant Sources

Figure 7-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0050-L_0. The upstream watershed’s indirect sources are predominately runoff from manure application on cropland (approximately 77 percent of the area) and open feedlots upstream of the impaired reach. Upstream areas also contain significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 75 NPDES-permitted WWTPs and 2 MS4 permits within the watershed. Of the 75 permitted WWTPs, 41 use disinfection during the recreation season. There are 34 discharge locations where no disinfection occurs; of these, 20 are controlled discharges. Because controlled discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration are unknown. The majority of the facilities not using disinfection are located on the eastern tributaries to the Cedar River. There are 14 continuous discharge locations where no disinfection occurs. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

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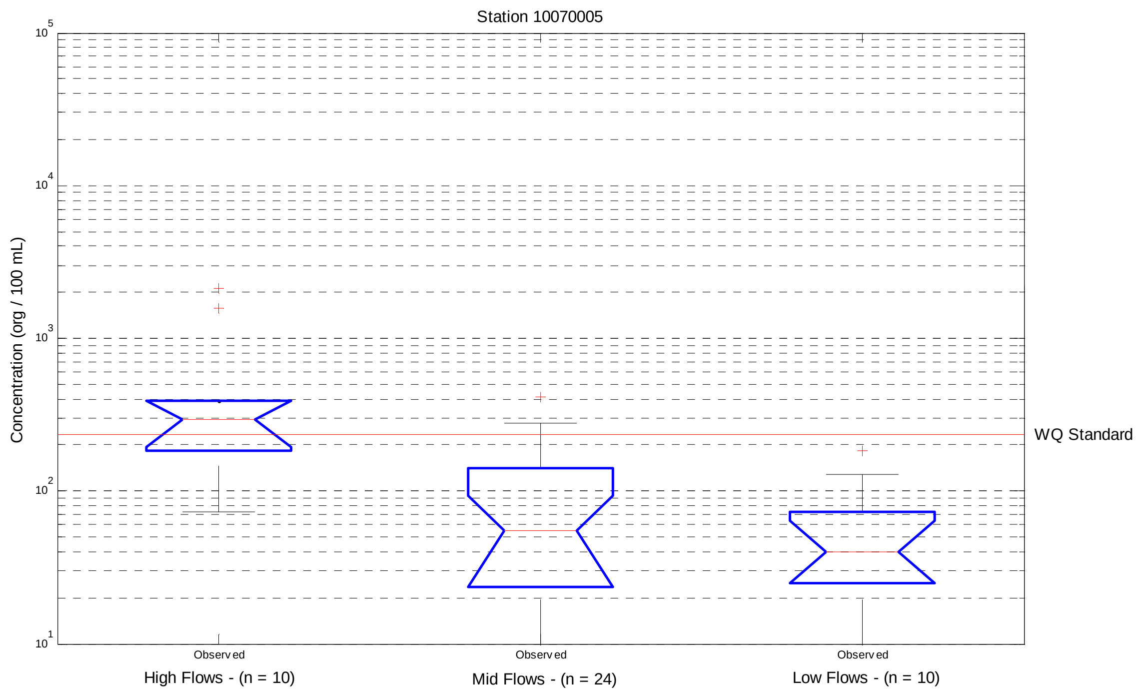


Figure 7-1. Boxplots for Water Quality Station 10070005 by Flow Range.

Table 7-2. Descriptive statistics for Water Quality Station 10070005 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	42	166.3	352.3	9.2	10	33.4	181	1,700
Summer	28	265	556	10	37	110	184	2,300
Fall	24	84.5	100.4	9.2	21.2	47.6	97.8	414
Winter	33	55.3	116.4	9.2	10	27.6	41.4	640

RSI-1748-08-041

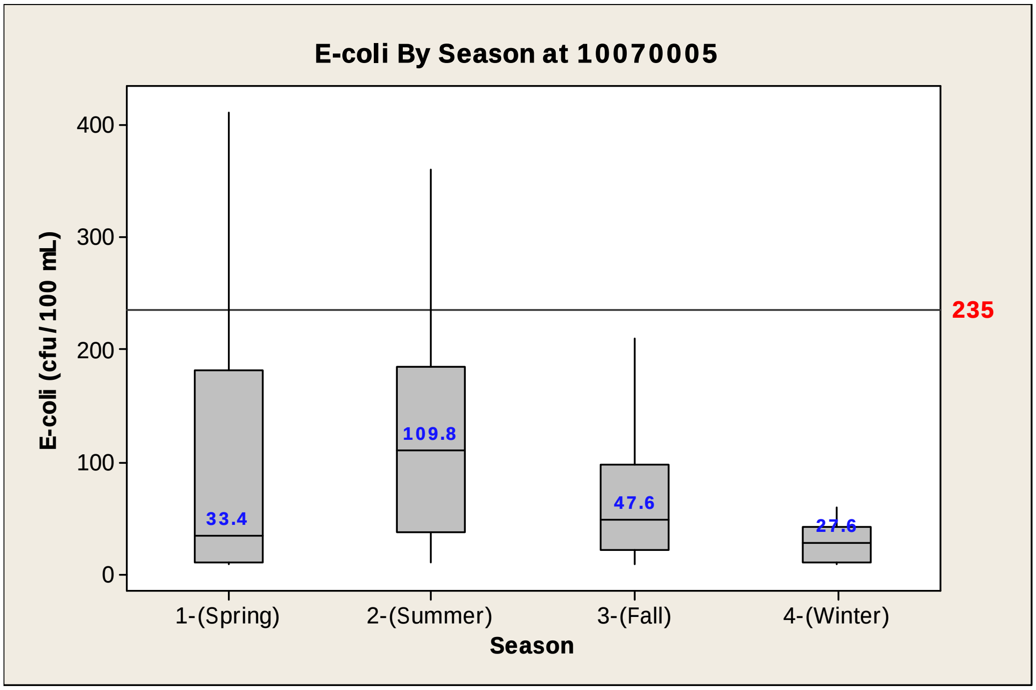


Figure 7-2. Boxplots for Water Quality Station 10070005 by Season.

RSI-1748-08-042

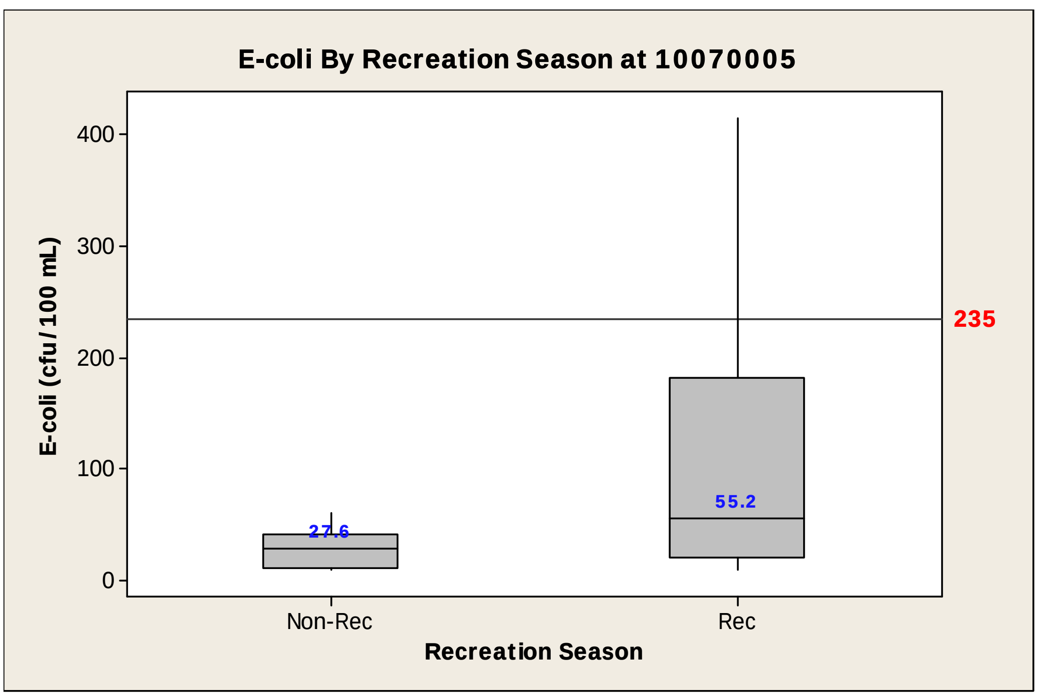
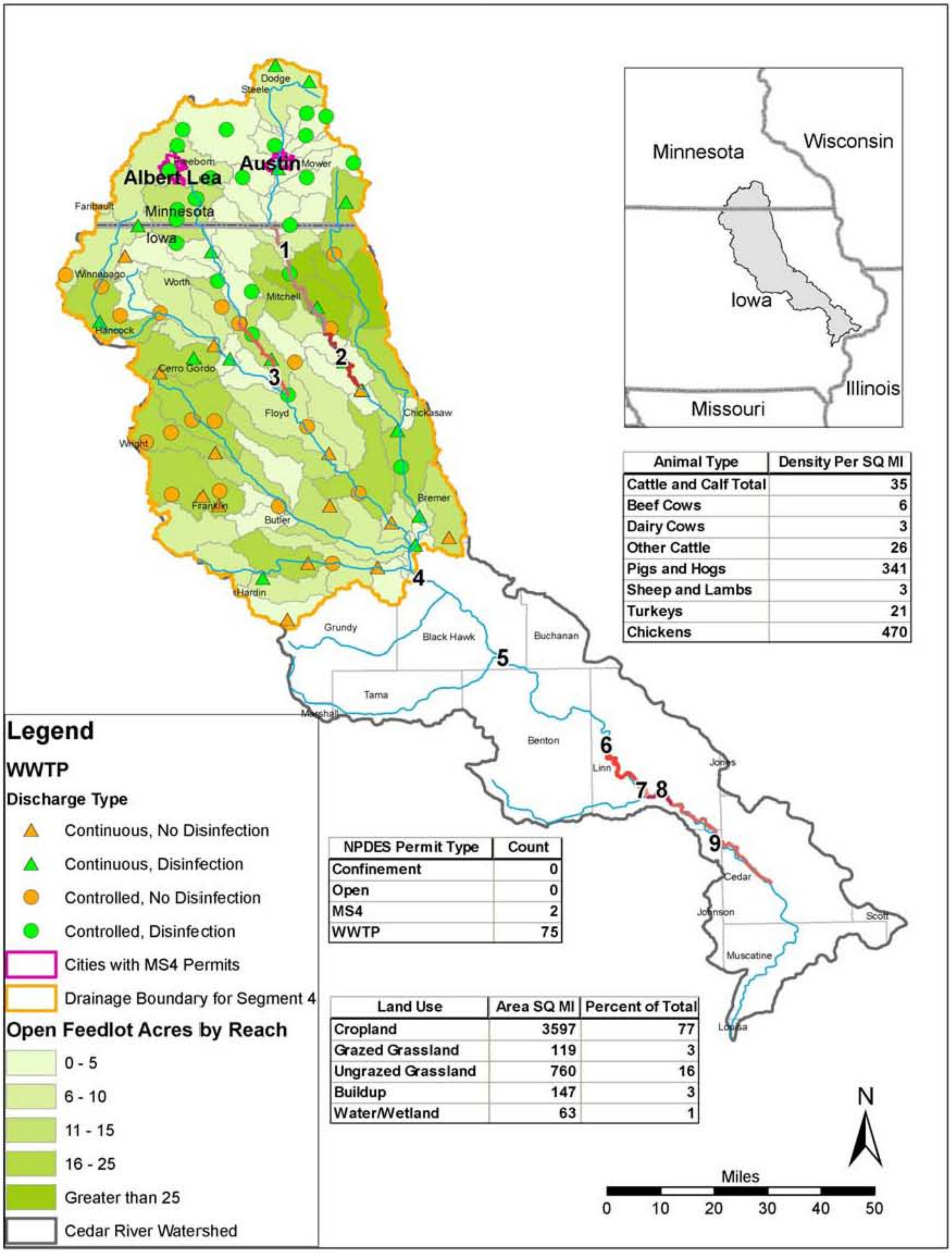


Figure 7-3. Boxplots of Water Quality Station 10070005 by Recreation Season.

RSI-1748-08-043



Animal Type	Density Per SQ MI
Cattle and Calf Total	35
Beef Cows	6
Dairy Cows	3
Other Cattle	26
Pigs and Hogs	341
Sheep and Lambs	3
Turkeys	21
Chickens	470

NPDES Permit Type	Count
Confinement	0
Open	0
MS4	2
WWTP	75

Land Use	Area SQ MI	Percent of Total
Cropland	3597	77
Grazed Grassland	119	3
Ungrazed Grassland	760	16
Buildup	147	3
Water/Wetland	63	1

Figure 7-4. Pollutant Sources for Cedar River Segment IA 02-CED-0050-L_0.

7.3. Flow Variable TMDL Approach and Target

7.3.1. Existing Load and Departure From Load Capacity

Figure 7-5 presents the LDC for IA 02-CED-0050-L_0. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 94 bacteria samples collected at Water Quality Station 10070005 during the recreation season, 17 percent (or 16 samples) exceeded the WQS. Of these 94 samples, flow estimates are available for 44 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 44 pollutant loads are plotted on the curve and symbolized by season. Table 7-3 summarizes the exceedances by quartile flow regime for these data.

RSI-1748-08-044

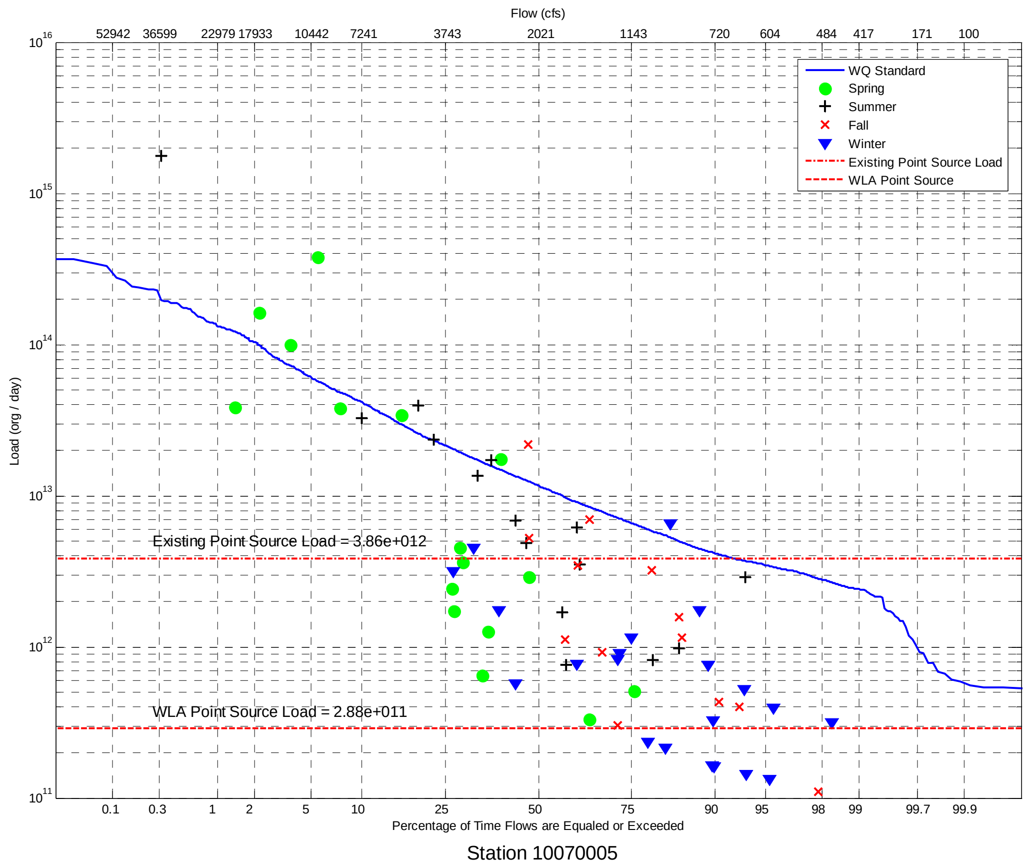


Figure 7-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10070005.

Table 7-4 provides an analysis of the **HSPF**-predicted daily concentrations for Reach 230 for the time period of 1995-2005 under existing conditions. These predictions show similar results (slightly higher) to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 7-3. Departure from load capacity for IA 02-CED-0050-L_0 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	10	0	0	0
0.25–0.50	10	0	0	0
0.50–0.75	14	21.4	14.9	43.2
0.75–1.00	10	70.0	42.3	88.9

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 7-4. HSPF-Predicted departure from load capacity for IA 02-CED-0050-L_0.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
33	119	333	32	49

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

7.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 7-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 7-5. The loads in Table 7-5 include a 15 percent MOS.

Table 7-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0050-L_0.

TMDL	Flow quartile (low to high flows)			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	2.41E+12	4.68E+12	8.26E+12	1.91E+13
Daily median flow (cfs)	782	1,519	2,680	6,185
Daily maximum load (cfu/day)	6.38E+12	1.13E+13	2.06E+13	1.26E+14
Daily maximum flow (cfs)	1,109	1,960	3,591	21,846

7.4. Pollutant Allocation

7.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 7-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland.

RSI-1748-08-045

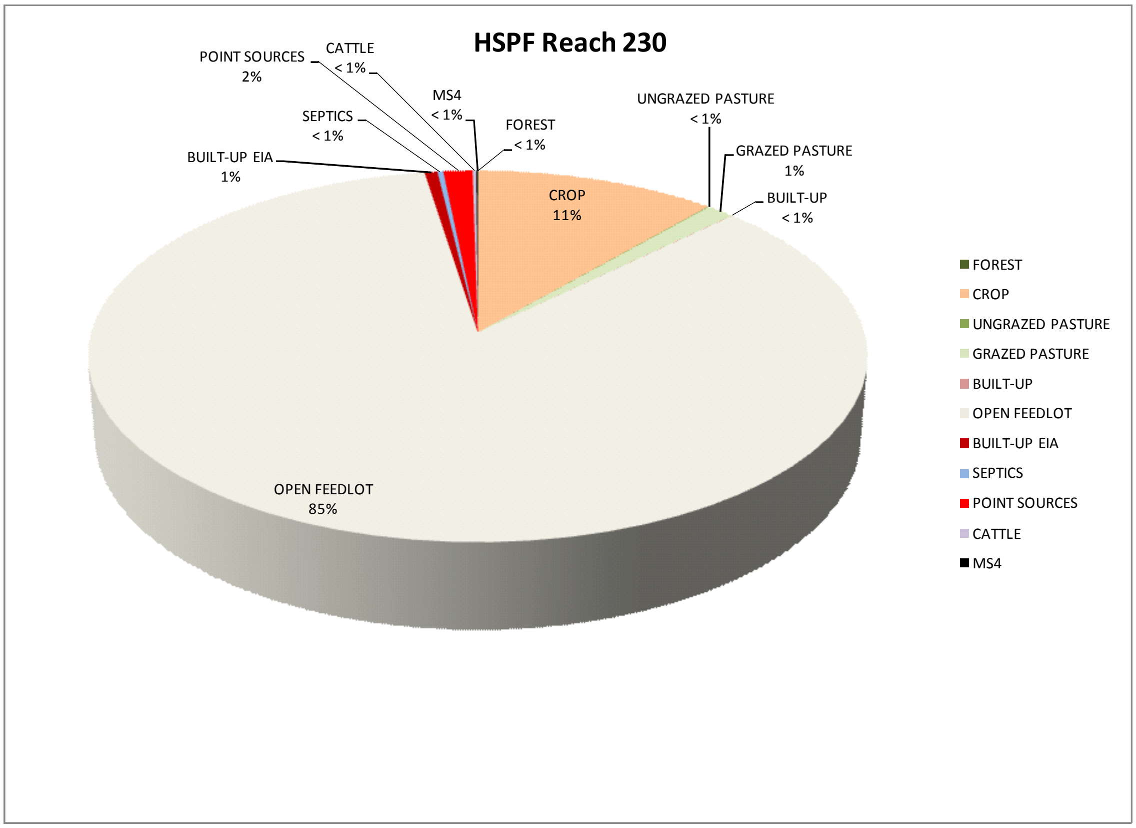


Figure 7-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0050-L_0.

7.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, most WLA is expressed as a static load. This segment also contains municipalities with MS4s. For this flow dependant point source the WLA was calculated using modeled flow from the MS4 areas and *the E. coli* criterion. The estimated static WLA component of the TMDL is shown in Figure 7-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0050-L_0, the static WLA was calculated to be 2.90E+11 *E. coli* cfu/day; this includes a reserve WLA of 1.82E+08 *E. coli* cfu/day for unsewered communities in the basin. The sum of the static and MS4 WLA was calculated to be 2.90E+11 *E. coli* cfu/day for the first quartile, 2.92E+11 *E. coli* cfu/day for the second quartile, 2.96E+11 *E. coli* cfu/day for the third quartile, and 3.10E+11 *E. coli* cfu/day for the fourth quartile. The existing point source load is 3.86E+12 *E. coli* cfu/day. To obtain the WLA at flows in the first quartile, the existing point source load needs to be reduced by 92 percent.

7.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (7\text{-}1)$$

Table 7-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 7-5.

Table 7-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0050-L_0.

LA	Flow quartile (low to high flows)[1]			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	1.76E+12	3.69E+12	6.73E+12	1.59E+13
Daily maximum load (cfu/day)	5.13E+12	9.29E+12	1.73E+13	1.06E+14

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

7.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 7-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0050-L_0.

MOS	Flow quartile (low to high flows)[1]			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	3.62E+11	7.02E+11	1.24E+12	2.86E+12
Daily maximum load (cfu/day)	9.56E+11	1.69E+12	3.10E+12	1.88E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

8. Indicator Bacteria Impairment for Cedar River from Wolf Creek to Bridge Crossing in LaPorte City (IA 02-CED-0040_1)

The drainage area of the 1.4-mile river segment, at its endpoint, is approximately 5,300 square miles, with the northern portion of the area extending into Minnesota (shown as Segment 5 on the figures). The nearest water quality station for this reach with a significant number of samples is 10070006; the station is located near the segment endpoint. Concurrent flow estimates are provided at the segment endpoint by **HSPF** Reach 270.

8.1. Problem Identification

8.1.1. Problem Statement

Of the 94 bacteria samples collected at Water Quality Station 10070006 during the recreation season, 32 percent (or 30 samples) exceeded the WQS. Of the 33 bacteria samples collected at Water Quality Station 10070006 during the nonrecreation season, 30 percent (or 10 samples) exceeded the WQS. Table 8-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 8-1. Descriptive statistics for Water Quality Station 10070006.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	79	234.9	355.7	10	50	130	260	2,500
Fecal	48	308.7	563.7	9.2	29.9	142.6	312.8	3,496

8.1.2. Data Interpretation

Figure 8-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 44 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are exceedances for all flow ranges. The figure shows the majority of the exceedances are associated with runoff events and indirect sources. However, 25 percent of the low flow range loads exceed the standard and would indicate significant direct loadings.

Table 8-2 presents descriptive statistics for Water Quality Station 10070006 by season. For all seasons, the upper quartile exceeds the WQS. Figure 8-2 shows this graphically by the four seasons and Figure 8-3 shows this by recreational season. It is evident from these tables and figures that larger concentrations are measured during mid to large range flows and all seasons. It is, therefore, likely that both indirect and direct sources contribute to the impairment.

8.2. Pollution Source Assessment

8.2.1. Identification of Pollutant Sources

Figure 8-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0040_1. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 76 percent of the area) and open feedlots upstream of the impaired reach. The upstream watershed contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 90 NPDES-permitted WWTPs and 7 MS4 permits within the watershed. Of the 90 permitted WWTPs, 44 use disinfection during the recreation season. There are 46 discharge locations where no disinfection occurs; of these, 26 are controlled discharges. Because controlled discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. There are 20 continuous discharge locations where no disinfection occurs. It is a logical assumption that direct sources contribute to the impairment under low flow conditions. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

RSI-1748-08-046

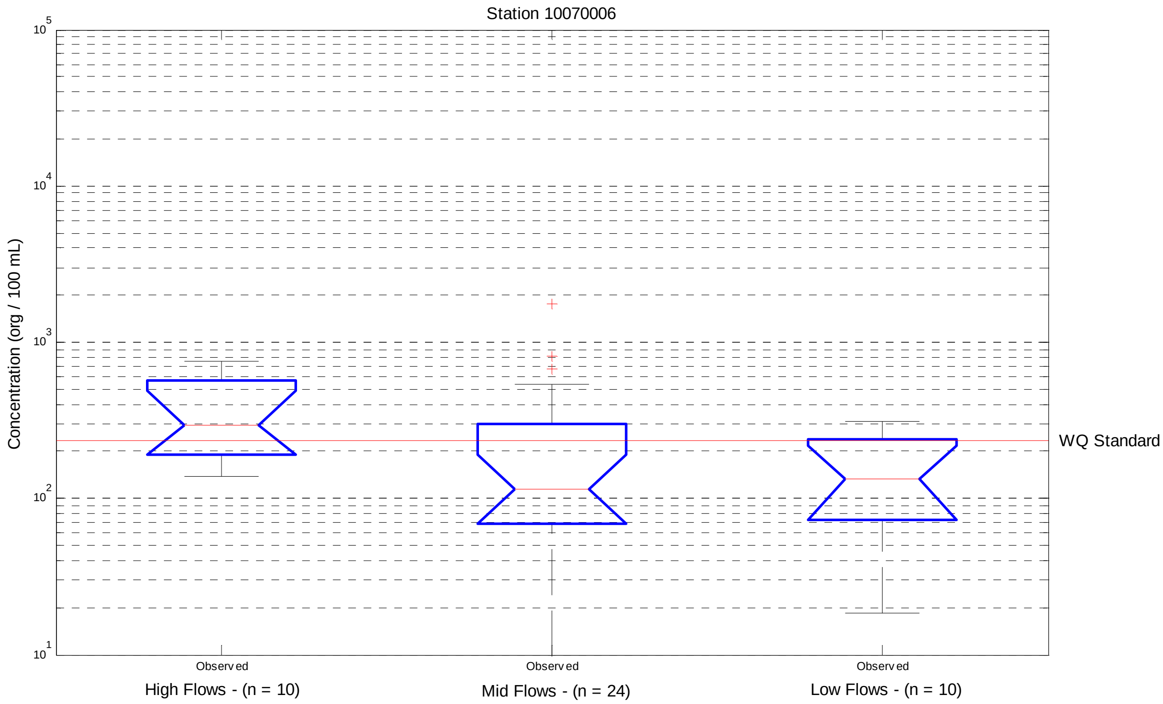


Figure 8-1. Boxplots for Water Quality Station 10070006 by Flow Range.

Table 8-2. Descriptive statistics for Water Quality Station 10070006 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	42	212.8	244.6	9.2	19.6	95	319.6	754.4
Summer	28	223.3	193.2	10	94	133.4	295	708.4
Fall	24	292.4	457.3	10	55	150	253.2	1,748
Winter	33	338	714	10	23	150	273	3,496

RSI-1748-08-047

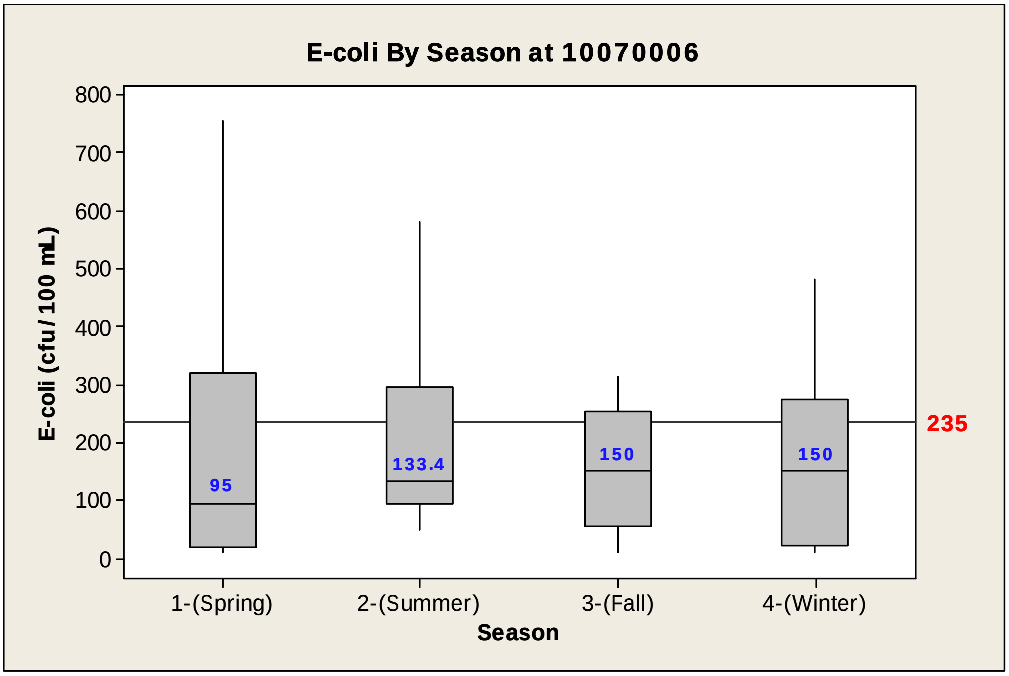


Figure 8-2. Boxplots for Water Quality Station 10070006 by Season.

RSI-1748-08-048

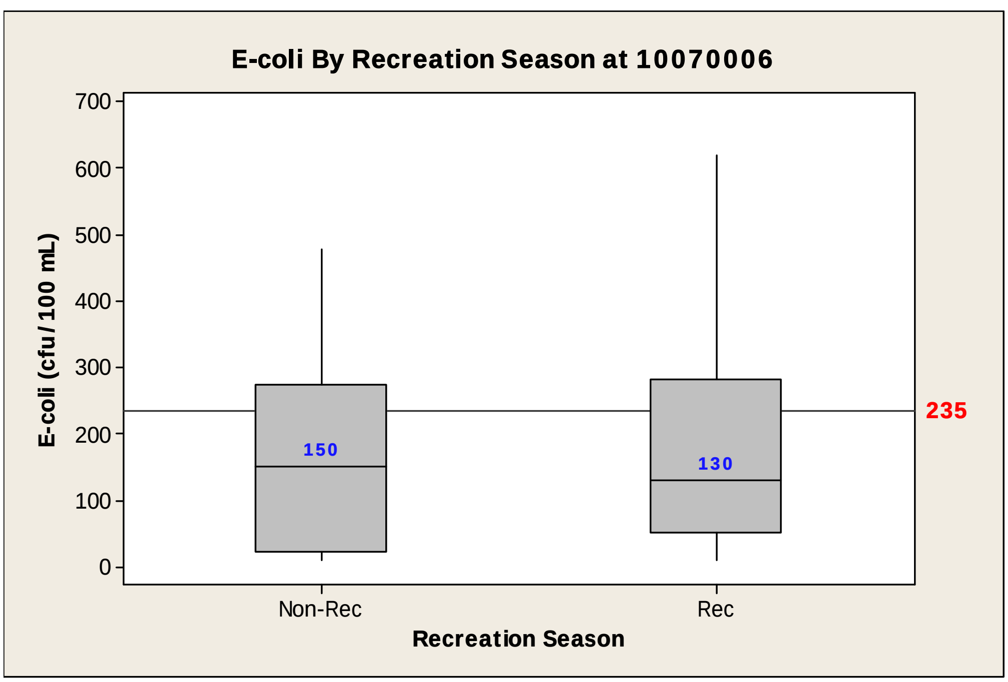


Figure 8-3. Boxplots of Water Quality Station 10070006 by Recreation Season.

RSI-1748-08-049

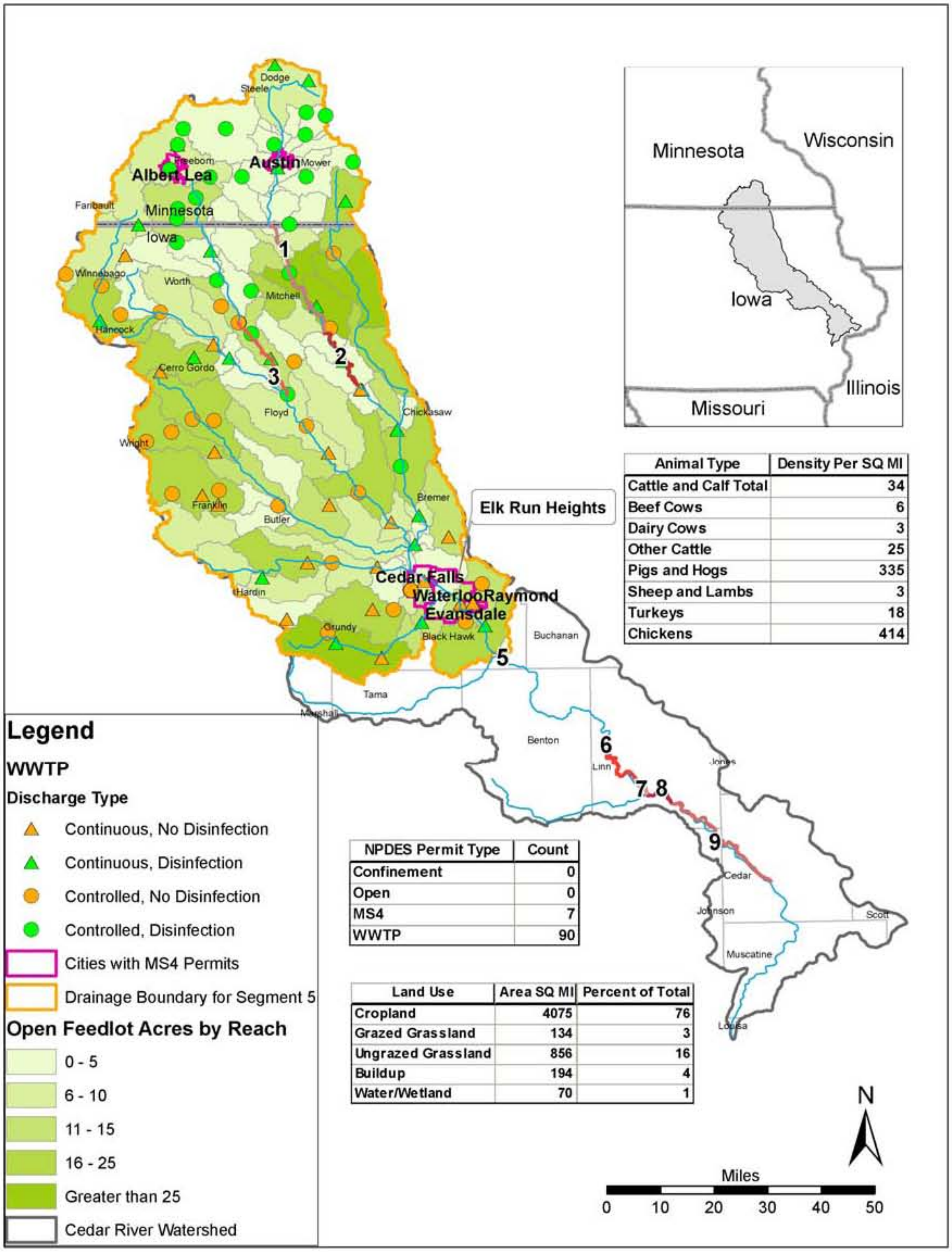


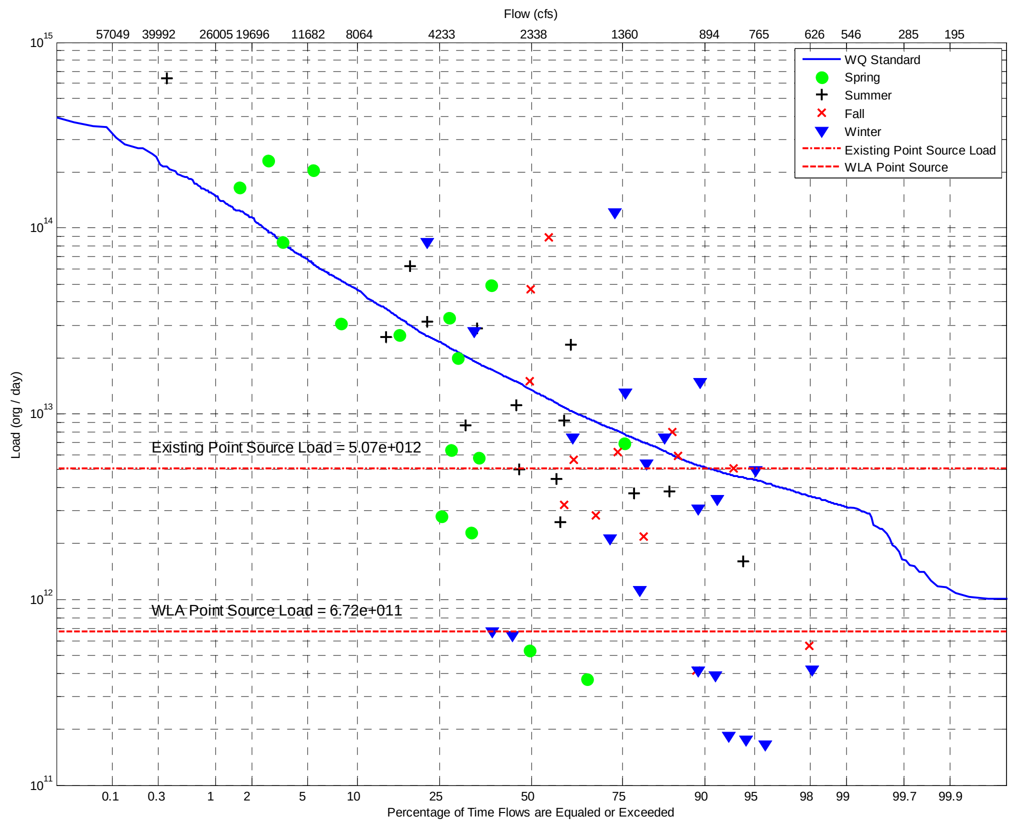
Figure 8-4. Pollutant Sources for Cedar River Segment IA 02-CED-0040_1.

8.3. Flow Variable TMDL Approach and Target

8.3.1. Existing Load and Departure From Load Capacity

Figure 8-5 presents the LDC for IA 02-CED-0040_1. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 94 bacteria samples collected at Water Quality Station 10070006 during the recreation season, 32 percent (or 30 samples) exceeded the WQS. Of these 94 samples, flow estimates are available for 44 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 44 pollutant loads are plotted on the curve and symbolized by season. Table 8-3 summarizes the exceedances by quartile flow regime for these data.

RSI-1748-08-050



Station 10070006

Figure 8-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10070006.

Table 8-4 provides an analysis of the **HSPF** predicted daily concentrations for Reach 270 for the time period of 1995-2005 under existing conditions. These predictions show similar results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 8-3. Departure from load capacity for IA 02-CED-0040_1 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	10	30.0	1.8	24.9
0.25–0.50	10	20.0	80.2	86.6
0.50–0.75	14	35.7	47.2	71.3
0.75–1.00	10	70.0	50.0	68.8

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 8-4. HSPF-Predicted departure from load capacity for IA 02-CED-0040_1.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
29	111	308	31	48

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

8.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 8-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 8-5. These loads in Table 8-5 include a 15 percent MOS.

Table 8-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0040_1.

TMDL	Flow quartile (low to high flows)			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	2.96E+12	5.45E+12	9.43E+12	2.12E+13
Daily median flow (cfs)	960	1,767	3,058	6,873
Daily maximum load (cfu/day)	7.58E+12	1.30E+13	2.34E+13	1.35E+14
Daily maximum flow (cfs)	1,318	2,269	4,074	23,478

8.4. Pollutant Allocation

8.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 8-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland and point sources that do not disinfect before discharge.

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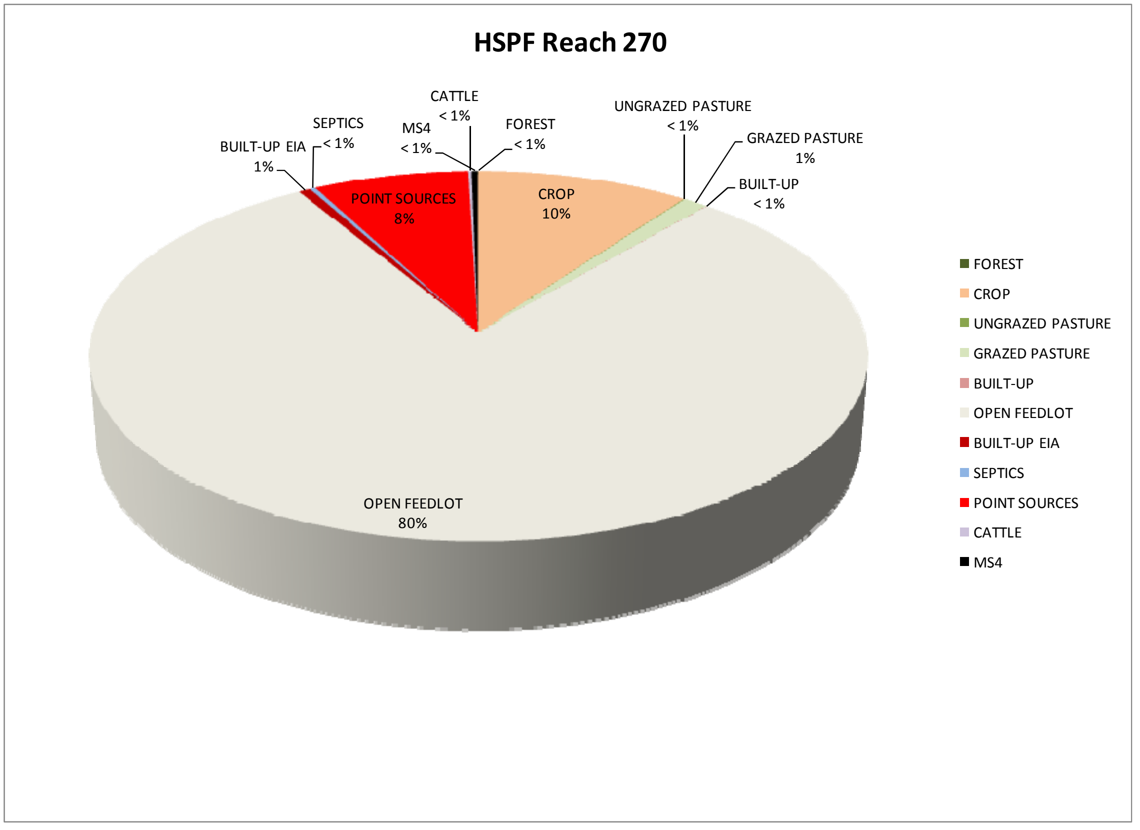

Figure 8-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0040_1.

8.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, the WLA is expressed as a static load. The estimated WLA component of the TMDL is shown in Figure 8-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0040_1, the WLA was calculated to be 6.72E+11 *E. coli* cfu/day; this includes a reserve WLA of 2.78E+08 *E. coli* cfu/day for unsewered communities in the basin. The existing point source load is 5.07E+12 *E. coli* cfu/day. To obtain the WLA, the existing point source load needs to be reduced by 87 percent.

8.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (8\text{-}1)$$

Table 8-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 8-5.

Table 8-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0040_1.

LA	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	1.84E+12	3.96E+12	7.34E+12	1.73E+13
Daily maximum load (cfu/day)	5.77E+12	1.04E+13	1.92E+13	1.14E+14

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

8.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 8-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0040_1.

MOS	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	4.44E+11	8.17E+11	1.41E+12	3.18E+12
Daily maximum load (cfu/day)	1.14E+12	1.96E+12	3.51E+12	2.02E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

9. Indicator Impairment for Cedar River from McCloud Run to Confluence with Bear Creek (IA 02-CED-0030_2)

The drainage area of the 12-mile river segment, at its endpoint, is approximately 6,450 square miles, with the northern portion of the area extending into Minnesota (shown as Segment 6 on the figures). The nearest water quality station for this reach with a significant number of samples is 10570002; the station is located at the segment inlet. Concurrent flow estimates are provided at the segment endpoint by HSPF Reach 320.

9.1. Problem Identification

9.1.1. Problem Statement

Of the 94 bacteria samples collected at Water Quality Station 10570002 during the recreation season, 19 percent (or 18 samples) exceeded the WQS. Of the 33 bacteria samples collected at Water Quality Station 10570002 during the nonrecreation season, 6 percent (or two samples) exceeded the WQS. Table 9-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 9-1. Descriptive statistics for Water Quality Station 10570002.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	79	398	1,596	10	10	27	100	12,000
Fecal	48	717	2,621	9	10	23	108	16,560

9.1.2. Data Interpretation

Figure 9-1 presents boxplots of concentration data grouped by flow range (high, mid, and, low). There were 44 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are exceedances within the high flow range; other flow ranges appear to be in compliance with WQS. This indicates indirect sources are the predominant stressor.

Table 9-2 presents descriptive statistics for Water Quality Station 10570002 by season. For all seasons, the upper quartile is less than the WQS. Figure 9-2 shows this graphically by the four seasons and Figure 9-3 shows this by recreational season. It is evident from these tables and figures that larger concentrations are measured during times of high runoff and not directly affected by season.

9.2. Pollution Source Assessment

9.2.1. Identification of Pollutant Sources

Figure 9-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0030_2. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 76 percent of the area) and open feedlots upstream of the impaired reach. The upstream watershed contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 114 NPDES-permitted WWTPs (two facilities have two discharge locations) and 7 MS4 permits within the watershed. Of the 112 permitted WWTPs, 52 use disinfection during the recreation season. There are 62 discharge locations where no disinfection occurs. Of these, 32 are controlled discharge. Because controlled discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration are unknown. There are 30 continuous discharge locations (approximately 25 percent) where no disinfection occurs. However, there were only eight samples in the low flow range analyzed. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

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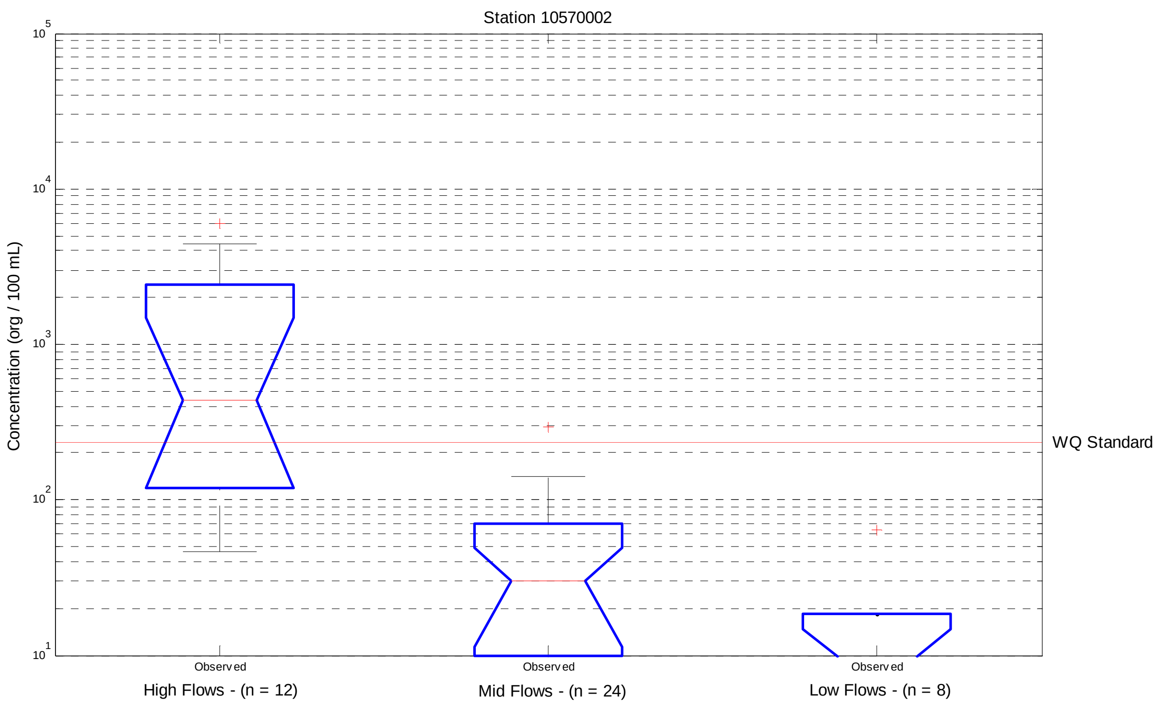


Figure 9-1. Boxplots for Water Quality Station 10570002 by Flow Range.

Table 9-2. Descriptive statistics for Water Quality Station 10570002 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	42	250	730	9	16	40	125	4,140
Summer	28	539	1,557	9	10	46	88	6,000
Fall	24	430	1,291	10	10	19	54	4,800
Winter	33	908	3,496	9	10	10	105	16,560

RSI-1748-08-053

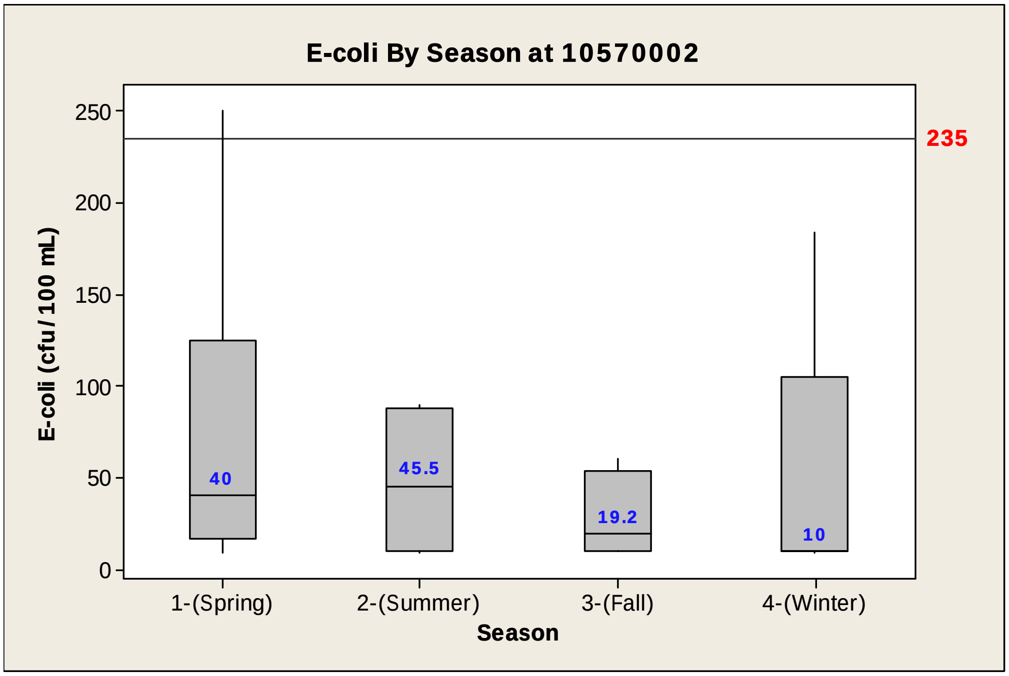


Figure 9-2. Boxplots for Water Quality Station 10570002 by Season.

RSI-1748-08-054

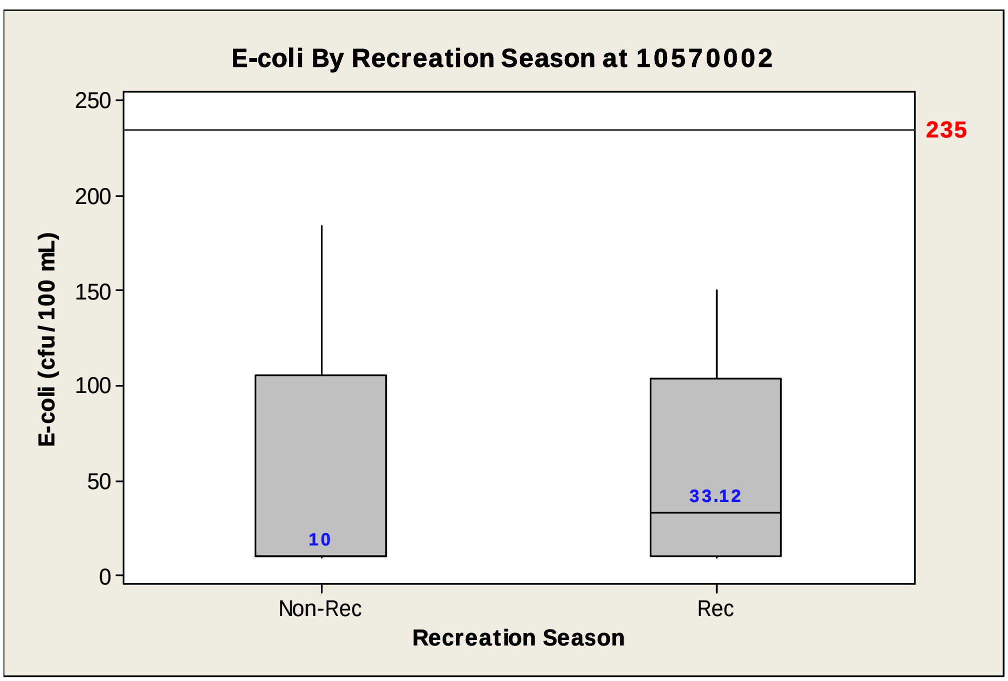
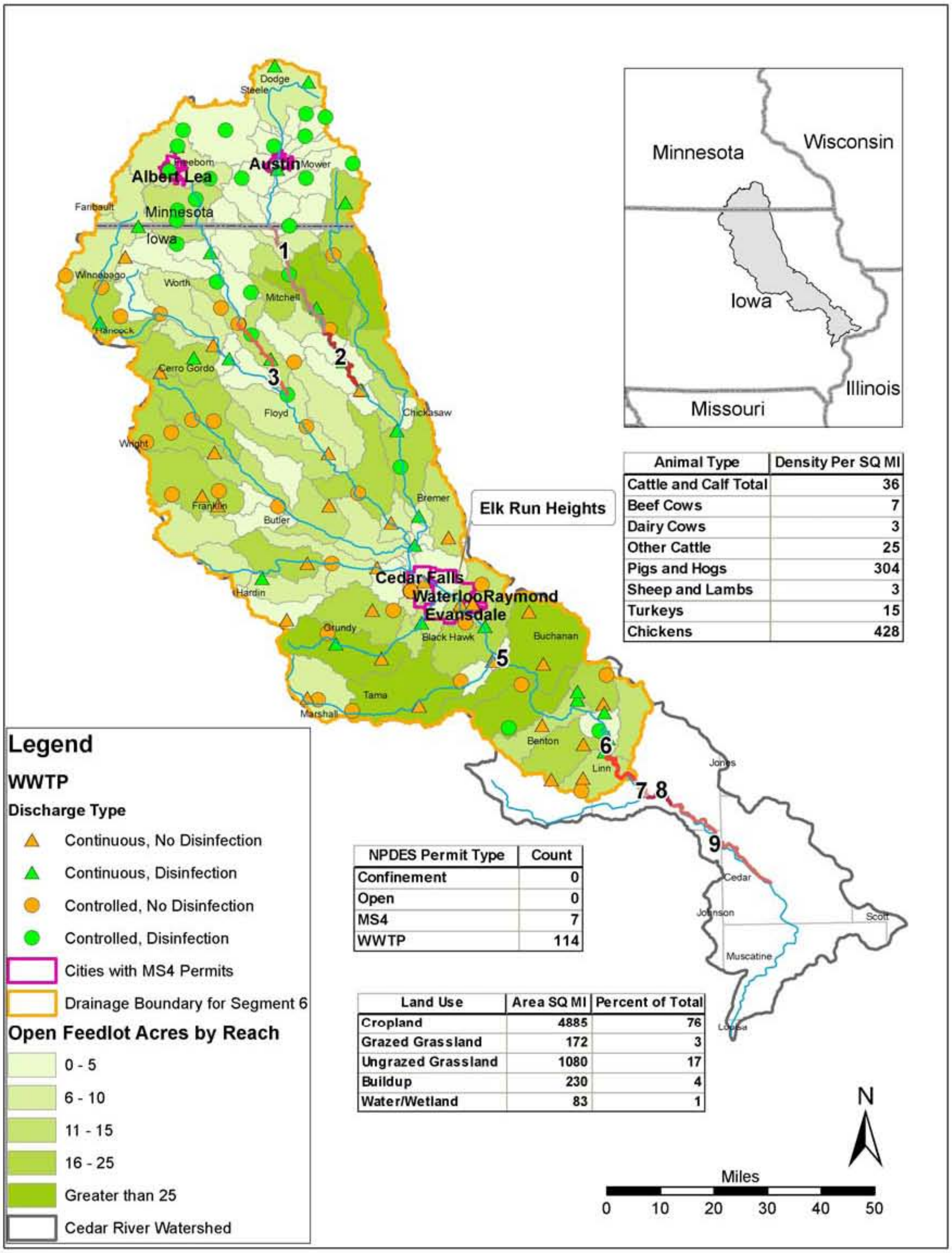


Figure 9-3. Boxplots of Water Quality Station 10570002 by Recreation Season.

RSI-1748-08-055



Animal Type	Density Per SQ MI
Cattle and Calf Total	36
Beef Cows	7
Dairy Cows	3
Other Cattle	25
Pigs and Hogs	304
Sheep and Lambs	3
Turkeys	15
Chickens	428

NPDES Permit Type	Count
Confinement	0
Open	0
MS4	7
WWTP	114

Land Use	Area SQ MI	Percent of Total
Cropland	4885	76
Grazed Grassland	172	3
Ungrazed Grassland	1080	17
Buildup	230	4
Water/Wetland	83	1

Figure 9-4. Pollutant Sources for Cedar River Segment IA 02-CED-0030_2.

9.3. Flow Variable TMDL Approach and Target

9.3.1. Existing Load and Departure From Load Capacity

Figure 9-5 presents the LDC for IA 02-CED-0030_2. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 94 bacteria samples collected at Water Quality Station 10570002 during the recreation season, 19 percent (or 18 samples) exceeded the WQS. Of these 94 samples, flow estimates are available for 44 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 44 pollutant loads are plotted on the curve and symbolized by season. Table 9-3 summarizes the exceedances by quartile flow regime for these data.

RSI-1748-08-056

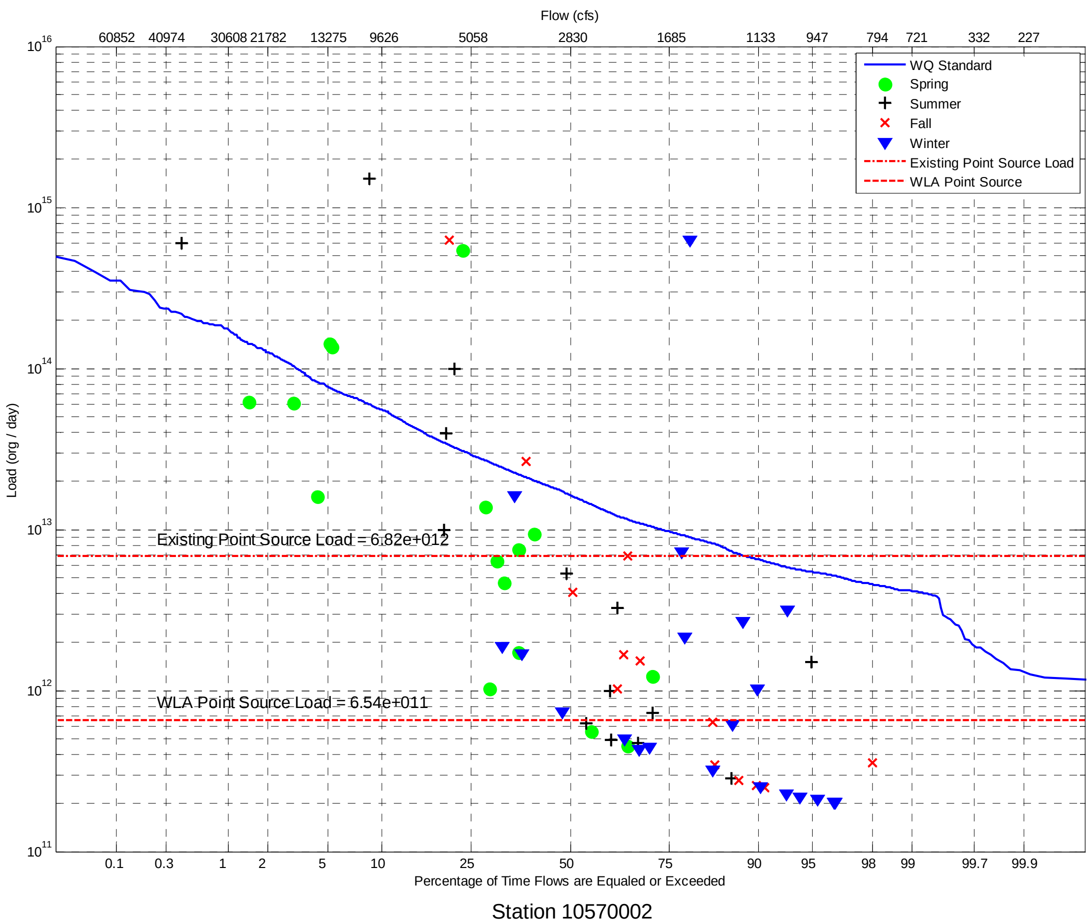


Figure 9-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10570002.

Table 9-4 provides an analysis of the **HSPF**-predicted daily concentrations for Reach 320 for the time period of 1995-2005 under existing conditions. These predictions show similar, yet slightly higher, results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 9-3. Departure from load capacity for IA 02-CED-0030_2 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	8	0	0	0
0.25–0.50	15	0	0	0
0.50–0.75	9	11.1	20.2	20.2
0.75–1.00	12	66.7	86.3	96.1

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 9-4. HSPF-Predicted departure from load capacity for IA 02-CED-0030_2.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
29	122	374	35	52

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

9.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 9-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 9-5. These loads in Table 9-5 include a 15 percent MOS.

Table 9-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_2.

TMDL	Flow quartile (low to high flows)			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	3.76E+12	6.49E+12	1.14E+13	2.55E+13
Daily median flow (cfs)	1,219	2,104	3,712	8,288
Daily maximum load (cfu/day)	9.48E+12	1.58E+13	2.81E+13	1.52E+14
Daily maximum flow (cfs)	1,648	2,749	4,885	26,382

9.4. Pollutant Allocation

9.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 9-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure applications on cropland and point sources that do not disinfect before discharge.

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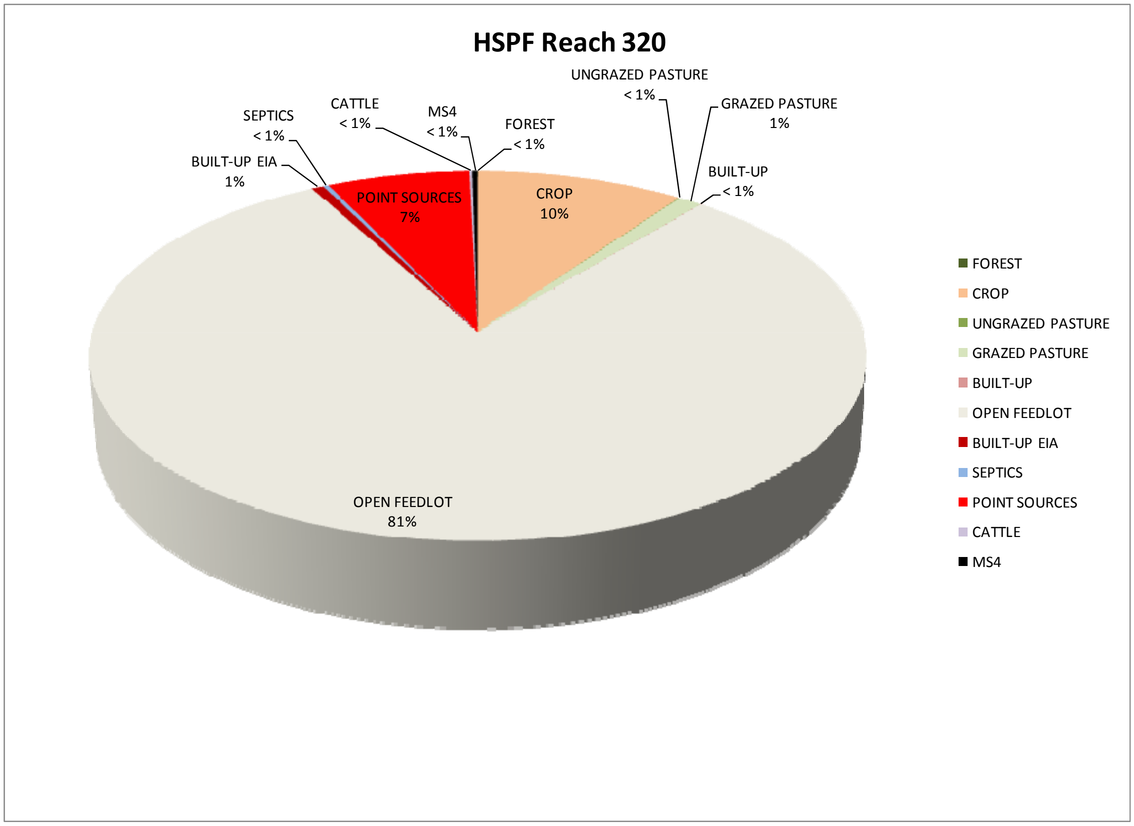

Figure 9-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0030_2.

9.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, most WLA is expressed as a static load. This segment also contains municipalities with MS4s. For this flow dependant point source the WLA was calculated using modeled flow from the MS4 areas and the *E. coli* standards. The estimated static WLA component of the TMDL is shown in Figure 7-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0030_2, the static WLA was calculated to be 6.54E+11 *E. coli* cfu/day; this segment contains no additional reserve WLA. The sum of the static and MS4 WLA was calculated to be 6.60E+11 *E. coli* cfu/day for the first quartile, 6.68E+11 *E. coli* cfu/day for the second quartile, 6.82E+11 *E. coli* cfu/day for the third quartile, and 7.32E+11 *E. coli* cfu/day for the fourth quartile. To obtain the WLA for the first quartile, the existing point source load needs to be reduced by 91 percent.

9.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \quad (9\text{-}1)$$

Table 9-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 9-5.

Table 9-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_2.

LA	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	2.53E+12	4.84E+12	9.04E+12	2.10E+13
Daily maximum load (cfu/day)	7.39E+12	1.28E+13	2.32E+13	1.28E+14

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

9.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 9-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_2.

MOS	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	5.64E+11	9.73E+11	1.72E+12	3.83E+12
Daily maximum load (cfu/day)	1.42E+12	2.37E+12	4.21E+12	2.28E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

10. Indicator Bacteria Impairment for Cedar River from Prairie Creek to Confluence with McCloud Run (IA 02-CED-0030_1)

The drainage area of the 4.6-mile river segment, at its endpoint, is approximately 6,700 square miles, with the northern portion of the area extending into Minnesota (shown as Segment 7 on the figures). The nearest water quality station for this reach with a significant number of samples is 10570001; the station is located approximately 6 miles from the segment endpoint. Concurrent flow estimates are provided at the segment endpoint by HSPF Reach 340.

10.1. Problem Identification

10.1.1. Problem Statement

Of the 157 bacteria samples collected at Water Quality Station 10570001 during the recreation season, 38 percent (or 60 samples) exceeded the WQS. Of the 33 bacteria samples collected at Water Quality Station 10570001 during the nonrecreation season, 64 percent (or 21 samples) exceeded the WQS. Table 10-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 10-1. Descriptive statistics for Water Quality Station 10570001.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	142	1,393	7,315	10	64	150	523	82,000
Fecal	48	1,960	5,090	10	61	235	1,104	31,280

10.1.2. Data Interpretation

Figure 10-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 107 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are exceedances for mid and high flow ranges. Over 50 percent of the high flows and over 25 percent of the mid range flows exceed the WQS.

Table 10-2 presents descriptive statistics for Water Quality Station 10570001 by season. For all seasons, the upper quartile exceeds the WQS. Figure 10-2 shows this graphically by the four seasons and Figure 10-3 shows this by recreational season. It is evident from these tables and figures that both indirect and direct sources contribute significantly to the impairment. A large number of point sources that do not disinfect are located along tributaries located shortly upstream that enter the main stem of the Cedar River.

10.2. Pollution Source Assessment

10.2.1. Identification of Pollutant Sources

Figure 10-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0030_1. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 76 percent of the area) and open feedlots upstream of the impaired reach. This watershed contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 117 NPDES-permitted WWTPs (three facilities have two discharge locations) and 10 MS4 permits within the watershed. Of the 120 discharge locations, 52 (or 43 percent) use disinfection during the recreation season. There are 68 discharge locations where no disinfection occurs; of these, 33 are controlled discharges. Because controlled discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. There are 35 continuous discharge locations (approximately 30 percent) where no disinfection occurs. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

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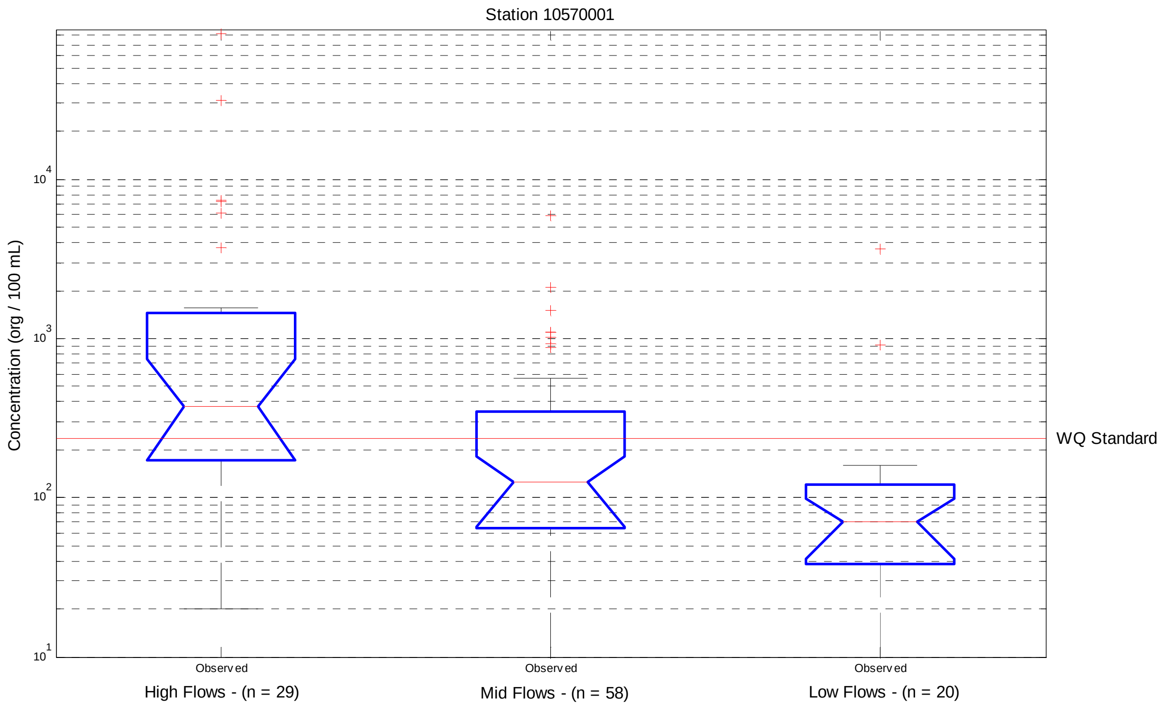

Figure 10-1. Boxplots for Water Quality Station 10570001 by Flow Range.

Table 10-2. Descriptive statistics for Water Quality Station 10570001 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	61	2,157	10,524	10	55	250	862	82,000
Summer	59	515	1,021	27	80	130	380	6,164
Fall	37	2,049	6,688	10	36	100	311	31,280
Winter	33	1,641	3,367	10	124	360	1,242	14,720

RSI-1748-08-059

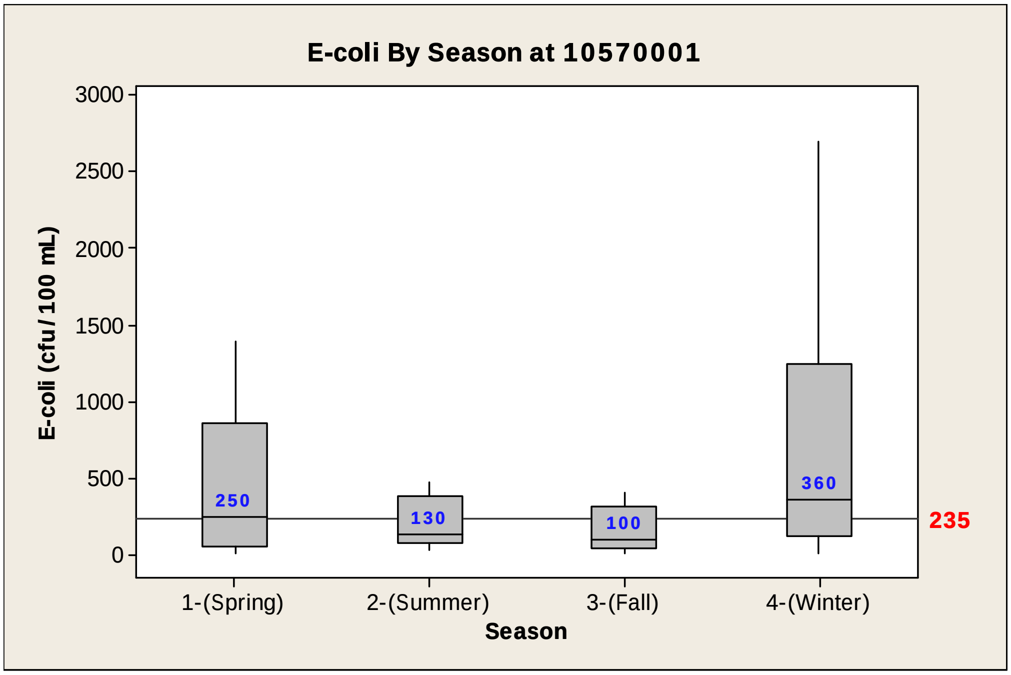

Figure 10-2. Boxplots for Water Quality Station 10570001 by Season.

RSI-1748-08-060

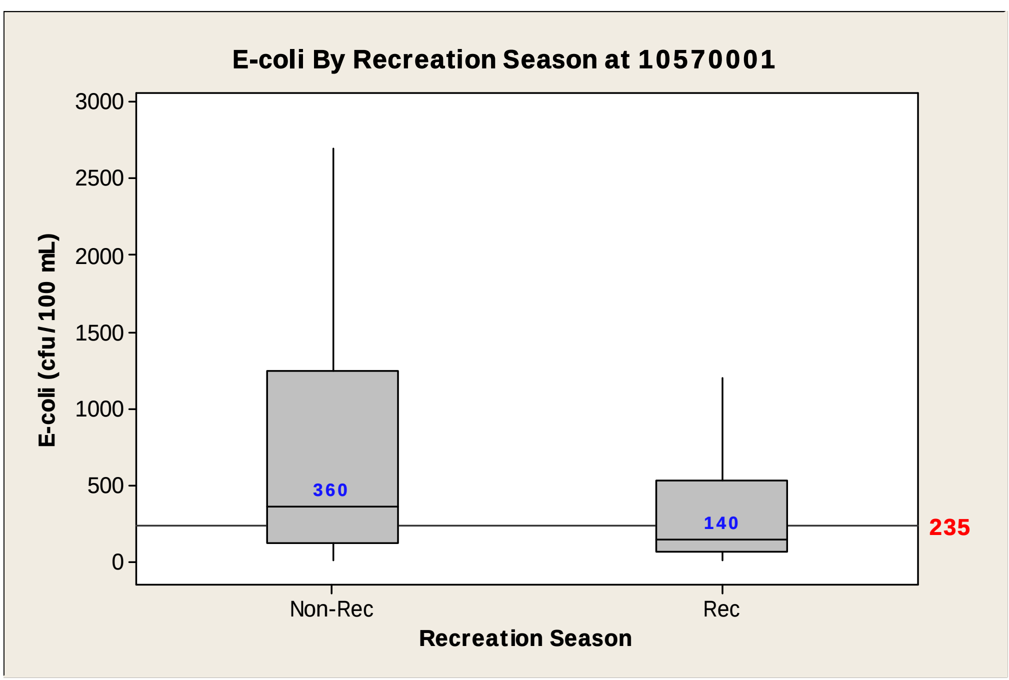

Figure 10-3. Boxplots of Water Quality Station 10570001 by Recreation Season.

RSI-1748-08-061

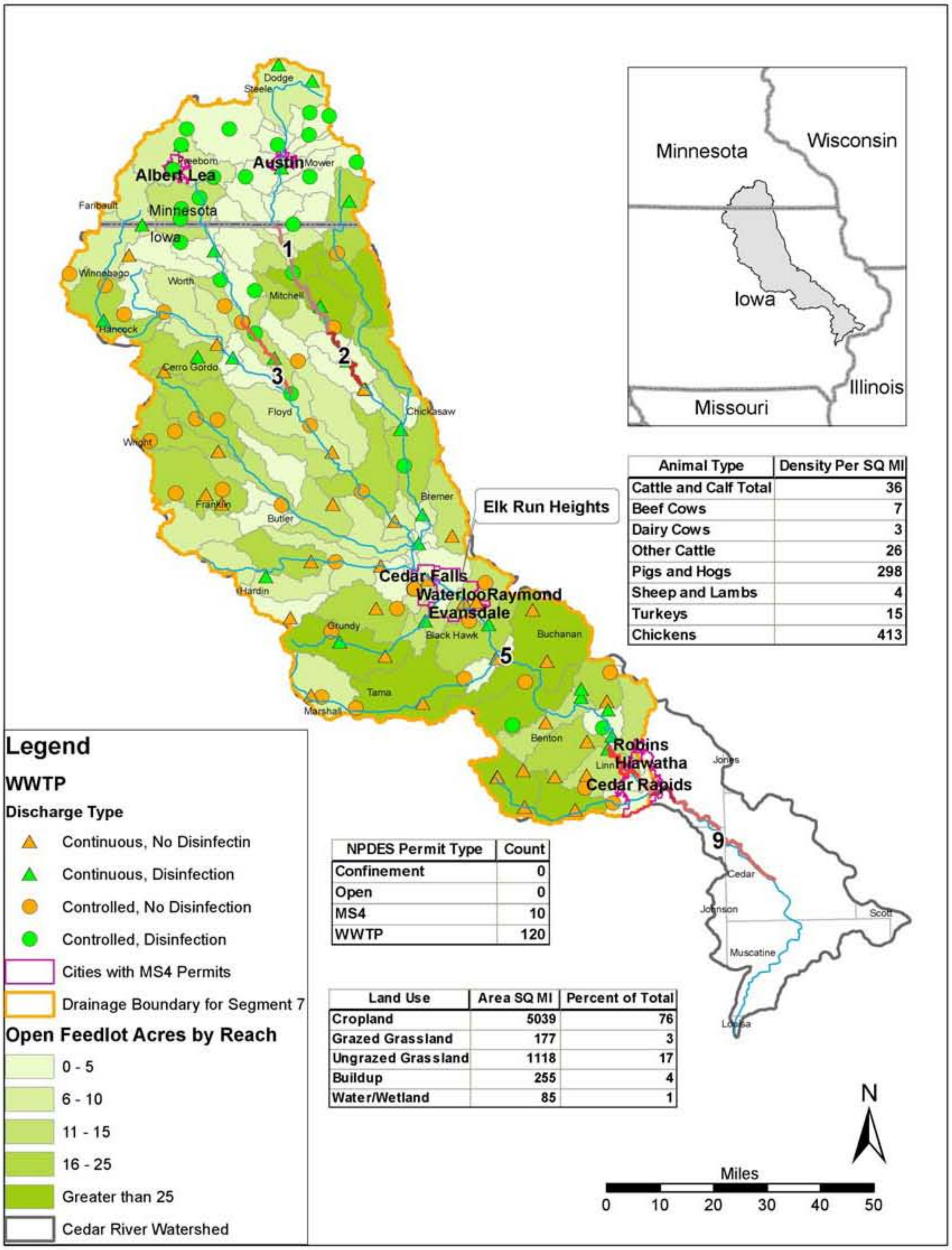

Figure 10-4. Pollutant Sources for Cedar River Segment IA 02-CED-0030_1.

10.3. Flow Variable TMDL Approach and Target

10.3.1. Existing Load and Departure From Load Capacity

Figure 10-5 presents the LDC for IA 02-CED-0030_1. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 157 bacteria samples collected at Water Quality Station 10570001 during the recreation season, 38 percent (or 60 samples) exceeded the WQS. Of these 157 samples, flow estimates are available for 107 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 107 pollutant loads are plotted on the curve and symbolized by season. Table 10-3 summarizes the exceedances by quartile flow regime for these data.

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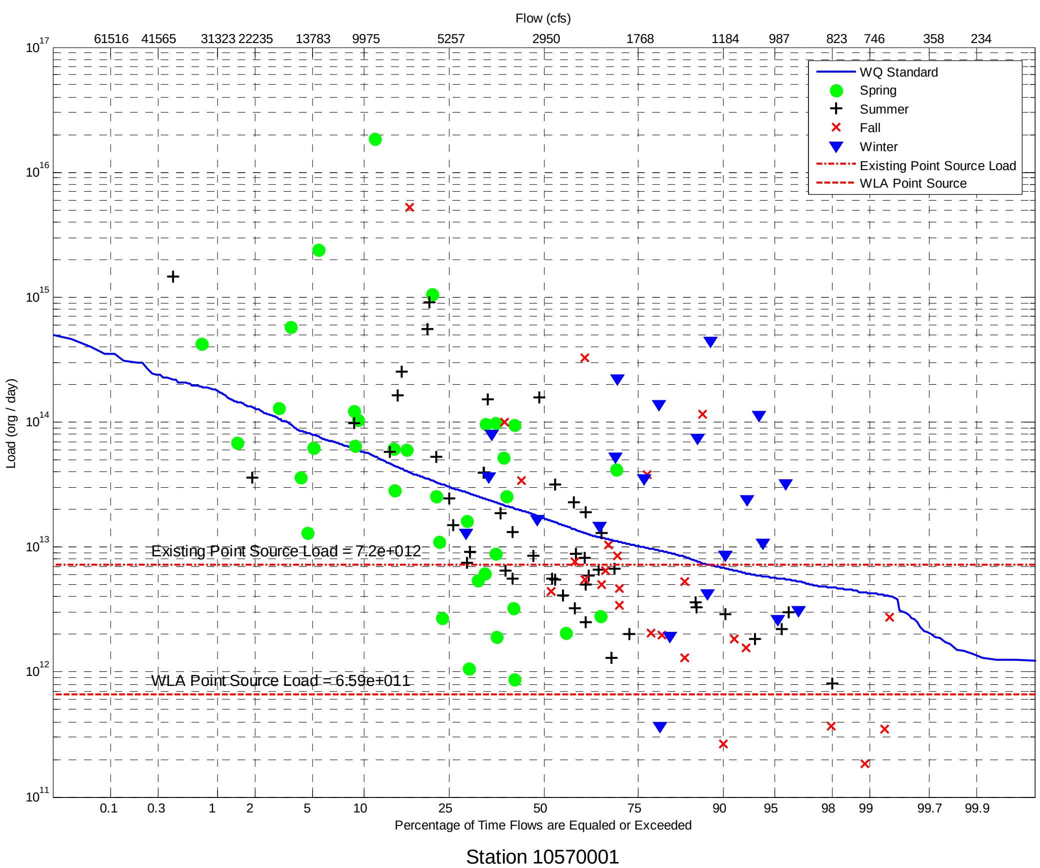

Figure 10-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10570001.

Table 10-4 provides an analysis of the **HSPF**-predicted daily concentrations for Reach 340 for the time period of 1995-2005 under existing conditions. These predictions show similar results to the available data in terms of the percent of samples exceeding the maximum standard.

Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 10-3. Departure from load capacity for IA 02-CED-0030_1 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	20	10.0	88.8	93.6
0.25–0.50	30	20.0	52.8	96.0
0.50–0.75	28	39.3	77.2	88.9
0.75–1.00	29	69.0	76.2	99.7

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 10-4. HSPF-Predicted departure from load capacity for IA 02-CED-0030_1.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
31	130	396	36	53

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

10.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 10-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 10-5. These loads in Table 10-5 include a 15 percent MOS.

Table 10-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_1.

TMDL	Flow quartile (low to high flows)			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	3.92E+12	6.78E+12	1.19E+13	2.66E+13
Daily median flow (cfs)	1,270	2,201	3,867	8,636
Daily maximum load (cfu/day)	9.95E+12	1.65E+13	2.92E+13	1.54E+14
Daily maximum flow (cfs)	1,731	2,870	5,082	26,872

10.4. Pollutant Allocation

10.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 10-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland and point sources that do not disinfect before discharge.

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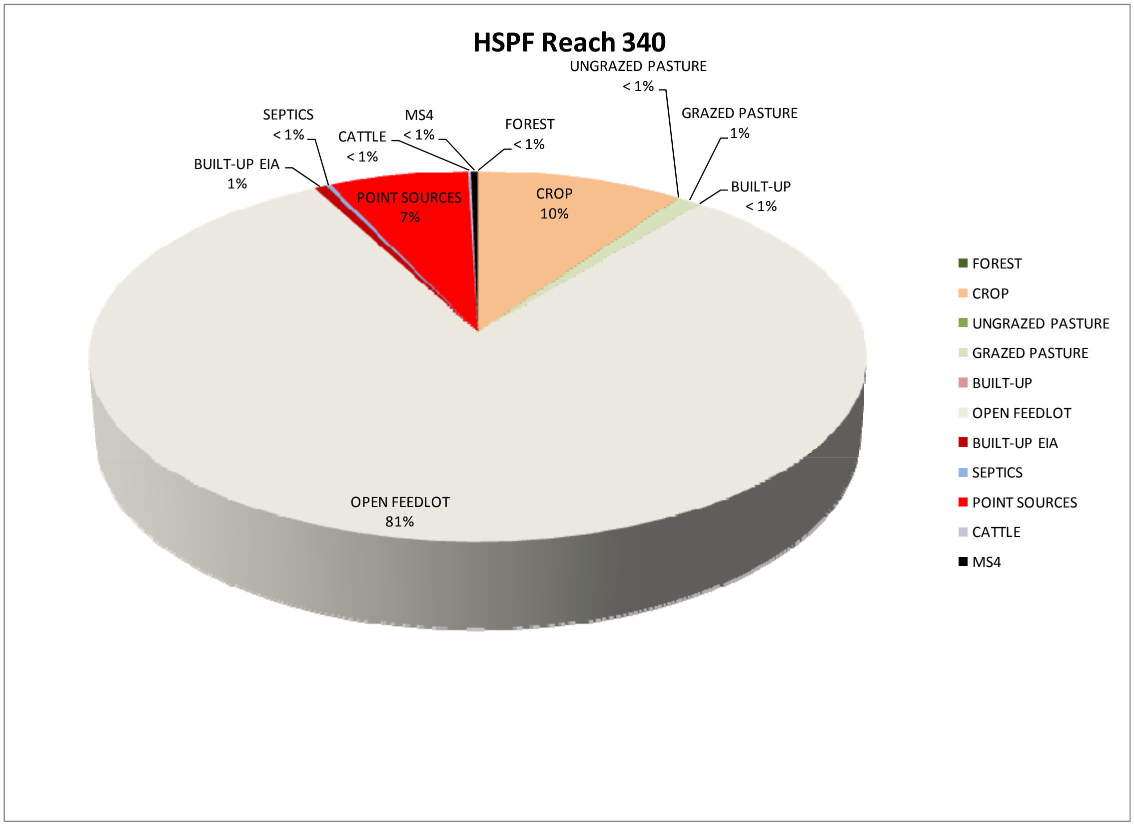

Figure 10-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0030_1.

10.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, most WLA is expressed as a static load. This segment also contains municipalities with MS4s. For this flow dependant point source the WLA was calculated using modeled flow from the MS4 areas and the *E. coli* standards. The estimated static WLA component of the TMDL is shown in Figure 7-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0030_1, the static WLA was calculated to be 6.59E+11 *E. coli* cfu/day; there is no reserve capacity for this segment. The sum of the static and MS4 WLA was calculated to be 6.74E+11

E. coli cfu/day for the first quartile, 6.92E +11 *E. coli* cfu/day for the second quartile, 7.28E+11 *E. coli* cfu/day for the third quartile, and 8.91E+11 *E. coli* cfu/day for the fourth quartile. The existing point source load is 7.20E+12 *E. coli* cfu/day. To obtain the WLA at flows in the first quartile, the existing point source load needs to be reduced by 91 percent.

10.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \quad (10\text{-}1)$$

Table 10-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 10-5.

Table 10-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_1.

LA	Flow quartile (low to high flows)[1]			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	2.65E+12	5.08E+12	9.40E+12	2.17E+13
Daily maximum load (cfu/day)	7.79E+12	1.33E+13	2.41E+13	1.30E+14

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

10.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 10-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0030_1.

MOS	Flow quartile (low to high flows)[1]			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	5.87E+11	1.02E+12	1.79E+12	3.99E+12
Daily maximum load (cfu/day)	1.49E+12	2.48E+12	4.38E+12	2.32E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

11. Indicator Bacteria Impairment for Cedar River from Highway 30 Bridge at Cedar Rapids to Confluence with Prairie Creek (IA 02-CED-0020_3)

The drainage area of the 6.8-mile river segment, at its endpoint, is approximately 6,800 square miles, with the northern portion of the area extending into Minnesota (shown as Segment 8 on the figures). The nearest water quality station for this reach with a significant number of samples is 10570001; the station is located near the segment endpoint. Note that this water quality gage was also used for assessing departure from WQS for the immediate upstream impaired Reach IA 02-CED-0030_1. The load duration curve and concurrent flow estimates are now provided at the segment endpoint by **HSPF** Reach 350. It is worth noting that the flows for **HSPF** Reach 340 are only slightly less than those predicted at **HSPF** Reach 350, as would be expected. However, this increase in flow and volume at reach endpoint 350 results in a slightly larger TMDL. The WLA is also different because of additional WWTP loadings and some assimilation of upstream loadings within the segment.

11.1. Problem Identification

11.1.1. Problem Statement

Of the 157 bacteria samples collected at Water Quality Station 10570001 during the recreations season, 38 percent (or 60 samples) exceeded the WQS. Of the 33 bacteria samples collected at Water Quality Station 10570001 during the recreations season, 64 percent (or 21 samples) exceeded the WQS. Table 11-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 11-1. Descriptive statistics for Water Quality Station 10570001.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	142	1,393	7,315	10	64	150	523	82,000
Fecal	48	1,960	5,090	10	61	235	1,104	31,280

11.1.2. Data Interpretation

Figure 11-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 107 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are exceedances for mid and high flow ranges. Over 50 percent of the high flows and over 25 percent of the mid range flows exceed the WQS.

Table 11-2 presents descriptive statistics for Water Quality Station 10570001 by season. For all seasons the upper quartile exceeds the WQS. Figure 11-2 shows this graphically by the four seasons and Figure 11-3 shows this by recreational season. It is evident from these tables and figures that both indirect and direct sources contribute significantly to the impairment. A large number of point sources that do not disinfect are located along tributaries located shortly upstream that enter the main stem of the Cedar River.

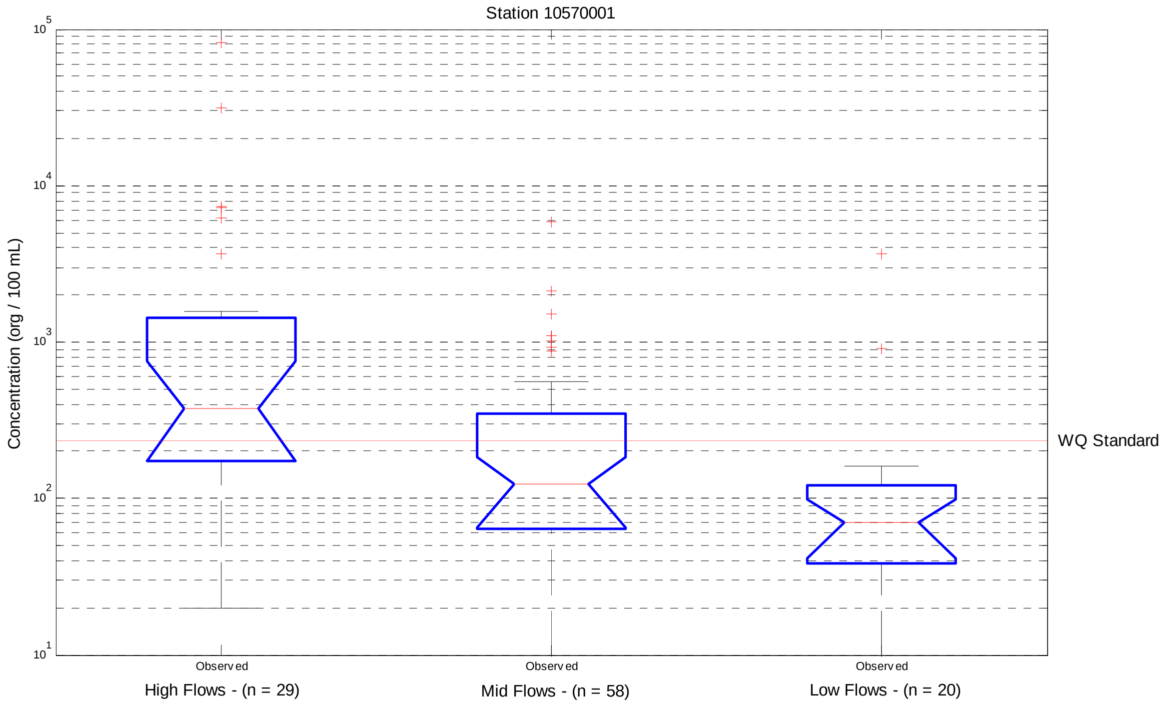

Figure 11-1. Boxplots for Water Quality Station 10570001 by Flow Range.

Table 11-2. Descriptive statistics for Water Quality Station 10570001 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	61	2,157	10,524	10	55	250	862	82,000
Summer	59	515	1,021	27	80	130	380	6,164
Fall	37	2,049	6,688	10	36	100	311	31,280
Winter	33	1,641	3,367	10	124	360	1,242	14,720

11.2. Pollution Source Assessment

11.2.1 Identification of Pollutant Sources

Figure 11-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0020_3. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 75 percent) of the area and open feedlots upstream of the impaired reach. The upstream watershed also contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 120 NPDES-permitted WWTPs (three facilities have two discharge locations) and 11 MS4 permits within the watershed. Of the 123 discharge locations, 53 use disinfection during the recreation season. There are 70 discharge locations where no disinfection occurs; of these, 35 are controlled discharges. Because controlled discharge is

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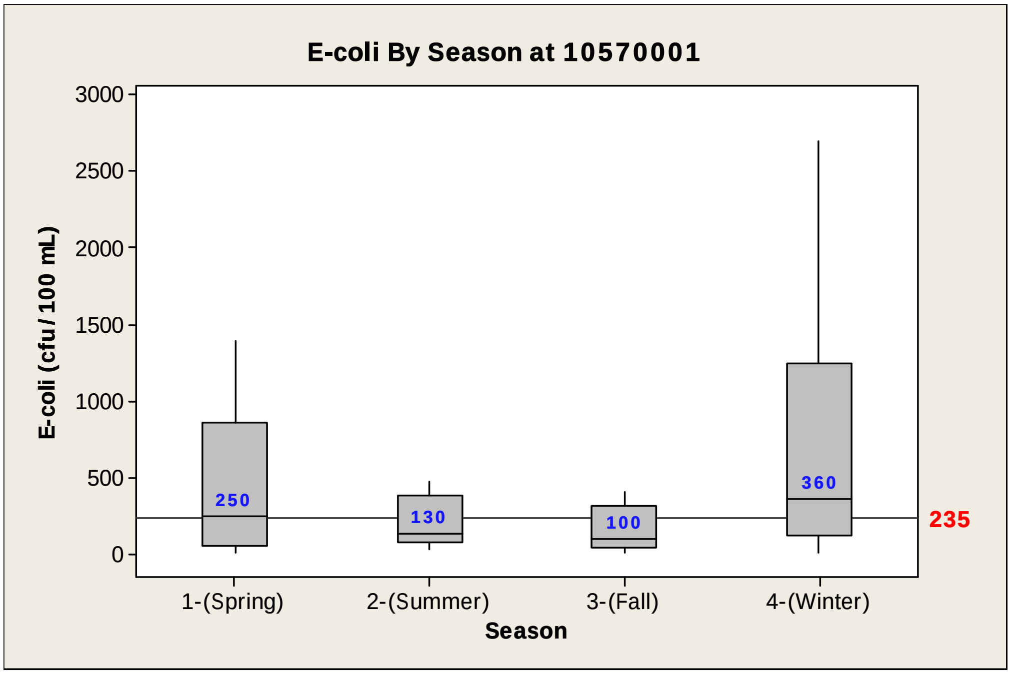

Figure 11-2. Boxplots for Water Quality Station 10570001 by Season.

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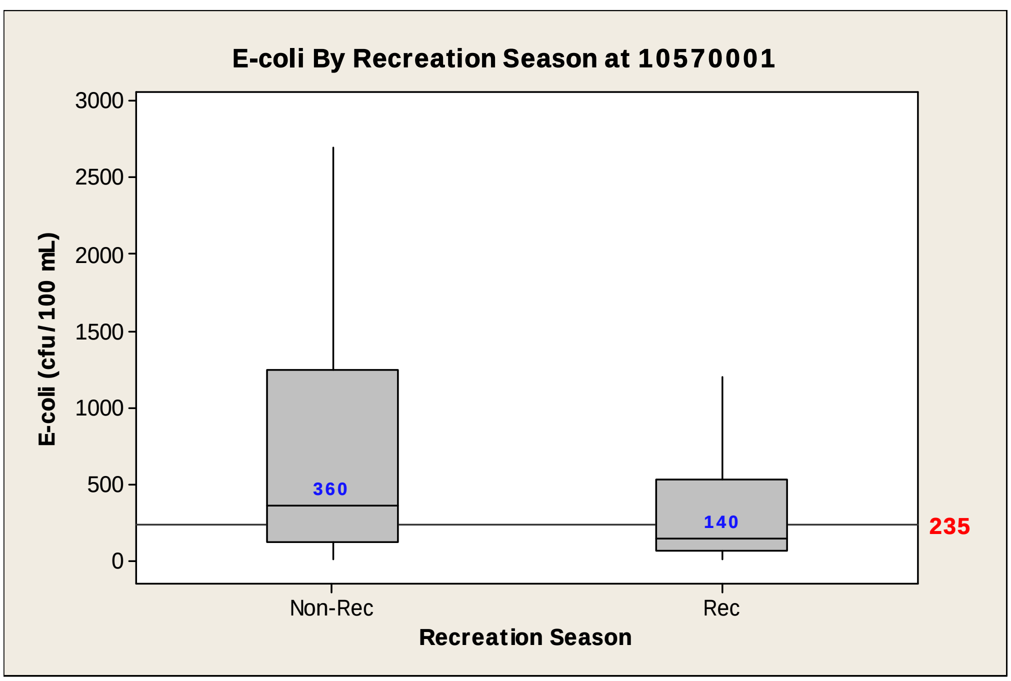
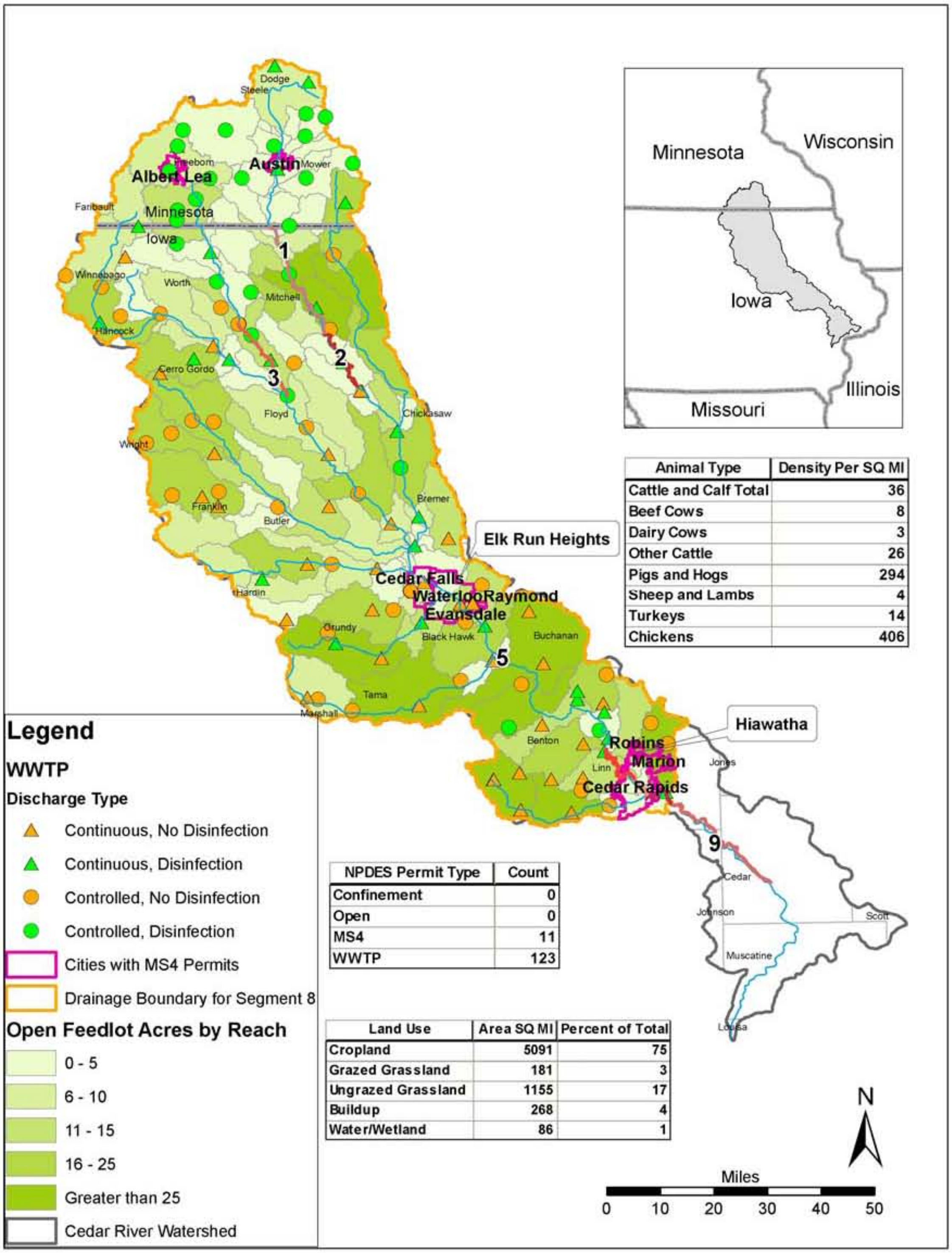


Figure 11-3. Boxplots of Water Quality Station 10570001 by Recreation Season.



Animal Type	Density Per SQ MI
Cattle and Calf Total	36
Beef Cows	8
Dairy Cows	3
Other Cattle	26
Pigs and Hogs	294
Sheep and Lambs	4
Turkeys	14
Chickens	406

NPDES Permit Type	Count
Confinement	0
Open	0
MS4	11
WWTP	123

Land Use	Area SQ MI	Percent of Total
Cropland	5091	75
Grazed Grassland	181	3
Ungrazed Grassland	1155	17
Buildup	268	4
Water/Wetland	86	1

Figure 11-4. Pollutant Sources for Cedar River Segment IA 02-CED-0020_3.

conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. There are 35 continuous discharge locations (approximately 30 percent) where no disinfection occurs. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

11.3. Flow Variable TMDL Approach and Target

11.3.1. Existing Load and Departure From Load Capacity

Figure 11-5 presents the LDC for IA 02-CED-0020_3. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 157 bacteria samples collected at Water Quality Station 10570001 during the recreations season, 38 percent (or 60 samples) exceeded the WQS. Of these 157 samples, flow estimates are available for 107 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 107 pollutant loads are plotted on the curve and symbolized by season. Table 11-3 summarizes the exceedances by quartile flow regime for these data.

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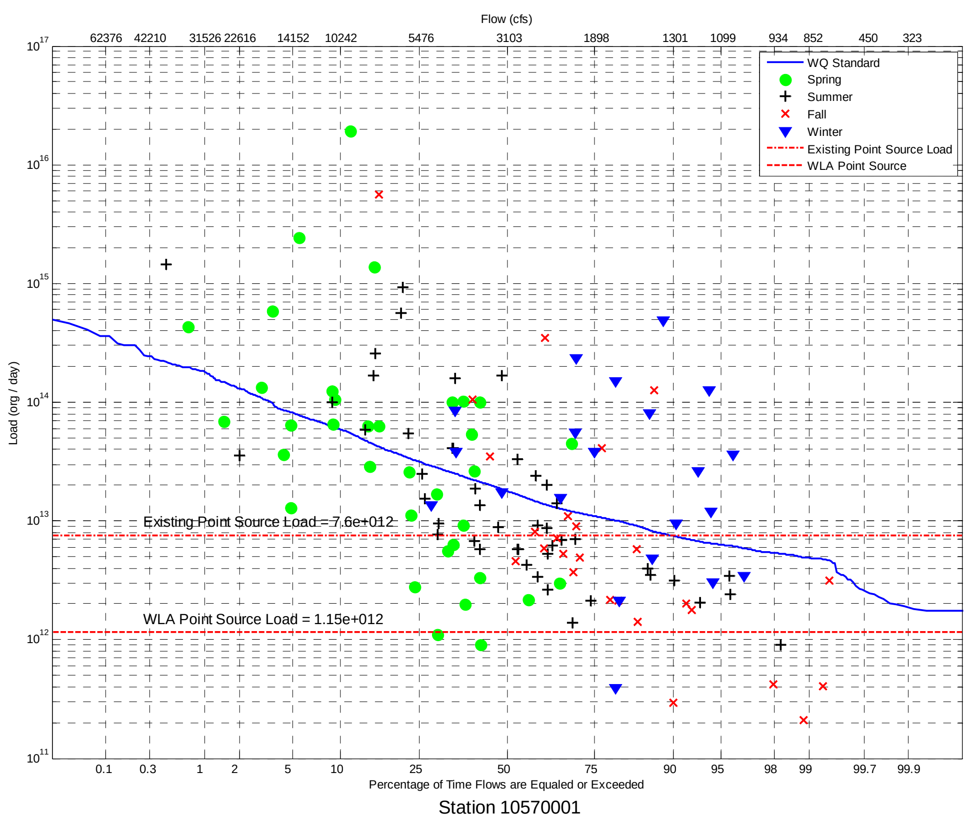

Figure 11-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10570001.

Table 11-3. Departure from load capacity for IA 02-CED-0020_3 by flow regime.

Flow range[1]	# Samples	% of Samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	20	10.0	88.9	93.6
0.25–0.50	30	20.0	52.4	96.0
0.50–0.75	28	39.3	77.5	88.9
0.75–1.00	29	69.0	76.0	99.7

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 11-4 provides an analysis of the HSPF-predicted daily concentrations for Reach 350 for the time period of 1995-2005 under existing conditions. These predictions show similar results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 11-4. HSPF-Predicted departure from load capacity for IA 02-CED-0020_3.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
34	133	399	36	54

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

11.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 11-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 11-5. These loads in Table 11-5 include a 15 percent MOS.

Table 11-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_3.

TMDL	Flow quartile (low to high flows)			
	<25	25-50	50-75	>75
Daily median load (cfu/day)	4.29E+12	7.24E+12	1.25E+13	2.75E+13
Daily median flow (cfs)	1,393	2,348	4,050	8,932
Daily maximum load (cfu/day)	1.07E+13	1.74E+13	3.02E+13	1.56E+14
Daily maximum flow (cfs)	1,866	3,026	5,246	27,064

11.4. Pollutant Allocation

11.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 11-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland and point sources that do not disinfect before discharge.

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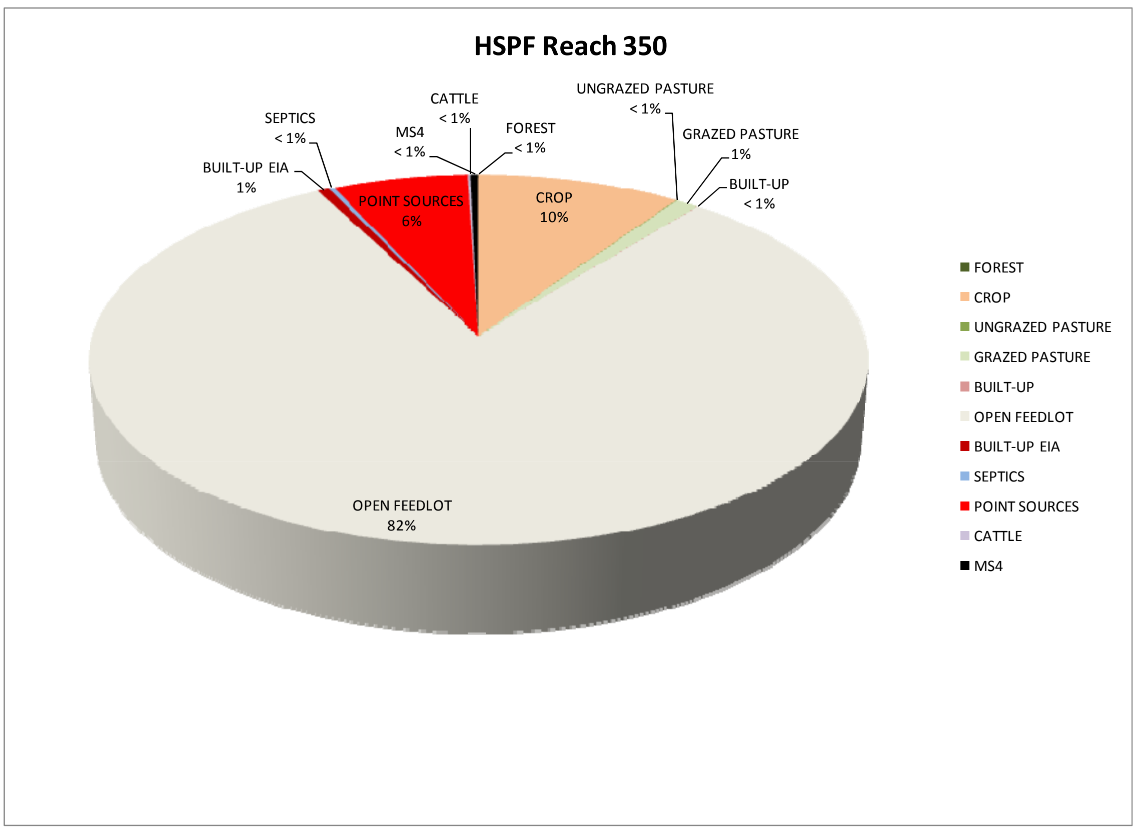

Figure 11-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0020_3.

11.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, most WLA is expressed as a static load. This segment also contains municipalities with MS4s. For this flow dependant point source the WLA was calculated using modeled flow from the MS4 areas and the *E. coli* standards. The estimated static WLA component of the TMDL is shown in Figure 7-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0020_3, the static WLA was calculated to be 1.15E+12 *E. coli* cfu/day; there is no reserve capacity for this segment. The sum of the static and MS4 WLA was calculated to be 1.20E+12 *E. coli* cfu/day for the first quartile, 1.25E+12 *E. coli* cfu/day for the second quartile, 1.34E+12 *E. coli* cfu/day for the third quartile, and 5.42E+12 *E. coli* cfu/day for the fourth quartile. The existing point source load is 1.60E+12 *E. coli* cfu/day. To obtain the WLA at flows in the first quartile, the existing point source load needs to be reduced by 25 percent.

11.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \qquad (11\text{-}1)$$

Table 11-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 11-5.

Table 11-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_3.

LA	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	2.45E+12	4.90E+12	9.27E+12	2.18E+13
Daily maximum load (cfu/day)	7.92E+12	1.35E+13	2.43E+13	1.31E+14

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

11.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 11-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_3.

MOS	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	6.44E+11	1.09E+12	1.87E+12	4.13E+12
Daily maximum load (cfu/day)	1.61E+12	2.61E+12	4.52E+12	2.33E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

12. Indicator Bacteria Impairment for Cedar River from Rock Run Creek to Highway 30 Bridge at Cedar Rapids (IA 02-CED-0020_2)

The drainage area of the 30-mile river segment, at its endpoint, is approximately 7,100 square miles, with the northern portion of the area extending into Minnesota (shown as Segment 9 on the figures). The nearest water quality station for this reach with a significant number of samples is 10160001; the station is located near the segment endpoint. Concurrent flow estimates are provided at the segment endpoint by **HSPF** Reach 370.

12.1. Problem Identification

12.1.1. Problem Statement

Of the 106 bacteria samples collected at Water Quality Station 10160001 during the recreation season, 34 percent (or 36 samples) exceeded the WQS. Of the 36 bacteria samples collected at Water Quality Station 10160001 during the recreation season, 25 percent (or nine samples) exceeded the WQS. Table 12-1 presents descriptive statistics for both fecal coliform and *E. coli* for all available data from the water quality station.

Table 12-1. Descriptive statistics for Water Quality Station 10160001.

Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
E. coli	83	604	1,744	10	30	110	340	13,000
Fecal	59	897	3,239	9	28	110	368	23,000

12.1.2. Data Interpretation

Figure 12-1 presents boxplots of concentration data grouped by flow range (high, mid, and low). There were 50 samples recorded during the recreational season for which flow estimates were available. From this plot, it is evident that there are over 25 percent exceedances for all flow ranges; however, higher exceedance frequency was associated with larger flows.

Table 12-2 presents descriptive statistics for Water Quality Station 10160001 by season. For all seasons, the upper quartile well exceeds the WQS. Figure 12-2 shows this graphically by the four seasons and Figure 12-3 shows this by recreational season. It is evident from these tables and figures that exceedances occur during all flow regimes and seasons. This would indicate both indirect and direct sources contribute to the impairment.

12.2. Pollution Source Assessment

12.2.1. Identification of Pollutant Sources

Figure 12-4 presents an accounting of potential bacteria pollution sources that are hydrologically connected to TMDL Segment IA 02-CED-0020_2. The upstream watershed's indirect sources are predominately runoff from manure application on cropland (approximately 74 percent of the area) and open feedlots upstream of the impaired reach. This upstream area also contains significant areas of karst geology which facilitates the movement of pollution to surface and groundwater sources. There are 126 NPDES-permitted WWTPs (four facilities have two discharge locations) and 11 MS4 permits within the watershed. Of the 129 discharge locations, 56 use disinfection during the recreation season. There are 73 discharge locations where no disinfection occurs; of these, 34 are controlled discharge. Because controlled discharge is conducted two times per year, bacteria concentrations are likely significantly reduced because of the detention time; however, the actual discharge concentration is unknown. There are 44 continuous discharge locations (approximately 35 percent) where no disinfection occurs. Table D-2 in Appendix D presents the loadings associated with these WWTPs.

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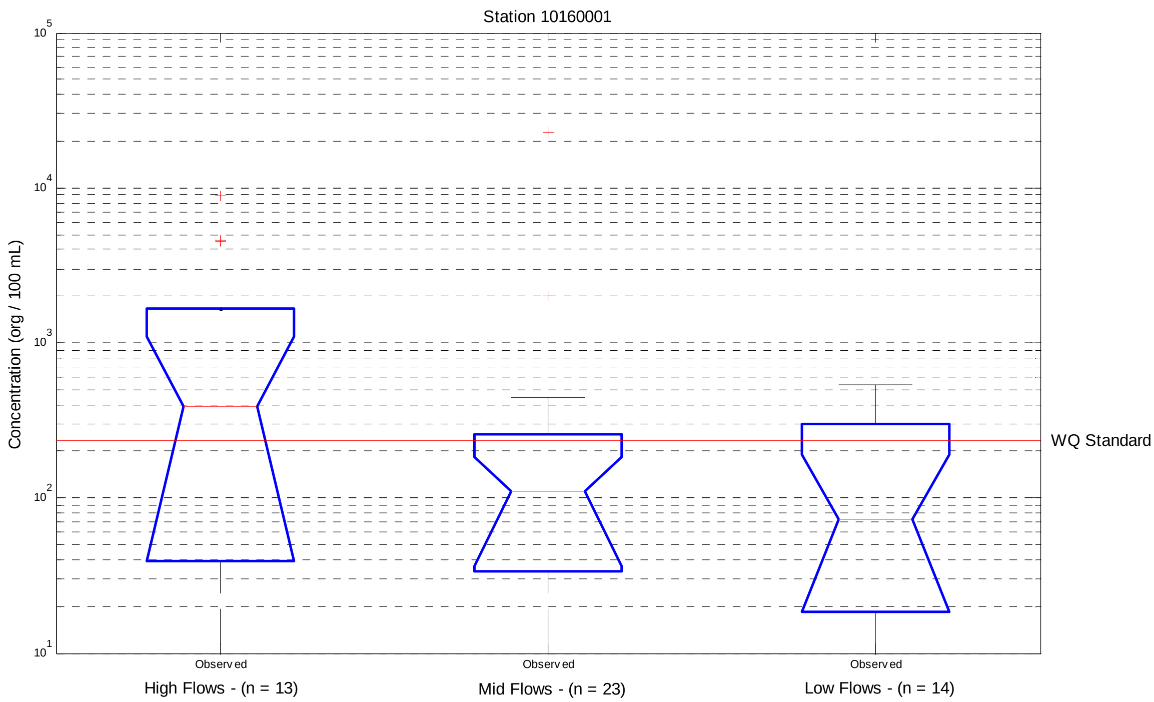

Figure 12-1. Boxplots for Water Quality Station 10160001 by Flow Range.

Table 12-2. Descriptive statistics for Water Quality Station 10160001 by season.

Season	Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Spring	48	311.6	667	9.2	10	76.5	357.4	3,588
Summer	34	608	1,304	18	98	165	443	5,000
Fall	24	2,222	5,481	9	25	76	359	23,000
Winter	36	391	871	9	38	80	297	3,800

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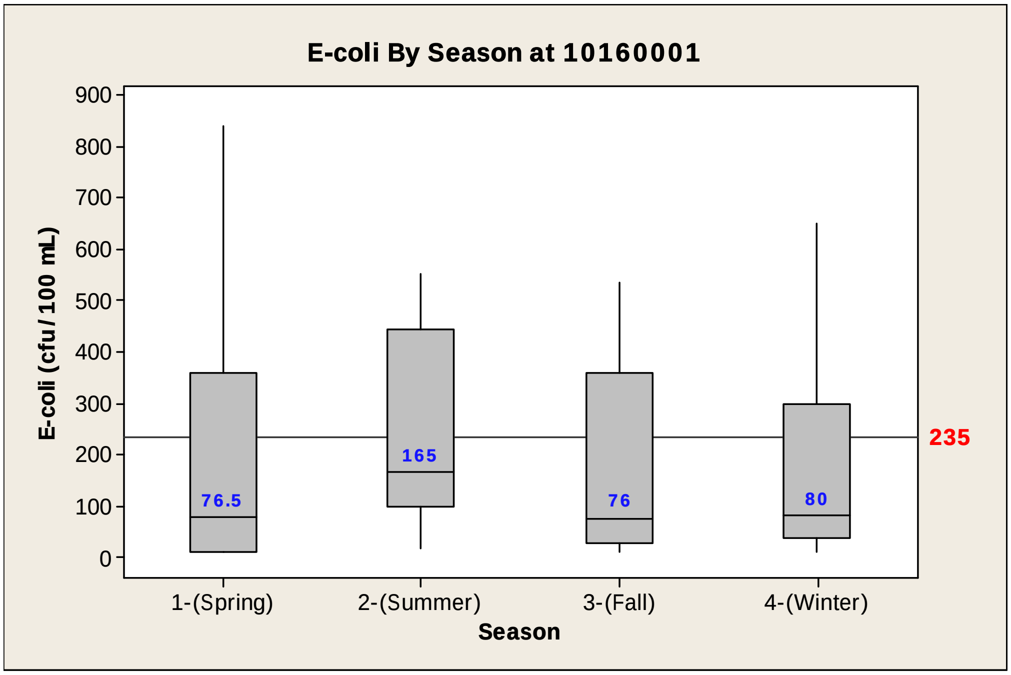


Figure 12-2. Boxplots for Water Quality Station 10160001 by Season.

RSI-1748-08-072

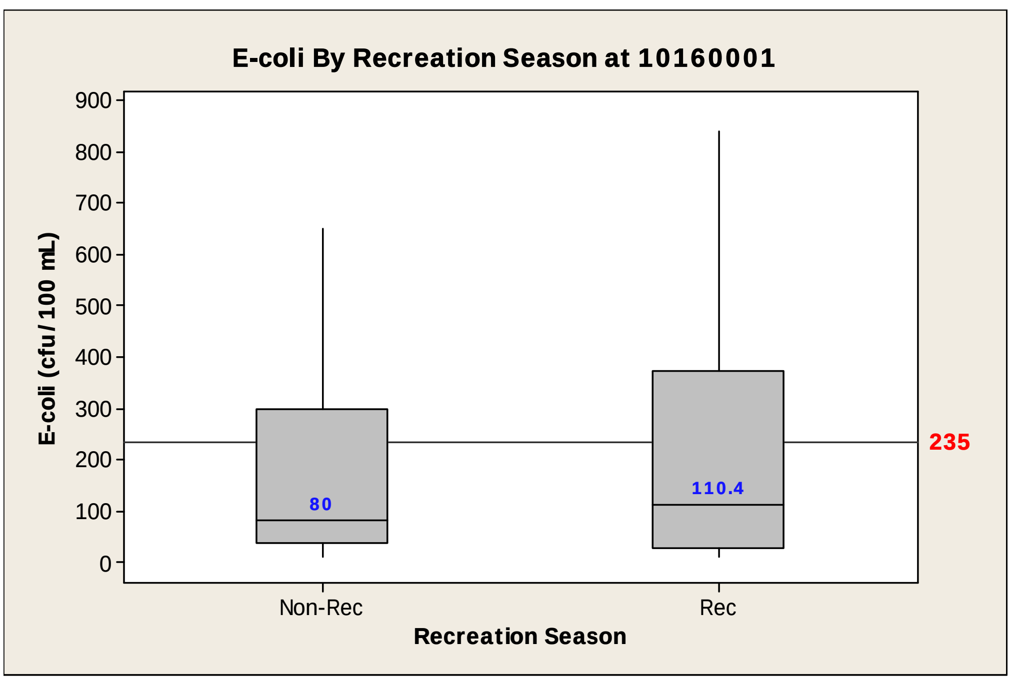
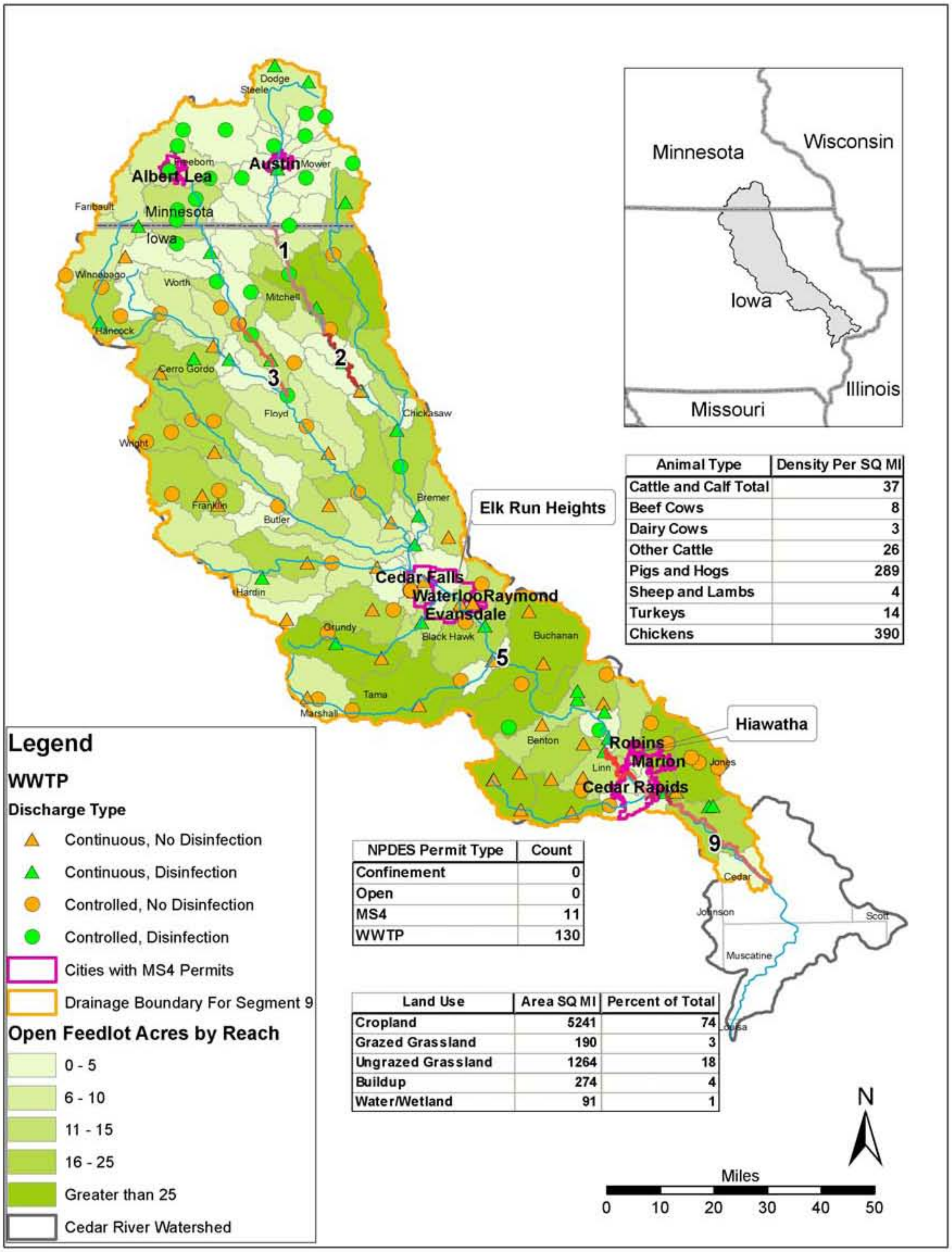


Figure 12-3. Boxplots of Water Quality Station 10160001 by Recreation Season.



Animal Type	Density Per SQ MI
Cattle and Calf Total	37
Beef Cows	8
Dairy Cows	3
Other Cattle	26
Pigs and Hogs	289
Sheep and Lambs	4
Turkeys	14
Chickens	390

NPDES Permit Type	Count
Confinement	0
Open	0
MS4	11
WWTP	130

Land Use	Area SQ MI	Percent of Total
Cropland	5241	74
Grazed Grassland	190	3
Ungrazed Grassland	1264	18
Buildup	274	4
Water/Wetland	91	1

Figure 12-4. Pollutant Sources for Cedar River Segment IA 02-CED-0020_2.

12.3. Flow Variable TMDL Approach and Target

12.3.1. Existing Load and Departure From Load Capacity

Figure 12-5 presents the LDC for IA 02-CED-0020_2. This curve presents a dynamic expression of the daily allowable load as a function of the range of flows predicted to occur over a wide range of hydrologic conditions at the segment endpoint. Of the 106 bacteria samples collected at Water Quality Station 10160001 during the recreation season, 34 percent (or 36 samples) exceeded the WQS. Of these 106 samples, flow estimates are available for 50 samples during the recreational season. Spring, summer, and fall were defined to be within the recreation season. These 50 pollutant loads are plotted on the curve and symbolized by season. Table 12-3 summarizes the exceedances by quartile flow regime for these data.

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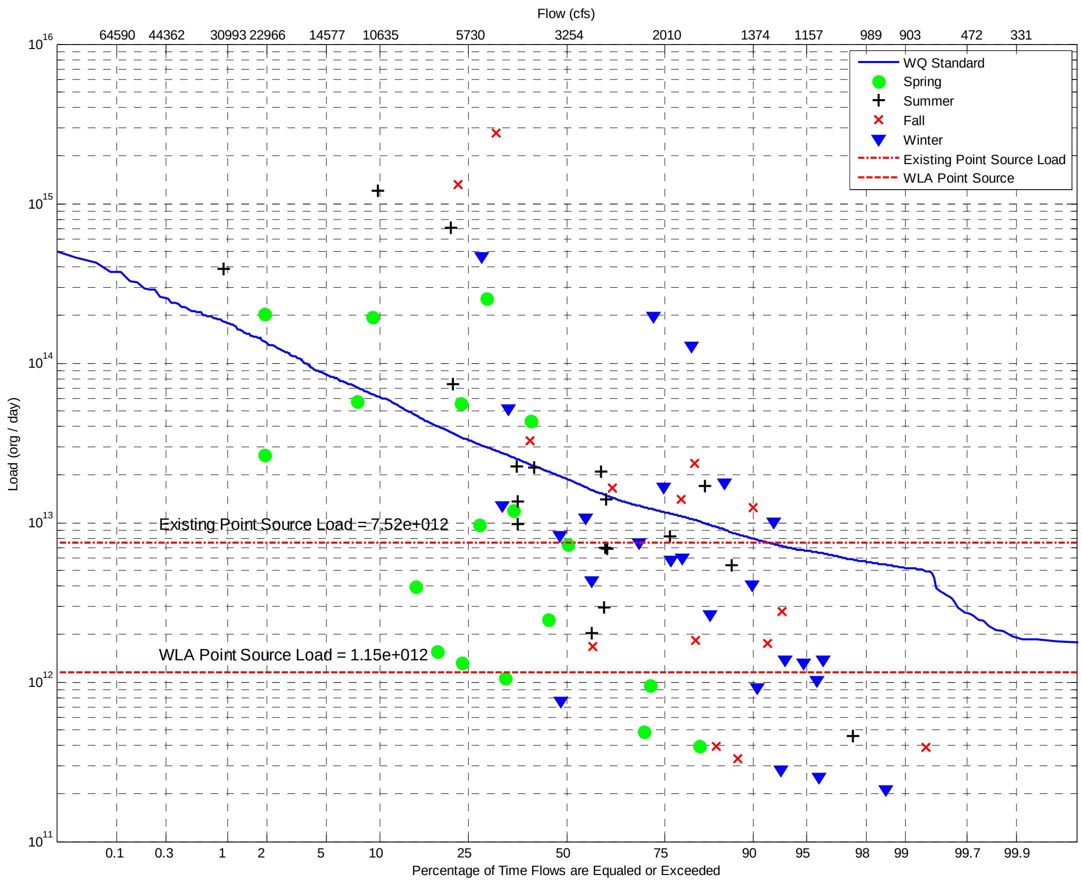

Station 10160001

Figure 12-5. Load Duration Curve for *E. coli* Measured at Water Quality Station 10160001.

Table 12-3. Departure from load capacity for IA 02-CED-0020_2 by flow regime.

Flow range[1]	# Samples	% of samples needing reduction	Median reduction needed	Max reduction
0.00–0.25	14	28.6	34.6	56.0
0.25–0.50	11	18.2	20.5	26.6
0.50–0.75	12	33.3	82.8	99.0
0.75–1.00	13	61.5	83.5	97.3

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

Table 12-4 provides an analysis of the HSPF-predicted daily concentrations for Reach 370 for the time period of 1995-2005 under existing conditions. These predictions show similar results to the available data in terms of the percent of samples exceeding the maximum standard. Appendix E presents the water quality calibration results for the application. The continuous time series also provides an estimate of the percent of time the EPA recommended, 30-day geometric standard is exceeded. Appendix G discusses the impact several alternative implementation scenarios have on load reductions and compliance with WQS.

Table 12-4. HSPF-Predicted departure from load capacity for IA 02-CED-0020_2.

Q1 percentile (cfu/100ml)	Median percentile (cfu/100 ml)	Q3 percentile (cfu/100ml)	% Exceed max-standard	% Exceed geom-standard
32	129	393	36	54

The LDC also provides insight into the proportion of the load that is attributable to point versus nonpoint sources. Under the existing conditions, it is estimated that the lowest 10 percent of flows would exceed WQS because of the point source loadings. This is caused by point sources that do not currently incorporate disinfection.

12.3.2. Flow Variable TMDL Targets for Daily Loads

As previously discussed, a dual target was established using the 95th percentile load as the daily maximum value to address variability in instantaneous concentrations and the 50th percentile load as the allowable daily median to represent long-term loading goals. Table 12-5 presents the TMDLs for each of the quartile flow categories. The 95th percentile load for each flow category establishes the daily maximum load and the 50th percentile load represents the allowable daily median load. The daily median and maximum flows within each quartile range are also presented in Table 12-5. These loads in Table 12-5 include a 15 percent MOS.

Table 12-5. Flow variable TMDL loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_2.

TMDL	Flow quartile (low to high flows)			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	4.59E+12	7.62E+12	1.32E+13	2.87E+13
Daily median flow (cfs)	1,488	2,473	4,278	9,301
Daily maximum load (cfu/day)	1.14E+13	1.83E+13	3.17E+13	1.61E+14
Daily maximum flow (cfs)	1,977	3,178	5,505	28,029

12.4. Pollutant Allocation

12.4.1. Source Allocation

The relative contribution to pollution, during the recreational season, of all stressors included within the **HSPF** model application is summarized in Figure 12-6. Based on model predictions, runoff from open feedlots is the predominant stressor followed by runoff from manure application on cropland and point sources that do not disinfect before discharge.

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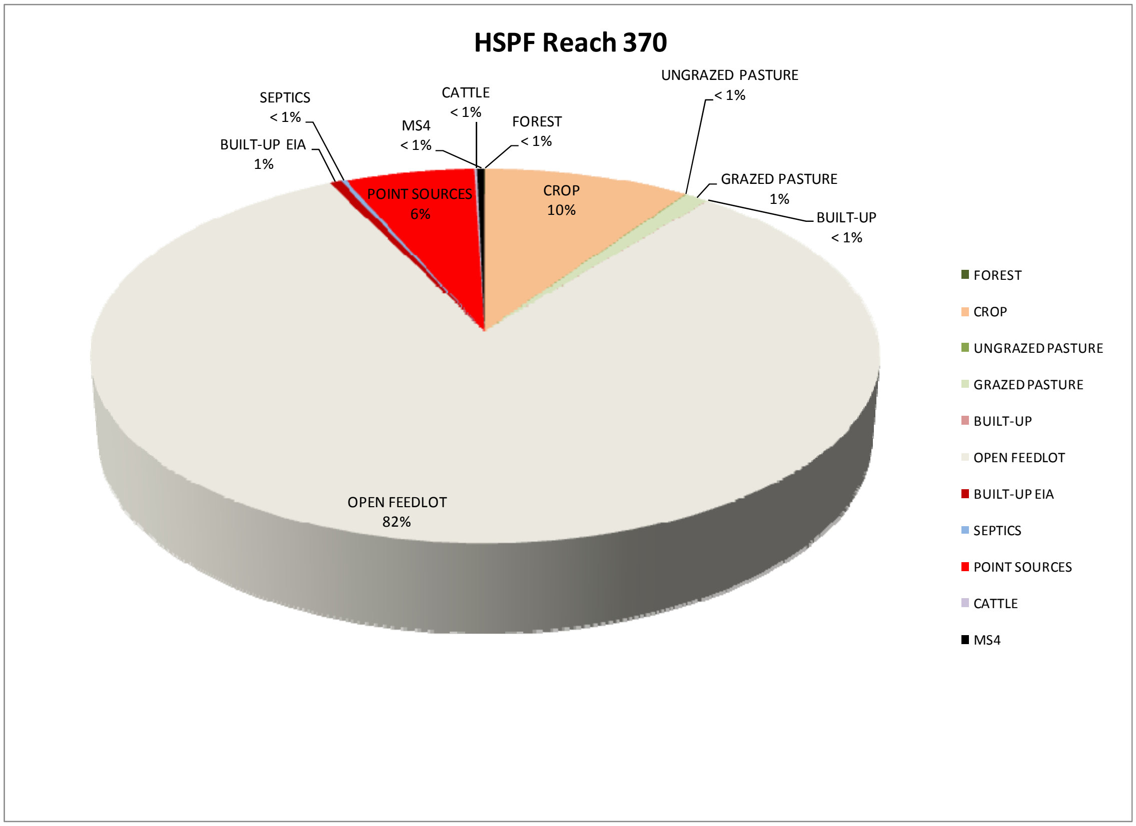

Figure 12-6. HSPF Source Allocation for Cedar River Segment IA 02-CED-0020_2.

12.4.2. Waste Load Allocation

The direct sources that dominate the WLA discharge continuously at relatively constant loadings; thus, the WLA is expressed as a static load. The estimated WLA component of the TMDL is shown in Figure 12-5. The daily load shown on the plots represents the waste load that was predicted to be delivered to the TMDL endpoint during the recreational season over the model simulation time period from 1995-2005. For Segment IA 02-CED-0020_2, the WLA was calculated to be 1.15E+12 *E. coli* cfu/day; there is no MS4 or reserve capacity for unsewered communities in this segment. The existing point source load is 7.52E+12 *E. coli* cfu/day. To obtain the WLA, the existing point source load needs to be reduced by 85 percent.

12.4.3. Load Allocation

The LA at the TMDL endpoint can be calculated for any given flow using the LDC model and/or for the dual TMDL targets specified for the quartile flow intervals using the following equation:

$$\sum LA = TMDL - \sum WLA - MOS \quad (12\text{-}1)$$

Table 12-6 presents the daily maximum LA and daily median LA for each of the quartile flow categories. The daily median and maximum flows within each quartile range were previously presented in Table 12-5.

Table 12-6. Flow variable LA loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_2.

LA	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	2.75E+12	5.33E+12	1.01E+13	2.32E+13
Daily maximum load (cfu/day)	8.51E+12	1.44E+13	2.58E+13	1.36E+14

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

12.4.4. Margin of Safety

The MOS has been set explicitly at 35 *E. coli* cfu×flow for sample maximum and 19 *E. coli* cfu×flow for median conditions, or 15 percent when expressed as a percentage of the TMDL.

Table 12-7. Flow variable MOS loads (cfu/day) for daily maximum load and daily median load for IA 02-CED-0020_2.

MOS	Flow quartile (low to high flows)[1]			
	<25	25–50	50–75	>75
Daily median load (cfu/day)	6.88E+11	1.14E+12	1.98E+12	4.30E+12
Daily maximum load (cfu/day)	1.71E+12	2.74E+12	4.75E+12	2.42E+13

1. The quartiles are listed from the lowest to highest flows; e.g., 0.00-0.25 represents the lowest 25 percent of flows over the time period.

13. Cedar River Watershed Model

The focus of the CRWM was to analyze the watershed as a whole, with sufficient detail to establish localized WLA, LA, and TMDL development for the impaired waterbodies. The watershed model was also used to analyze water quality conditions in all of the major perennial streams throughout the watershed. The model provided predictions of the existing and future water quality conditions in these perennial streams. The predictions for future conditions gave insight into the effectiveness of various alternative BMPs in remediating impairments. The watershed modeling package selected for this project was **HSPF**.

13.1. Model Description

HSPF is a comprehensive, continuous, long-term, watershed model of hydrology and water quality that includes modeling of both land surface and subsurface hydrologic and water quality processes, linked and closely integrated with corresponding stream and reservoir processes. It is considered a premier, high-level model among those currently available for comprehensive watershed assessments. **HSPF** has enjoyed widespread usage and acceptance since its initial release in 1980 as demonstrated through hundreds of applications across the United States and abroad. **HSPF** is jointly supported and maintained by both the EPA and the USGS. In addition, **HSPF** is the primary watershed model included in the EPA's **Better Assessment Science Integrating Point and Nonpoint Sources** (**BASINS**) modeling system and it has recently been incorporated into the Corps **WMS**. This widespread usage and support has helped to ensure the continuing availability and maintenance of the code for more than two decades, in spite of varying federal priorities and budget restrictions. **HSPF** has been used extensively to develop bacteria TMDLs.

13.2. Model Development, Calibration, and Verification

The major steps in the model application process consist of: (1) collection and development of time-series data, (2) characterization and segmentation of the watershed, and (3) calibration/verification of the model. These three steps are discussed in detail RESPEC (2007) and are only briefly summarized below.

13.3. Collection and Development of Time-Series Data

Data requirements for **HSPF** are extensive, in both spatial and temporal detail. The CRWM is exercised at an hourly time step and requires the following time series:

- 33 gages for precipitation
- 4 gages for wind speed, dew point, and cloud cover
- 3 gages for evaporation and solar radiation
- 149 point sources
- Septic and cattle in stream time series for 126 reaches
- Streamflow and water quality data.

Table 13-1 lists the meteorological stations used for model simulation and their locations are shown in Figure 13-1. As shown in the table, precipitation data are supplied from significantly more stations than the “other” meteorological data required. These “other” data are less variable, both spatially and temporally, than precipitation.

Table 13-1. Meteorological gages used for model simulations within HSPF.

All Stations		Meterological Assignment of Stations by Model Segment				
Station Name	Cooperative Station ID	Model Segment	Stations Precipitation	Air Temperature	Windspeed, Dewpoint, Cloud Cover	Evaporation and Solar Radiation
DODGE CENTER	212166	10	DODGE CENTER	CEDAR RAPIDS 1	CEDAR RAPIDS AP	CEDAR RAPIDS AP
AUSTIN 3 S	210355	20	AUSTIN 3 S	ALLISON	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
ST ANSGAR	137326	30	ST ANSGAR	BELLE PLAINE	CEDAR RAPIDS AP	CEDAR RAPIDS AP
OSAGE	136305	40	OSAGE	CEDAR RAPIDS AP	CEDAR RAPIDS AP	CEDAR RAPIDS AP
CHARLES CITY	131402	50	CHARLES CITY	CEDAR RAPIDS 1	CEDAR RAPIDS AP	CEDAR RAPIDS AP
ALBERT LEA 3 SE	210075	60	ALBERT LEA 3 SE	CHARLES CITY	MASON CITY MUNI AP	MASON CITY MUNI AP
NORTHWOOD	136103	70	NORTHWOOD	COLUMBUS JUNCT 1 N	CEDAR RAPIDS AP	CEDAR RAPIDS AP
LAKE MILLS	134557	80	LAKE MILLS	GRUNDY CENTER	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
FOREST CITY 2 NNE	132977	90	FOREST CITY 2 NNE	HAMPTON	MASON CITY MUNI AP	MASON CITY MUNI AP
MASON CITY MUNI AP	135235	100	MASON CITY MUNI AP	ALBERT LEA 3 SE	ALBERT LEA 3 SE	MASON CITY MUNI AP
MASON CITY	135230	110	MASON CITY	GRUNDY CENTER	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
SHEFFIELD 3 NW	137572	120	SHEFFIELD 3 NW	HAMPTON	MASON CITY MUNI AP	MASON CITY MUNI AP
HAMPTON	133584	130	HAMPTON	IOWA CITY	CEDAR RAPIDS AP	CEDAR RAPIDS AP
DUMONT	132388	140	DUMONT	IOWA FALLS	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
ALLISON	130157	150	ALLISON	ALBERT LEA 3 SE	ALBERT LEA 3 SE	MASON CITY MUNI AP
SHELL ROCK 2W	137602	160	SHELL ROCK 2W	CEDAR RAPIDS 1	CEDAR RAPIDS AP	CEDAR RAPIDS AP
IOWA FALLS	134142	170	IOWA FALLS	MASON CITY	MASON CITY MUNI AP	MASON CITY MUNI AP
STEAMBOAT ROCK	137932	180	STEAMBOAT ROCK	MASON CITY MUNI AP	MASON CITY MUNI AP	MASON CITY MUNI AP
PARKERSBURG	136492	190	PARKERSBURG	NORTHWOOD	ALBERT LEA 3 SE	MASON CITY MUNI AP
TRIPOLI	138339	200	TRIPOLI	OSAGE	MASON CITY MUNI AP	MASON CITY MUNI AP
GRUNDY CENTER	133487	210	GRUNDY CENTER	GRUNDY CENTER	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
WATERLOO MUNICIPAL AP	138706	220	WATERLOO MUNICIPAL AP	AUSTIN 3 S	ALBERT LEA 3 SE	MASON CITY MUNI AP
CONRAD	131742	230	CONRAD	MASON CITY MUNI AP	MASON CITY MUNI AP	MASON CITY MUNI AP
TRAER	138315	240	TRAER	ALLISON	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
VINTON	138568	250	VINTON	GRUNDY CENTER	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
BELLE PLAINE	130600	260	BELLE PLAINE	GRUNDY CENTER	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
WALFORD 2 SE	138632	270	WALFORD 2 SE	TRIPOLI	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
CEDAR RAPIDS AP	131314	280	CEDAR RAPIDS AP	VINTON	CEDAR RAPIDS AP	CEDAR RAPIDS AP
CEDAR RAPIDS 1	131319	290	CEDAR RAPIDS 1	CEDAR RAPIDS AP	CEDAR RAPIDS AP	CEDAR RAPIDS AP
LOWDEN	134963	300	LOWDEN	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP	WATERLOO MUNICIPAL AP
ILLINOIS CITY DAM 16	114355	310	ILLINOIS CITY DAM 16	ALBERT LEA 3 SE	ALBERT LEA 3 SE	MASON CITY MUNI AP
IOWA CITY	134101	320	IOWA CITY	AUSTIN 3 S	ALBERT LEA 3 SE	MASON CITY MUNI AP
COLUMBUS JUNCT 1 N	131731	330	COLUMBUS JUNCT 1 N	AUSTIN 3 S	ALBERT LEA 3 SE	MASON CITY MUNI AP

Other time series required to exercise the model (e.g., point sources, septic systems, and cattle in streams), along with data required to calibrate the model (e.g., streamflow and water quality), were discussed in Chapter 3.

13.4. Characterization and Segmentation of the Watershed

The purpose of watershed segmentation is to divide the study area into individual land and channel segments, or pieces, that are assumed to demonstrate relatively homogenous hydrologic/hydraulic and water quality behavior. This segmentation provides the basis for assigning similar or identical input and/or parameter values or functions to where they can be applied logically to all portions of a land area or channel length contained within a model segment. Since **HSPF** and most watershed models differentiate between land and channel portions of a watershed, each is modeled separately and each undergoes a segmentation process to produce separate land and channel segments that are linked together to represent the entire watershed area.

For the land segmentation, subbasins were first delineated in a manner to capture the regional hydrologic and water quality variability. The primary factors were the locations of the rain

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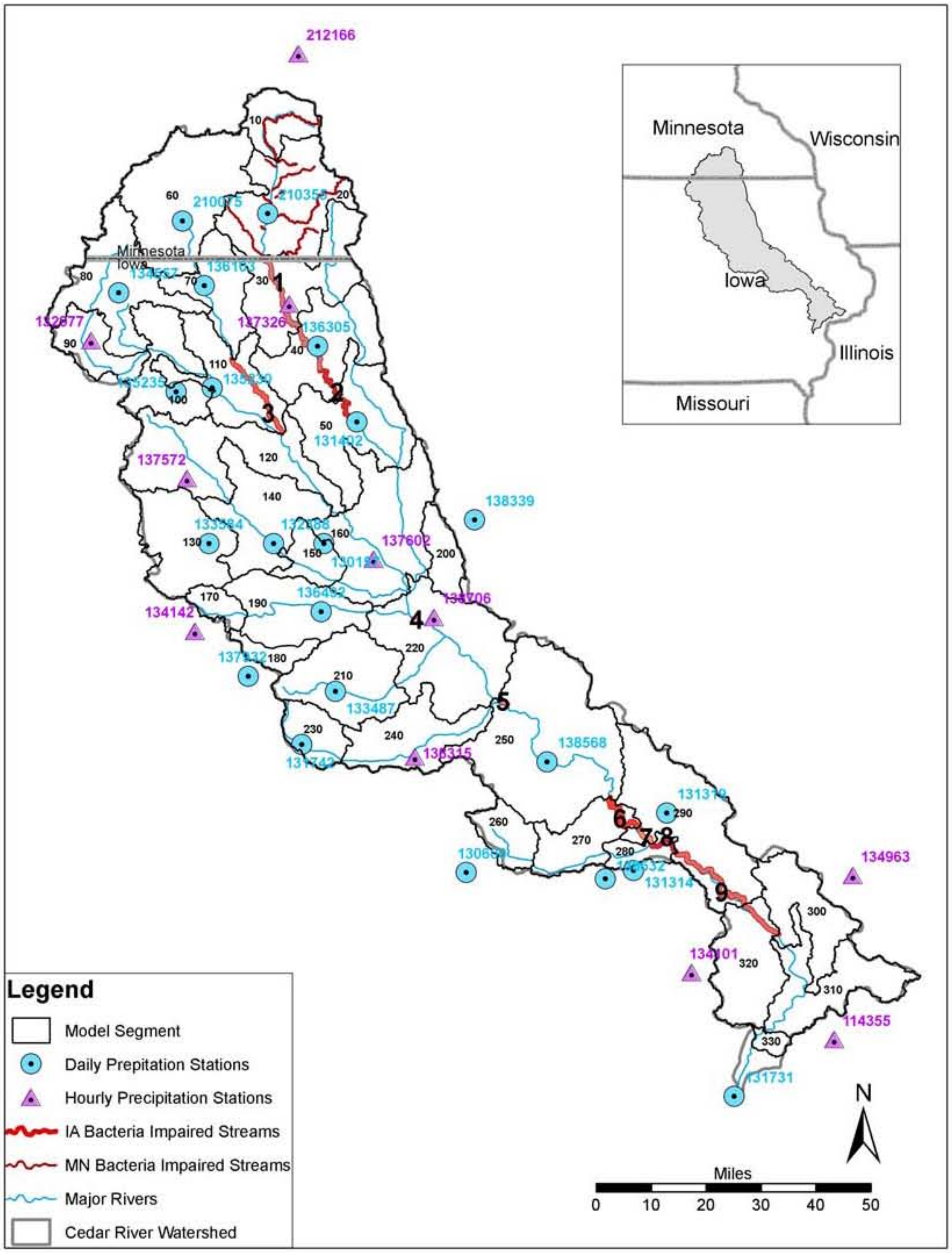

Figure 13-1. Meteorological Gage Locations Used for Cedar River Watershed Model Simulations in HSPF.

gauges, Thiessen network boundaries, isohyetal contours, physiography (e.g., Des Moines Lobe, Iowan Surface) and discussions with IDNR. This resulted in 33 segments shown in Figure 13-1. Within each of the 33 segments, a finer delineation was performed to represent seven types of response units corresponding to the following categories:

- Urban Pervious,
- Cropland,
- Forestland,
- Grazed Pasture,
- Ungrazed Pasture,
- Open Feedlots, and
- Urban Effectively Impervious.

Figure 13-2 shows the 2002 Iowa land use/land cover distribution (IDNR, 2002) for the 7,800 square-mile watershed. The categories in this coverage were mapped to model categories. Categories with an impervious component were divided into pervious and impervious areas based on estimated percent “effective” imperviousness (EIA) for each category. The term effective implies that the impervious region is directly connected to a local hydraulic conveyance system (e.g., open channel, river). EIA percentages were developed for categories: (1) barren, (2) commercial/industrial, (3) residential, and (4) roads. Open feedlots account for less than one percent of the total area; the area, location, and loadings associated with open feedlots were discussed in Chapter 3.

The river segmentation required consideration of river travel time, riverbed slope continuity, morphologic changes, entry points of major tributaries, TMDL reach end points, and calibration gage locations for flow and bacteria. Figure 13-3 shows the final reach segmentation, which includes 126 reach segments ranging in size from 0.5 square mile to 242 square miles with a mean size of 60 square miles. The reach hydraulic behavior is specified in an FTABLE, which contains the reach surface area, volume and discharge as functions of depth; i.e., an expanded rating curve. The FTABLES were developed using cross sections from Acoustic Doppler Current Profilers (ADCP) and rating curves from the USGS. Cross sections for unsurveyed tributaries were estimated as simple trapezoidal channels with dimensions consistent with available data.

13.5. Model Calibration/Verification

The standard **HSPF** hydrologic calibration is divided into four phases: (1) establish an annual water balance, (2) adjust low flow/high flow distribution, (3) adjust stormflow/hydrograph shape, and (4) make seasonal adjustments. By iteratively adjusting specific calibration parameter values, within accepted ranges, the simulation results are changed until an acceptable comparison of simulated results and measured data are achieved. The procedures and parameter adjustments involved in these phases are more completely described in Donigian, et. al. (1984) and the **HSPF Hydrologic Calibration Expert System** (**HSPEXP**) (Lumb, et. al., 1994).

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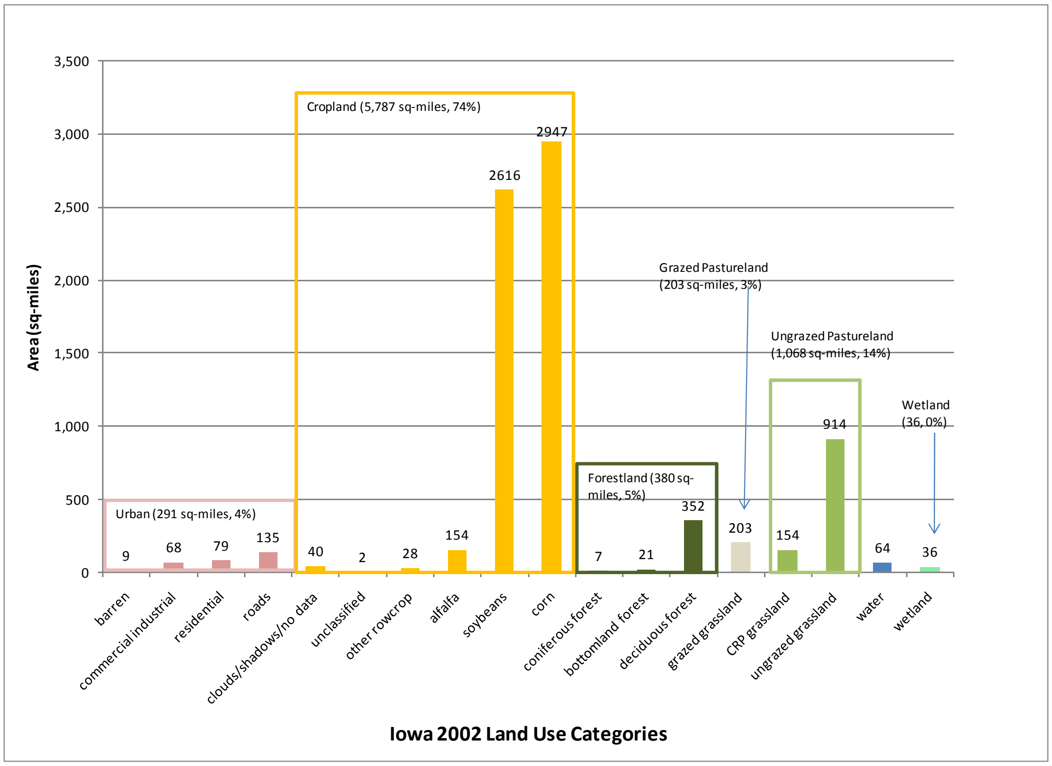

Figure 13-2. Iowa 2002 Land Use/ Land Cover Distribution and Aggregated Model Categories for the Cedar River Watershed (IDNR, 2002).

The primary goal of the water quality calibration/verification was to determine the reliability of the direct and indirect load generation developed through **BIT**. This was done by using the predicted hydrology to determine the transport and fate of these loads and then comparing the predicted concentrations with available data at multiple sites throughout the watershed. The water quality calibration focused on setting reasonable water quality parameters, checking for reasonable agreement between predicted and observed concentrations and, as necessary, reevaluating the **BIT** loads being generated. Model performance was based largely on graphical presentations since the frequency of data were often inadequate for accurate statistical measures.

The principal time-series data needed for hydrologic and water quality calibration/verification indicated that long-term simulations (1995 through 2005) were possible with calibration/ verification being performed for the flow and water quality gages shown in Tables 13-2 and 13-3, respectively. The locations of these stations are shown on Figure 13-4.

Model verification is an extension of the calibration/verification process. Its purpose is to ensure the calibrated model properly assesses all of the variables and conditions that can affect model results. There are different approaches to validating a model. The approach that was used for the present study involved first calibrating, over the time period of 1995 through 2005 at a subset of sites, where flow and water quality data were available.

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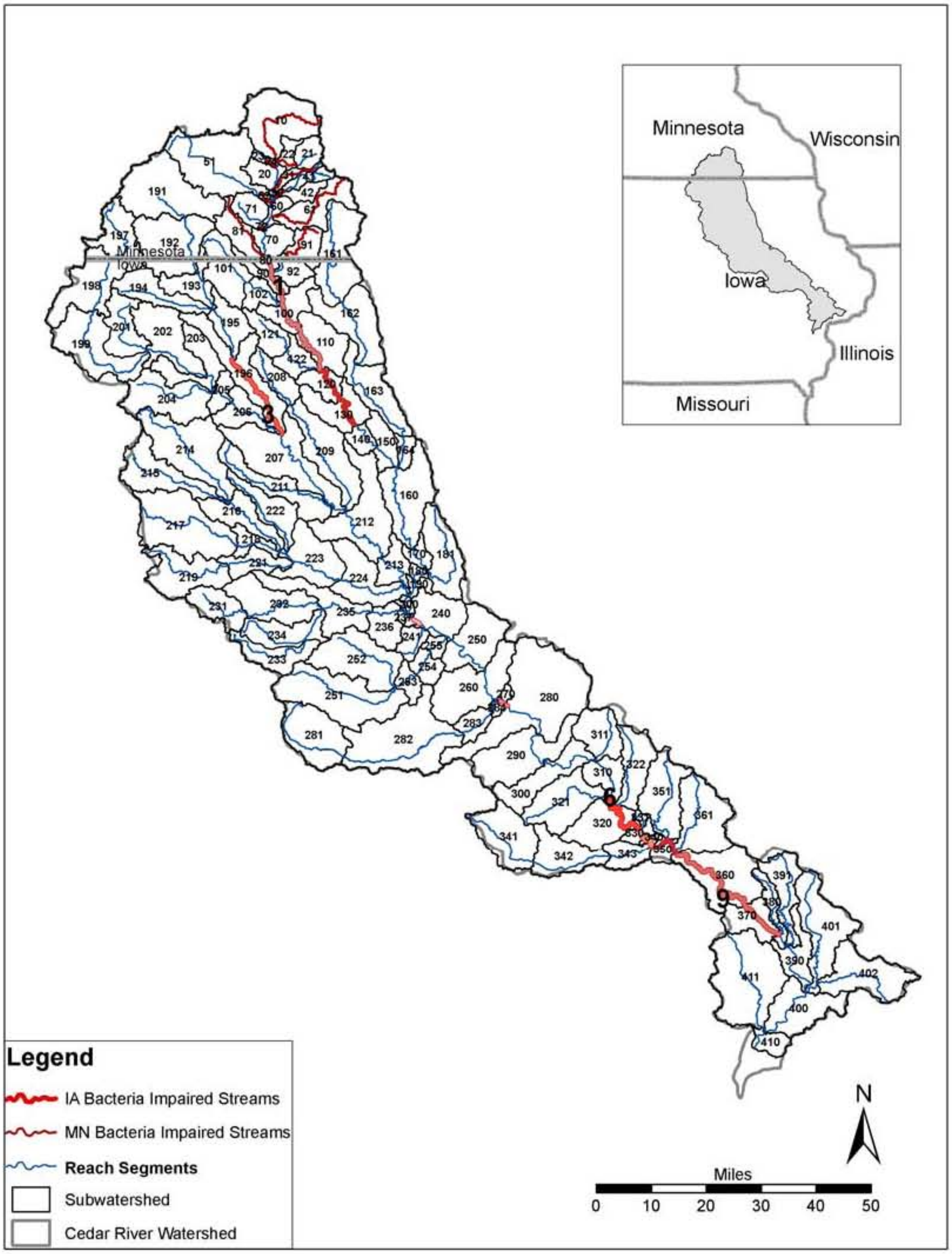

Figure 13-3. Reach Segmentation for the Cedar River Watershed.

Table 13-2. USGS flow gages used for HSPF hydrologic calibration/verification in the Cedar River Watershed TMDL (1902 – 2006).

HUC	Site number	Station name	Drainage area (sq-mile)	Start date	End date	Median flow (cfs)	Average flow (cfs)
07080201	05457000	Cedar River near Austin, MN	399	6/1/1909	9/30/2006	98	243
07080201	05457700	Cedar River at Charles City, IA	1,054	10/1/1964	9/30/2006	360	734
07080201	05458000	Little Cedar River near Ionia, IA	306	10/1/1954	9/30/2006	72	188
07080201	05458300	Cedar River at Waverly, IA	1,547	10/1/2000	9/30/2006	440	1,045
07080201	05458500	Cedar River at Janesville, IA	1,661	10/1/1904	9/30/2006	476	956
07080202	05462000	Shell Rock River at Shell Rock, IA	1,746	3/11/1953	9/30/2004	535	1,084
07080203	05459500	Winnebago River at Mason City, IA	526	10/1/1932	9/30/2006	114	289
07080204	05458900	West Fork Cedar River at Finchford, IA	846	10/1/1945	9/30/2006	242	561
07080205	05463000	Beaver Creek at New Hartford, IA	347	10/1/1945	9/30/2006	88	224
07080205	05463500	Black Hawk Creek at Hudson, IA	303	4/4/1952	9/30/2006	75	188
07080205	05464000	Cedar River at Waterloo, IA	5,146	10/1/1940	9/30/2006	1,800	3,320
07080205	05464220	Wolf Creek near Dysart, IA	299	6/5/1995	9/30/2006	70	176
07080205	05464500	Cedar River at Cedar Rapids, IA	6,510	10/1/1902	9/30/2006	2,160	3,780
07080206	05465000	Cedar River near Conesville, IA	7,787	9/16/1939	9/30/2006	3,130	5,179

Table 13-3. USGS Water Quality Gages used for water quality calibration/verification by reach in the Cedar River Watershed HSPF model.

Water Quality Gage	HSPF Reach
10340001	140
11190001	163
10090001	180
10170002	202
10170003	205
10120001	212
10070003	224
10070001	236
10070006	250
10070004	254
10070002	283
10570001	350
10160001	360

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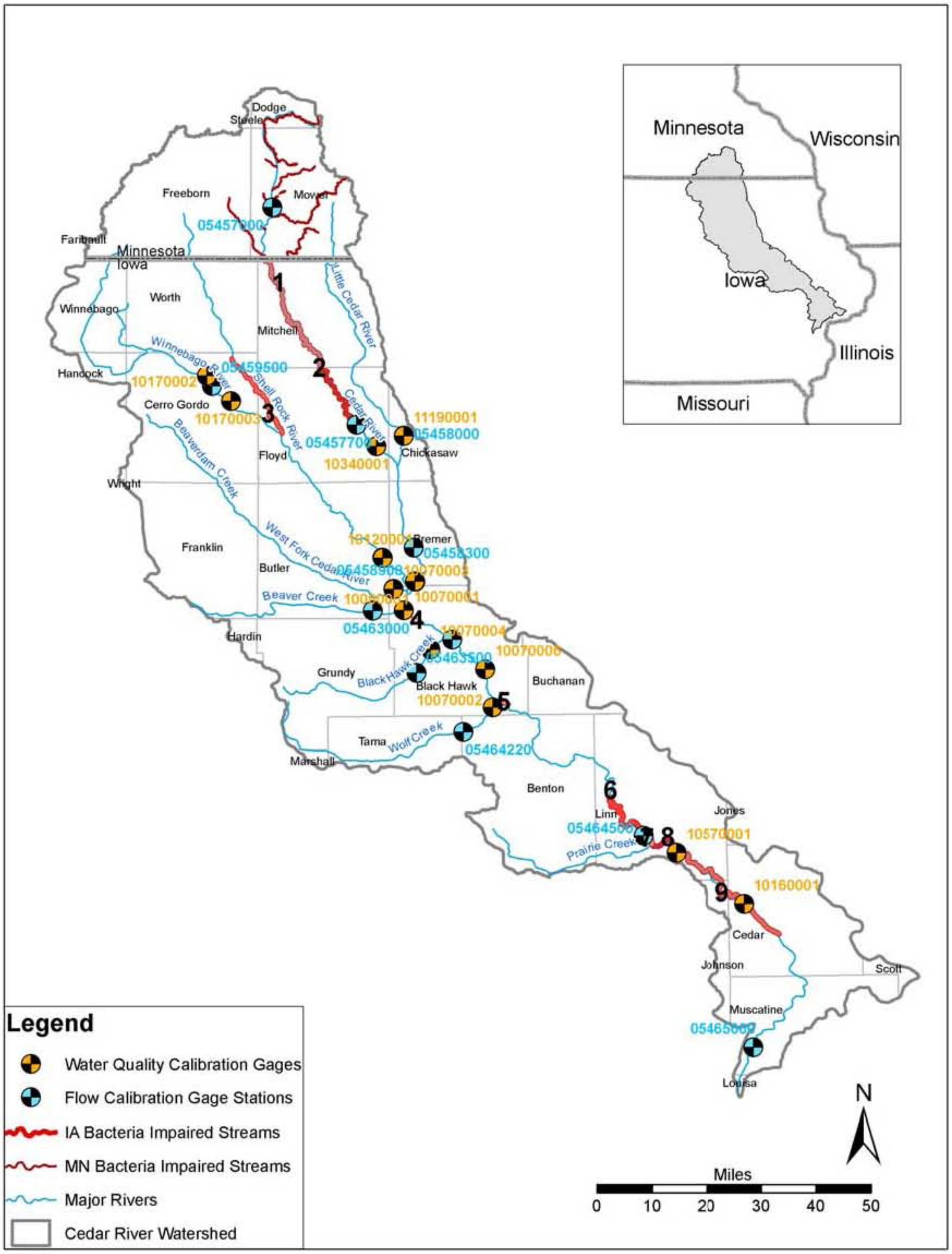

Figure 13-4. Locations of Calibration/Verification Gages for Flow and Water Quality within the Cedar River Watershed.

These sites were selected to represent the range of conditions expected to occur throughout the watershed. Primarily, this process was done by selecting some sites within the Des Moines Lobe and some within the Iowan Surface. The time period of 1995-2005 included both wet and dry years.

The model was then validated by transferring the parameter sets to other nearby regions with similar hydrologic and water quality characteristics. The model performance was then assessed at these "other" sites for the time period of 1995-2005. This process was done to spatially validate the model performance. Model performance was then assessed temporally by subsetting the 1995-2005 results to the more recent time period of 2000-2005 and reassessing the model performance at all gages.

Table 13-4 lists general hydrologic calibration/verification tolerances or targets that were provided to model users as part of **HSPF** training workshops over the past 15 years (Donigian, 2000) and presented as targets in the Work Plan (RESPEC, 2007). The values in the table attempt to provide some general guidance, in terms of the percent mean errors or differences between simulated and observed values, so that users can gauge what level of agreement or accuracy (i.e., very good, good, fair) may be expected from the model application. The caveats at the bottom of the table indicate that the tolerance ranges should be applied to mean values and that individual events, or observations, may show larger differences and still be acceptable. In addition, the level of agreement to be expected depends on many site- and application-specific conditions, including the data quality, purpose of the study, available resources, and available alternative assessment procedures that could meet the study objectives.

Table 13-4. General calibration/verification targets or tolerances for HSPF applications.

	nce between simulated and recorded values (%)		
	Fair	**Good**	**Very good**
Hydrology/Flow	15–25	10–15	<10

Caveats: Relevant to monthly and annual values; storm peaks may differ more.
Quality and detail of input and calibration data.
Purpose of model application.
Availability of alternative assessment procedures.
Resource availability (i.e., time, money, personnel).
Source: Donigian, 2000.

Another target set in the Work Plan (RESPEC, 2007) and by previous investigators for achieving an acceptable calibration for monthly flows is having a correlation coefficient greater than 0.85 and the coefficient of model-fit efficiency (MFE) greater than 0.8 (EPA, 1998).

13.6. Hydrology Calibration/Verification Results

The calibration of the **HSPF** model application was a cyclical process of making parameter changes, running the model, and producing comparisons of simulated and observed values and interpreting the results. The calibration process was greatly facilitated with the use of in-house **MATLAB** scripts and functions that are capable of reading the **HSPF** binary output file and automating statistical and graphical tests to assess the calibration. Some of the functions borrow logic from **HSPEXP**, an expert system for hydrologic calibration specifically designed for use with **HSPF**, developed under contract for the USGS (Lumb, et. al., 1994). The specific comparisons of simulated and observed values that are presented in Appendix E for each of the 14 gages include graphical and statistical tests for:

- Annual and monthly runoff volumes (inches).
- Daily time series of flow (cfs).
- Flow frequency (flow duration) curves (cfs).

Table 13-5 presents a summary of the monthly runoff errors averaged across the 14 calibration gages for both the 1995-2005 and 2000-2005 time periods. Individual gages showed larger deviations but were considered acceptable for the purposes of the model application’s objectives. For example, the average annual runoff error shown in Table 13-5 results from averaging the 14 gages that had annual runoff errors from 1995-2005 that ranged from (–4) to (+3) percent; these errors fall well within what is generally considered as a “very good” calibration. Appendix E provides graphical displays of the monthly observed and simulated runoff for each of the 14 gages for the 1995-2005 time period.

Table 13-5. Average and average annual mean error (%) for monthly runoff (inches) at 14 calibration/verification USGS gages used in the Cedar River Watershed HSPF model.

Month	Calibration mean error (1995-2005) (%)	Verification mean error (2000-2005) (%)
January	16.3	13.3
February	7.5	–6.2
March	9.3	30.4
April	–2.0	0.5
May	–3.7	–3.8
June	–7.1	–10.0
July	–5.7	–5.7
August	17.7	15.6
September	17.0	15.0
October	–1.4	–2.8
November	4.4	0.9
December	19.0	16.3
Average	–0.3	–0.9

Table 13-6 is a summary of the monthly runoff errors averaged across the 14 calibration/ verification gages by flow range. The results of this analysis show the model does a very good job of representing the conditions throughout the watershed under both high and low flows. Appendix E provides similar tables for each of 14 calibration gages for the 1995-2005 time period.

Table 13-6. Summary of mean monthy errors (%) for runoff (inches) for the 14 calibration/verification USGS gages by flow range.

Flow range	Calibration mean error (1995-2005) (%)	Verification mean error (2000-2005) (%)
All flows	–0.3	–0.9
10 percent highest flows	–4.6	–4.6
25 percent highest flows	–5.1	–5.3
25 percent lowest flows	4.1	5.3
10 percent lowest flows	–6.0	0.70
Storm peaks	–3.0	–0.4

Percentiles are listed from low to high flows; e.g., the 5th percentile reflects flows that are exceeded 95 percent of the time.

The average monthly R^2 and the monthly MFE were both 0.90, for both the calibration and verification time periods and is generally accepted as a good calibration as stated in the Work Plan (RESPEC, 2007). This also shows the model is very consistent through time.

Based on the model results presented in the Appendix F and summarized herein, we conclude that the current **HSPF** application to the Cedar River Watershed provides a sound, calibrated hydrologic watershed model that provides a framework for TMDL development and impact evaluation of mitigation alternatives. This is the outcome of a wide range of graphical and statistical comparisons and measures of the model performance for annual runoff, daily and monthly streamflow, flow duration, water balance components, and storm event simulations.

13.7. Water Quality Calibration/Verification Results

For the bacteria constituents, model performance was based largely on visual and graphical presentations since the frequency of data was often inadequate for accurate statistical measures. These visual graphics included probability plots and flow quartile boxplots for paired data. The probability plots are presented in Appendix E for each of the calibration gages listed in Table 13-3. The probability plots for most of the stations show good agreement between the predicted concentrations and the available data. With the probability plots in good agreement, it can be said that the statistical metrics, such as quartile concentrations and percent of time exceeding WQS, are also in relatively good agreement. Based on these results, it was determined that the estimated loads and concentrations estimated by the combination of **BIT** and the **HSPF** application were reasonable and provided a sound framework for determining source allocation and evaluating the impact of alternative management scenarios.

14. Implementation Plan

For the non-established supplemental implementation plan see Appendix G.

15. PUBLIC PARTICIPATION

EPA regulations require that TMDLs be subject to public review (40 CFR 130.7). When EPA establishes a TMDL, such as this document, public notice is provided on the EPA, Region 7, website: http://www.epa.gov.region07/water/tmdl public_notice_htm. EPA established TMDLs will be available on the internet for at least 30 days. EPA will respond to comments on the draft TMDL after the public notice period ends. EPA publishes response to comments and final TMDLs on the EPA, Region 7, TMDL website: http://www.epa.gov/region07/water/apprtmdl.htm. The state may submit and EPA may approve another TMDL for this water at a later time.

This TMDL is being produced by EPA to meet the requirements of the **2001 Consent Decree, Sailors, Inc., Mississippi River Revival and Sierra Club v. EPA, No. C98-134-MJM**. Comments for the **Cedar River Watershed** TMDL were accepted from December 29, 2009, through February 10, 2010. During the Public Notice comment period five comments were received. Changes were made to the TMDL document. For more information see the Response to Public Comment document.

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Appendix A —Glossary of Terms and Acronyms

303(d) list: Refers to section 303(d) of the Federal Clean Water Act, which requires a listing of all public surface water bodies (creeks, rivers, wetlands, and lakes) that do not support their general and/or designated uses. Also called the state's "Impaired Waters List."

305(b) assessment: Refers to section 305(b) of the Federal Clean Water Act, it is a comprehensive assessment of the state's public water bodies ability to support their general and designated uses. Those bodies of water which are found to be not supporting or just partially supporting their uses are placed on the 303(d) list.

AWW: Average wet weather design flow.

BASINS: EPA's **Better Assessment Science Integrating Point and Nonpoint Sources** modeling system.

BMP: Best Management Practice. A general term for any structural or upland soil or water conservation practice. For example terraces, grass waterways, sediment retention ponds, reduced tillage systems, etc.

BIT: EPA's **Bacteria Indicator Tool** spreadsheet, used to estimate bacterial loading based on watershed sources.

CDA: Contributing drainage area.

Boxplot: A graphical representation of data where the box includes 50% of the individual data points, the solid line extends to 1.5 times the inter-quartile range, and the individual points represent outliers in the dataset.

cfu: Colony forming units. A reporting unit for bacterial analysis using membrane filtration.

Designated use(s): Refer to the type of economic, social, or ecologic activities that a specific water body is intended to support. See Appendix B for a description of all general and designated uses.

DNR (or IDNR): Iowa Department of Natural Resources.

Ecoregion: A system used to classify geographic areas based on similar physical characteristics such as soils and geologic material, terrain, and drainage features.

EPA (or USEPA): United States Environmental Protection Agency.

E. coli: *Escherichia coli* is a subset of fecal coliform bacteria which indicates warm-blooded animal's fecal contamination of a waterbody.

General use(s): Refer to narrative water-quality criteria that all public water bodies must meet to satisfy public needs and expectations. See Appendix B for a description of all general and designated uses.

HSPF: EPA's **Hydrological Simulation Program-FORTRAN** is a computer model used to simulate hydrological processes on a watershed basis.

IBC: Iowa Beef Center at Iowa State University.

Integrated report: Refers to a comprehensive document which combines the 305(b) assessment with the 303(d) list, as well as narratives and discussion of overall water quality trends in the state's public water bodies. The Iowa Department of Natural Resources submits an integrated report to the EPA biennially in even numbered years.

LA: Load Allocation. The fraction of the total pollutant load of a water body which is assigned to all combined *nonpoint sources* in a watershed. (The total pollutant load is the sum of the waste load and load allocations.)

LDC: Load duration curve. A graphical method of expressing loads in relation to flow at the flow's percentile of exceedance. Reference http://www.epa.gov/owow/tmdl/duration_curve_guide_aug2007.pdf

Load: The total amount (mass) of a particular pollutant in a waterbody.

MATLAB®: The MathWorks program which assists in the analysis of complex numeric outputs from models such as **HSPF**.

ml: Milliliter. 1/1000 of a liter.

MOS: Margin of Safety. In a total maximum daily load (TMDL) report, it is a set-aside amount of a pollutant load to allow for any uncertainties in the data or modeling.

MS4 Permit: Municipal Separate Storm Sewer System Permit. An NPDES license required for some cities and universities which obligates them to ensure adequate water quality and monitoring of runoff from urban storm water and construction sites, as well as public participation and outreach.

Nonpoint source pollution: A collective term for contaminants which originate from a diffuse source.

NPDES: National Pollution Discharge Elimination System, which allows a facility (e.g. an industry, or a wastewater treatment plant) to discharge to a water of the United States under regulated conditions.

STORET: EPA's **Sto**rage and **Ret**rieval system used to make water quality data available through a central repository.

Stormwater: The fraction of discharge (flow) in a river which arrived as surface runoff directly caused by a precipitation event. *Storm water* generally refers to runoff which is routed through some artificial channel or structure, often in urban areas.

TMDL: Total Maximum Daily Load. As required by the Federal Clean Water Act, a comprehensive analysis and quantification of the maximum amount of a particular pollutant that a water body can tolerate while still meeting its general and designated uses.

USGS: United States Geologic Survey (United States Department of the Interior). Federal agency responsible for implementation and maintenance of discharge (flow) gauging stations on the nation's water bodies.

Watershed: The land (measured in units of surface area) which drains water to a particular body of water or outlet.

WLA: Waste Load Allocation. The fraction of waterbody loading capacity assigned to point sources in a watershed. Alternatively, the allowable pollutant load that an NPDES permitted facility may discharge without exceeding water-quality standards.

WMS: The U.S. Army Corps of Engineers **Watershed Modeling System**.

WQS: Water-quality Standards. Defined in Chapter 61 of Environmental Protection Commission [567] of the Iowa Administrative Code, they are the specific criteria by which water quality is gauged in Iowa.

WWTP: Waste Water Treatment Plant. General term for a facility which processes municipal, industrial, or agricultural waste into effluent suitable for release to public waters or land application.

Appendix B — General and Designated Uses of Iowa's Waters

Introduction

Iowa's water-quality standards (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code) provide the narrative and numerical criteria by which water bodies are judged when determining the health and quality of our aquatic ecosystems. These standards vary depending on the type of water body (lakes vs. rivers) and the assigned uses (general use vs. designated uses) of the water body that is being dealt with. This appendix is intended to provide information about how Iowa's water bodies are classified and what the use designations mean, hopefully providing a better general understanding for the reader.

All public surface waters in the state are protected for certain beneficial uses, such as livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and other incidental uses (e.g. withdrawal for industry and agriculture). However, certain rivers and lakes warrant a greater degree of protection because they provide enhanced recreational, economical, or ecological opportunities. Thus, all public bodies of surface water in Iowa are divided into two main categories: *general* use segments and *designated* use segments. This is an important classification because it means that not all of the criteria in the state's water-quality standards apply to all water ways; rather, the criteria which apply depend on the use designation & classification of the water body.

General Use Segments

A general use segment water body is one which does not maintain perennial (year-round) flow of water or pools of water in most years (i.e. ephemeral or intermittent waterways). In other words, stream channels or basins which consistently dry up year after year would be classified as general use segments. Exceptions are made for years of extreme drought or floods. For the full definition of a general use water body, consult section 61.3(1) in the state's published water-quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

General use waters are protected for the beneficial uses listed above, which are: livestock and wildlife watering, aquatic life, non-contact recreation, crop irrigation, and industrial, agricultural, domestic and other incidental water withdrawal uses. The criteria used to ensure protection of these uses are described in section 61.3(2) in the state's published water-quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Designated Use Segments

Designated use segments are water bodies which maintain flow throughout the year, or at least hold pools of water which are sufficient to support a viable aquatic community (i.e. perennial waterways). In addition to being protected for the same beneficial uses as the general use segments, these perennial waters are protected for more specific activities such as primary contact recreation, drinking water sources, or cold-water fisheries. There are a total of thirteen different designated use classes (Table B-1) which may apply, and a water body may have more than one designated use. For definitions of the use classes and more detailed descriptions, consult section 61.3(1) in the state's published water-quality standards, which became effective on March 22, 2006 (Environmental Protection Commission [567], Chapter 61 of the Iowa Administrative Code).

Table B-1. Designated use classes for Iowa water bodies.

Class prefix	Class	Designated use	Brief comments
A	A1	Primary contact recreation	Supports swimming, water skiing, etc.
	A2	Secondary contact recreation	Limited/incidental contact occurs, such as boating
	A3	Children's contact recreation	Urban/residential waters that are attractive to children
B	B(CW1)	Cold water aquatic life – Type 2	Able to support coldwater fish (e.g. trout) populations
	B(CW2)	Cold water aquatic life – Type 2	Typically unable to support consistent trout populations
	B(WW-1)	Warm water aquatic life – Type 1	Suitable for game and nongame fish populations
	B(WW-2)	Warm water aquatic life – Type 2	Smaller streams where game fish populations are limited by physical conditions & flow
	B(WW-3)	Warm water aquatic life – Type 3	Streams that only hold small perennial pools which extremely limit aquatic life
	B(LW)	Warm water aquatic life – Lakes and Wetlands	Artificial and natural impoundments with "lake-like" conditions
C	C	Drinking water supply	Used for raw potable water
Other	HQ	High quality water	Waters with exceptional water quality
	HQR	High quality resource	Waters with unique or outstanding features
	HH	Human health	Fish are routinely harvested for human consumption

Appendix C — Water-Quality Data

Table C-1. Summary of Measured Bacteria Data

Site No.	Station Name	Start Date	End Date	Number of Samples		
				E *Coli*	Fecal Coliform	Total (E *coli* and Fecal Coliform)
10070001	Beaver Creek near Cedar Falls	10/25/1999	02/08/2007	121	90	211
10070002	Wolf Creek at La Porte City	10/25/1999	02/08/2007	11	81	92
10070003	West Fork Cedar River at Finchford	10/01/1987	02/08/2007	127	94	221
10070004	Black Hawk Creek at Waterloo	10/25/1999	02/08/2007	171	76	247
10070005	Cedar River Upstream of Waterloo/Cedar Falls	11/09/1999	02/08/2007	79	48	127
10070006	Cedar River Downstream of Waterloo	11/09/1999	02/08/2007	79	48	127
10090001	Cedar River near Janesville	10/25/1999	02/08/2007	89	58	147
10120001	Shell Rock River at Shell Rock	10/25/1999	02/08/2007	125	94	219
10160001	Cedar River at Cedar Bluff	10/19/1999	07/05/2006	83	59	142
10170001	Winnebago River at Mason City	10/18/1999	09/05/2000	12	12	24
10170002	Winnebago River Upstream of Mason City	11/11/1999	02/15/2007	103	72	175
10170003	Winnebago River Downstream of Mason City	11/11/1999	02/15/2007	79	48	127
10340001	Cedar River near Charles City	10/08/1986	02/15/2007	105	72	177
10340002	Flood Creek at Greene	10/02/2000	09/05/2006	54	34	88
10340003	Cedar River Upstream of Charles City	07/02/2003	11/07/2006	41	13	54
10570001	Cedar River Downstream of Cedar Rapids	11/03/1999	02/07/2007	142	48	190
10570002	Cedar River Upstream of Cedar Rapids	11/03/1999	02/07/2007	79	48	127
10700001	Cedar River near Conesville	10/14/1999	02/12/2007	89	58	147
11070001	Prescotts Creek at Waterloo (18)	03/19/2001	11/07/2001	9	9	18
11070002	Black Hawk Creek in Waterloo (14)	03/19/2001	11/07/2001	9	9	18

Site No.	Station Name	Start Date	End Date	Number of Samples		
				E *Coli*	Fecal Coliform	Total (E *coli* and Fecal Coliform)
11070003	Black Hawk Creek at Popp Access (17)	03/19/2001	09/12/2005	16	9	25
11070004	Black Hawk Creek NE of Hudson (16)	03/19/2001	11/07/2001	9	9	18
11070005	Black Hawk Creek at Waterloo (15)	03/19/2001	09/12/2005	16	9	25
11070006	Dry Run Creek at Cedar Falls (Site 1)	09/12/2006	02/15/2007	6	0	6
11070007	Dry Run Creek at Cedar Falls (Site 4)	09/12/2006	02/15/2007	4	0	4
11070008	Dry Run Creek at Cedar Falls (Site 6D1)	09/12/2006	02/15/2007	4	0	4
11190001	Little Cedar River at Ionia (69)	04/19/2001	12/08/2004	66	66	132
11340001	Shell Rock River at Rockford (68)	04/19/2001	12/08/2004	40	40	80
11380005	Black Hawk Creek upstream of 230th Street	04/21/2005	09/12/2005	7	0	7
11380006	Black Hawk Creek at Grundy Center	04/21/2005	09/12/2005	7	0	7
11380007	Black Hawk Creek near Holland	04/21/2005	09/12/2005	7	0	7
11380008	Holland Creek	04/21/2005	09/12/2005	7	0	7
11380009	North Fork Black Hawk Creek	04/21/2005	09/12/2005	7	0	7
15070001	DRC2 University Branch Dry Run Creek at 18th St.	09/12/2006	01/09/2007	7	0	7
15070002	DRC3 Dry Run Creek at 18th St.	09/12/2006	01/09/2007	7	0	7
15070003	DRC5 Dry Run Creek at University Ave.	09/12/2006	01/09/2007	7	0	7
15070004	DRC7 Dry Run Creek at Union Rd.	09/12/2006	01/09/2007	7	0	7
15070005	DRC8 South Branch Dry Run Creek at Greenhill Rd.	09/12/2006	01/09/2007	7	0	7
15070006	DRC9 Southwest Branch Dry Run Creek at Union Rd.	09/12/2006	01/09/2007	7	0	7
15070007	DRC10 South Branch Dry Run Creek at Viking Rd.	09/12/2006	01/09/2007	7	0	7
15160001	Hoover Creek at Johnson /Cedar Co. lines (HeHo 1)	07/07/2004	07/07/2005	13	0	13
15160002	Hoover Creek at Main St. (HeHo 2)	06/08/2004	07/07/2005	14	0	14
15160003	Hoover Creek in park (HeHo 3)	06/08/2004	07/07/2005	14	0	14
15160004	Hoover Creek at 2nd St. (HeHo 4)	06/08/2004	07/07/2005	14	0	14
15570001	Indian Creek near Cedar Rapids	05/29/2002	08/10/2005	87	78	165
15570002	Indian Creek near Marion	05/30/2002	08/10/2005	12	3	15

Site No.	Station Name	Start Date	End Date	Number of Samples		
				E *Coli*	Fecal Coliform	Total (E *coli* and Fecal Coliform)
15570003	McCloud Run at Cedar Rapids	05/29/2002	08/10/2005	89	81	170
15570004	Indian Creek at Thomas Park	07/01/2005	08/10/2005	9	0	9
15570005	Dry Creek at Donnelly Park	07/01/2005	08/10/2005	9	0	9
15570006	McCloud Run at 42nd Street	07/06/2005	08/10/2005	8	0	8
21070001	George Wyth Beach (George Wyth Memorial State Park)	06/01/1999	09/26/2006	203	103	306
21170001	Clear Lake State Park Beach (Clear Lake State Park)	06/2/1999	09/25/2006	183	103	286
21170002	McIntosh Beach (McIntosh Woods State Park)	06/01/1999	09/04/2006	162	104	266
21350001	Beeds Lake Beach (Beeds Lake State Park)	05/22/2000	09/25/2006	195	132	327
21350002	Beeds Lake Alternate Beach Site #1	04/17/2006	09/25/2006	24	0	24
21350003	Beeds Lake Alternate Beach Site #2	04/17/2006	09/25/2006	24	0	24
21570001	Pleasant Creek Beach (Pleasant Creek State Park)	06/01/1999	09/26/2006	194	101	295

Minitab Project Report

OVERALL STATISTICS

Descriptive Statistics: Result

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	3204	794.2	3624.5	10.0	18.0	91.0	357.5	90000.0
	Fecal	1909	1293	5467	9	18	92	460	110400

Results for STORET ID = 10070001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	121	1358	3163	10	40	230	860	22000
	Fecal	90	1849	3900	9	46	258	1863	23920

Results for STORET ID = 10070002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	111	2552	7057	10	40	250	850	47000
	Fecal	81	3950	8843	9	66	331	2852	43240

Results for STORET ID = 10070003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	127	447.3	968.3	10.0	20.0	130.0	440.0	8000.0
	Fecal	94	563	1070	9	18	161	619	7360

Results for STORET ID = 10070004

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	171	1207	3911	10	110	240	580	42000
	Fecal	76	2537	6773	9	64	193	1012	47840

Results for STORET ID = 10070005

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	79	134.8	326.3	10.0	18.0	36.0	120.0	2300.0
	Fecal	48	158.7	373.0	9.2	18.4	39.1	170.2	2116.0

Results for STORET ID = 10070006

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	79	234.9	355.7	10.0	50.0	130.0	260.0	2500.0
	Fecal	48	308.7	563.7	9.2	29.9	142.6	312.8	3496.0

Results for STORET ID = 10090001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	88	211.9	549.8	10.0	20.0	71.5	147.5	3600.0
	Fecal	58	271.6	659.9	9.2	18.4	75.4	147.2	3312.0

Results for STORET ID = 10120001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	125	490.0	1085.0	10.0	20.0	80.0	615.0	9100.0
	Fecal	94	628	1228	9	18	124	837	9200

Results for STORET ID = 10160001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	83	604	1744	10	30	110	340	13000
	Fecal	59	897	3239	9	28	110	368	23000

Results for STORET ID = 10170001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	12	319	758	10	18	60	203	2700
	Fecal	12	277	700	9	10	46	138	2484

Results for STORET ID = 10170002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	103	1981	6177	10	30	160	1100	50000
	Fecal	72	3788	10747	9	39	294	3174	80040

Results for STORET ID = 10170003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	79	868	1929	10	91	180	580	10000
	Fecal	48	1095	2261	9	113	271	796	11040

Results for STORET ID = 10340001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	105	730	3245	10	91	230	450	33000
	Fecal	72	985	4740	9	156	313	529	40480

Results for STORET ID = 10340002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	54	1233	3953	10	60	165	650	24000
	Fecal	34	2219	6060	28	99	336	1104	32200

Results for STORET ID = 10340003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	41	846	3650	10	10	64	205	23000
	Fecal	13	2603	7631	9	10	51	478	27600

Results for STORET ID = 10570001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	142	1393	7315	10	64	150	523	82000
	Fecal	48	1960	5090	10	61	235	1104	31280

Results for STORET ID = 10570002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	79	398	1596	10	10	27	100	12000
	Fecal	48	717	2621	9	10	23	108	16560

Results for STORET ID = 10700001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	88	150.0	491.0	10.0	10.0	27.0	127.5	4300.0
	Fecal	58	207	806	9	10	26	113	5980

Results for STORET ID = 11070001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	9	1262	1810	10	136	600	2050	5600
	Fecal	9	1739	2705	18	138	635	2484	8464

Results for STORET ID = 11070002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	9	778	1016	20	65	330	1450	3000
	Fecal	9	932	1231	18	64	304	1794	3588

Results for STORET ID = 11070003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	16	817	571	20	400	825	1375	2000
	Fecal	9	965	808	51	241	865	1886	2116

Results for STORET ID = 11070004

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	9	489	594	70	160	290	570	2000
	Fecal	9	557	621	64	193	396	621	2116

Results for STORET ID = 11070005

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	16	581	583	45	203	395	798	2400
	Fecal	9	586	709	41	156	432	607	2392

Results for STORET ID = 11070006

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	6	688	724	50	110	480	1243	2000

Results for STORET ID = 11070007

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	4	205	224	20	43	135	438	530

Results for STORET ID = 11070008

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	4	278	296	10	35	210	588	680

Results for STORET ID = 11190001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	66	4633	13020	10	77	600	3150	90000
	Fecal	66	6437	17934	9	77	681	3634	110400

Results for STORET ID = 11340001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	40	237.2	599.3	10.0	20.0	91.0	207.5	3700.0
	Fecal	40	281	671	9	18	88	265	4048

Results for STORET ID = 11380005

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	1116	771	460	680	690	1300	2700

Results for STORET ID = 11380006

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	1501	1259	760	760	1100	1500	4300

Results for STORET ID = 11380007

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	554	439	40	40	580	1100	1100

Results for STORET ID = 11380008

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	941	1024	18	18	430	2000	2600

Results for STORET ID = 11380009

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	556	283	240	330	400	860	970

Results for STORET ID = 15070001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	188.6	172.8	10.0	40.0	140.0	310.0	510.0

Results for STORET ID = 15070002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	351	315	73	73	280	400	1000

Results for STORET ID = 15070003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	878	1330	55	110	180	1900	3500

Results for STORET ID = 15070004

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	121	274	10	10	10	55	740

Results for STORET ID = 15070005

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	145.4	226.6	20.0	27.0	60.0	140.0	650.0

Results for STORET ID = 15070006

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	264.6	241.7	27.0	55.0	230.0	360.0	740.0

Results for STORET ID = 15070007

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	7	192.1	143.7	73.0	82.0	130.0	250.0	480.0

Results for STORET ID = 15160001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	13	522	547	10	65	440	900	1700

Results for STORET ID = 15160002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	14	365.7	337.2	10.0	30.0	235.0	712.5	950.0

Results for STORET ID = 15160003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	14	485	627	10	76	210	710	2300

Results for STORET ID = 15160004

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	14	1057	1256	64	223	585	1328	4300

Results for STORET ID = 15570001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	87	1812	5574	10	140	290	900	44000
	Fecal	78	2622	7665	9	136	336	1495	54280

Results for STORET ID = 15570002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	12	2221	4069	130	285	570	940	12000
	Fecal	3	5646	8660	377	377	920	15640	15640

Results for STORET ID = 15570003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	89	1404	2826	27	180	300	1300	17000
	Fecal	81	1692	3923	25	198	359	1242	26680

Results for STORET ID = 15570004

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	9	3113	4016	140	325	1200	5750	12000

Results for STORET ID = 15570005

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	9	384.4	108.6	180.0	290.0	410.0	470.0	510.0

Results for STORET ID = 15570006

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	8	3639	4408	430	660	1850	6325	13000

Results for STORET ID = 21070001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	203	188.7	723.5	10.0	10.0	20.0	100.0	8100.0
	Fecal	103	270.7	939.4	9.2	10.0	24.8	138.0	7452.0

Results for STORET ID = 21170001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	183	253.9	804.3	10.0	10.0	20.0	150.0	6900.0
	Fecal	103	157.1	686.3	9.2	10.0	10.0	67.2	6624.0

Results for STORET ID = 21170002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	162	63.2	193.6	10.0	10.0	20.0	61.0	2100.0
	Fecal	104	57.8	205.8	9.2	10.0	17.5	36.8	1932.0

Results for STORET ID = 21350001

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	195	282.6	901.8	10.0	10.0	30.0	150.0	7700.0
	Fecal	132	364	1228	9	10	28	129	8280

Results for STORET ID = 21350002

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	24	36.3	65.3	10.0	10.0	10.0	20.0	230.0

Results for STORET ID = 21350003

Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	24	32.08	35.30	10.00	10.00	10.00	61.50	110.00

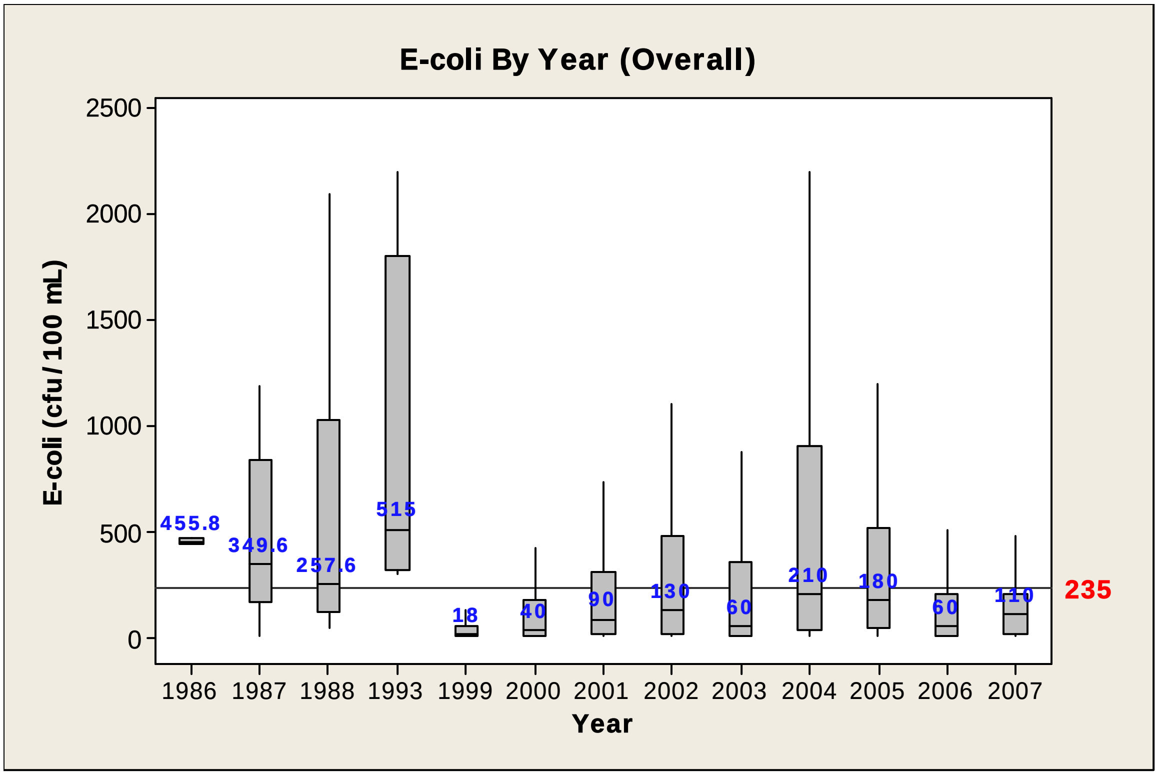
Results for STORET ID = 21570001

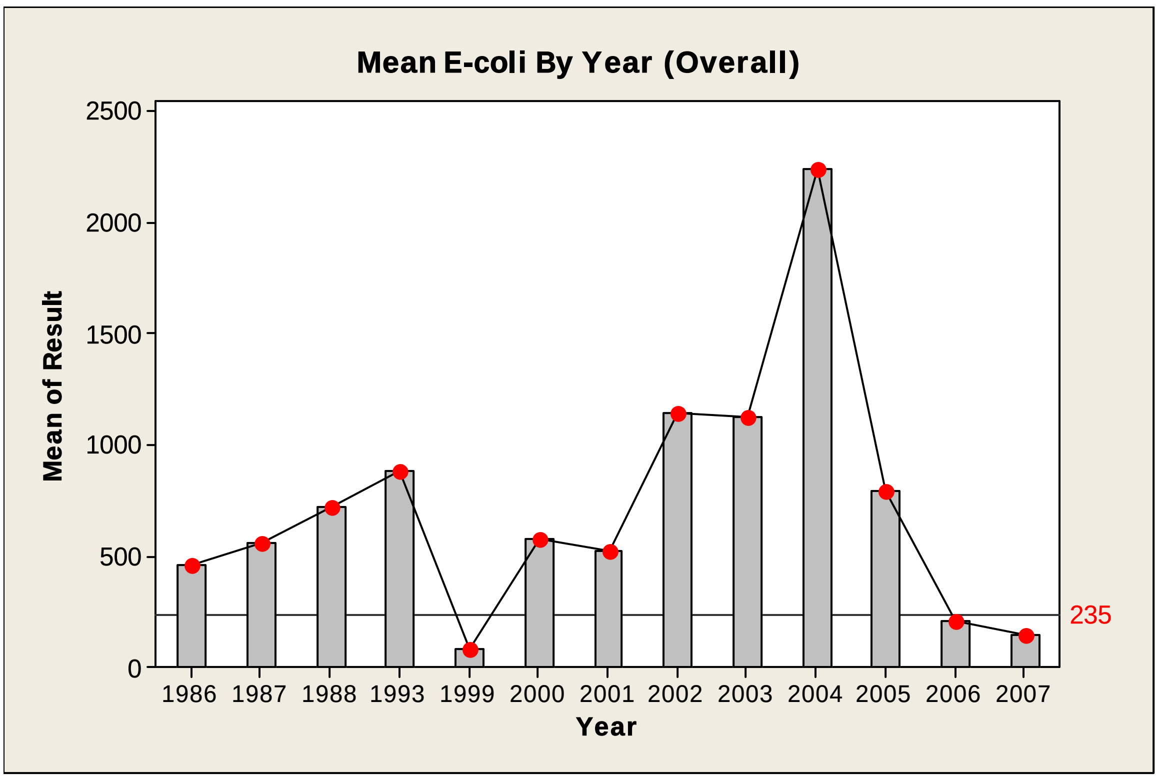
Variable	Parameter	N	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	E-coli	194	44.4	171.9	10.0	10.0	10.0	20.0	2000.0
	Fecal	101	16.41	19.69	9.20	10.00	10.00	10.00	156.40

OVERALL STATISTICS BY YEAR

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1986	2	455.8	20.1	441.6	*	455.8	*	470.0
	1987	14	553	599	9	167	350	838	2200
	1988	14	719	968	46	121	258	1029	3300
	1993	4	883	889	300	325	515	1808	2200
	1999	175	77.0	239.9	9.2	10.0	18.0	60.0	2484.0
	2000	462	573	2340	9	10	40	184	30360
	2001	754	518.9	1965.5	9.2	18.4	90.0	310.0	36800.0
	2002	1191	1140	4361	9	17	130	480	80960
	2003	912	1127	4505	9	10	60	360	47840
	2004	655	2239	8134	9	40	210	910	110400
	2005	485	788	4002	10	45	180	525	82000
	2006	406	207.0	443.3	10.0	10.0	60.0	210.0	3600.0
	2007	41	139.8	141.2	10.0	20.0	110.0	205.0	640.0


E-coli By Year (Overall)
E-coli (cfu/ 100 mL)
2500
2000
1500
1000
500
0
455.8
349.6
257.6
515
18
40
90
130
60
210
180
60
110
235
1986 1987 1988 1993 1999 2000 2001 2002 2003 2004 2005 2006 2007
Year

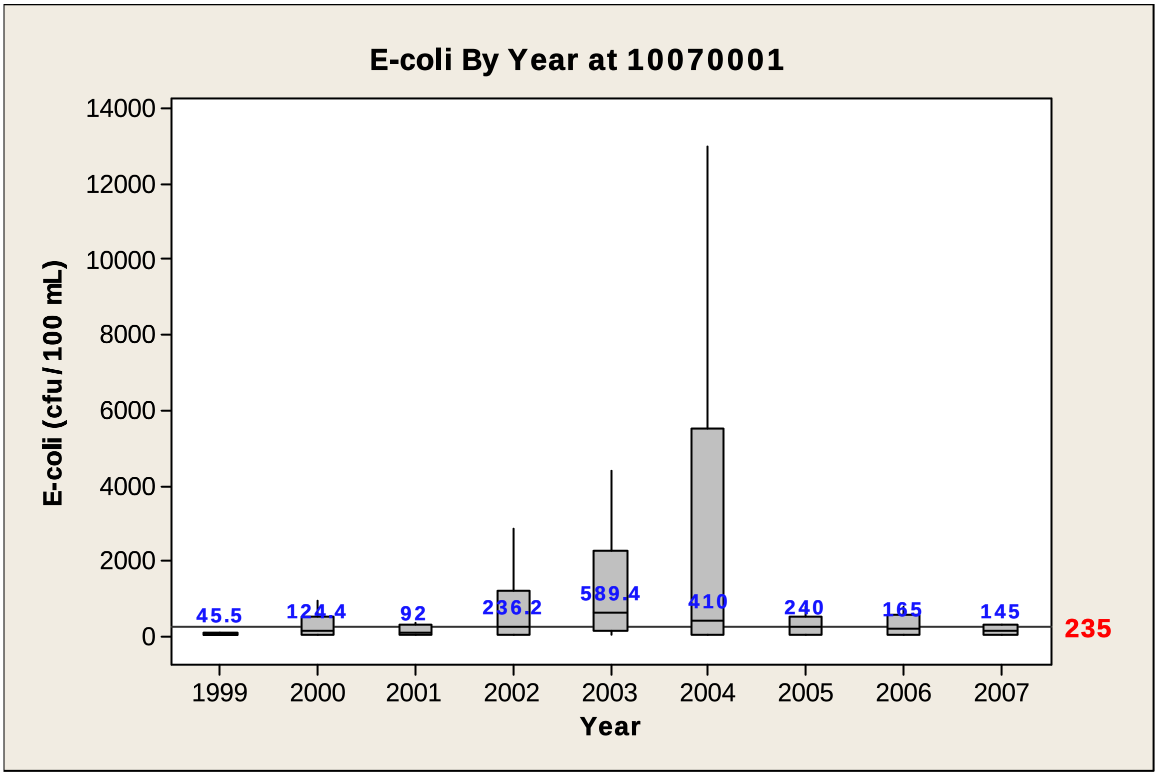

Mean E-coli By Year (Overall)
Mean of Result
2500
2000
1500
1000
500
0
235
1986 1987 1988 1993 1999 2000 2001 2002 2003 2004 2005 2006 2007
Year

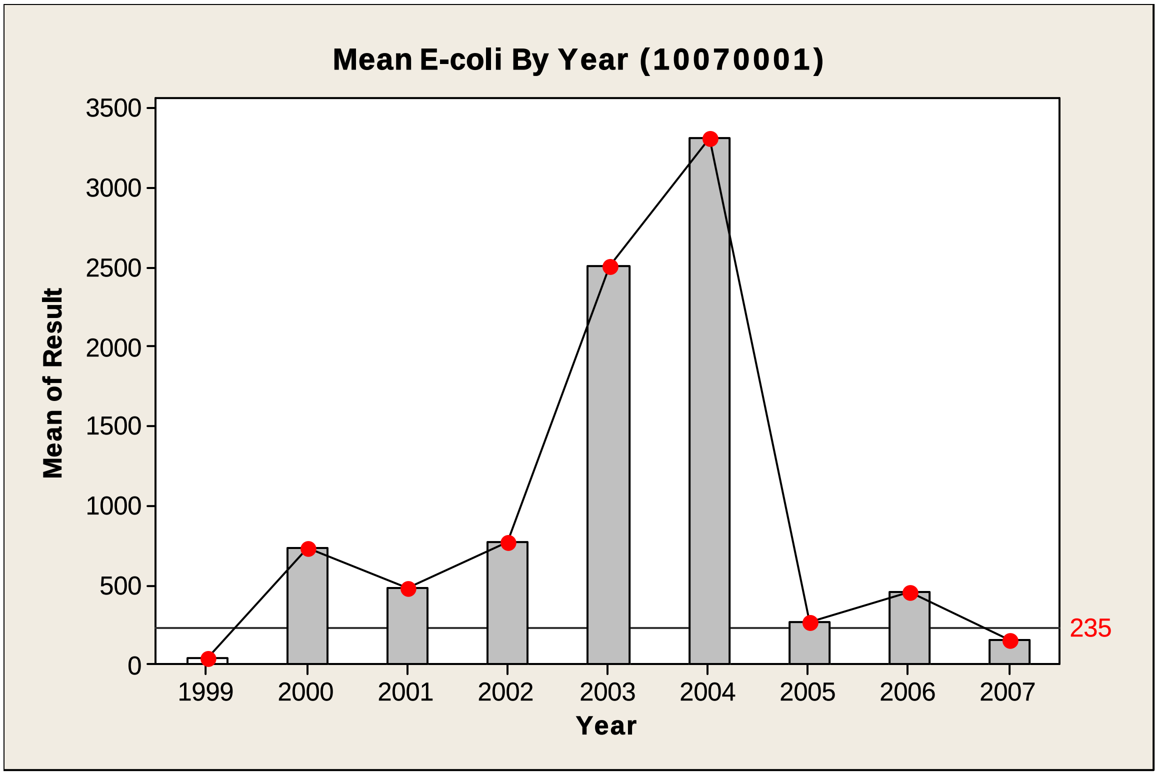
STATISTICS BY YEAR BY IMPAIRED SITE

SITE 10070001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	43.4	26.4	10.0	16.3	45.5	64.7	82.0
	2000	24	731	1354	9	30	124	509	4416
	2001	24	480	1064	9	45	92	285	3900
	2002	36	772	1109	9	38	236	1182	3772
	2003	62	2510	4770	10	110	589	2231	23920
	2004	33	3309	4950	10	50	410	5474	17480
	2005	12	268.0	251.7	10.0	37.0	240.0	502.5	750.0
	2006	12	448	784	10	12	165	565	2800
	2007	2	145	191	10	*	145	*	280

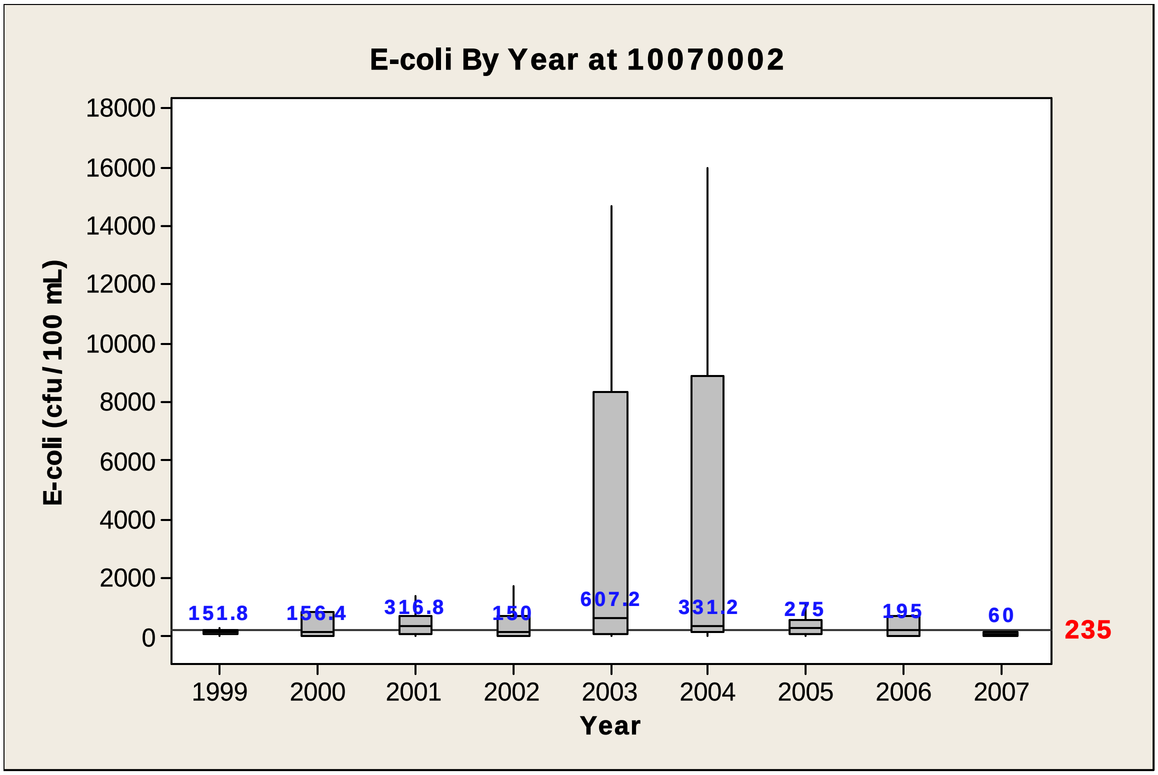


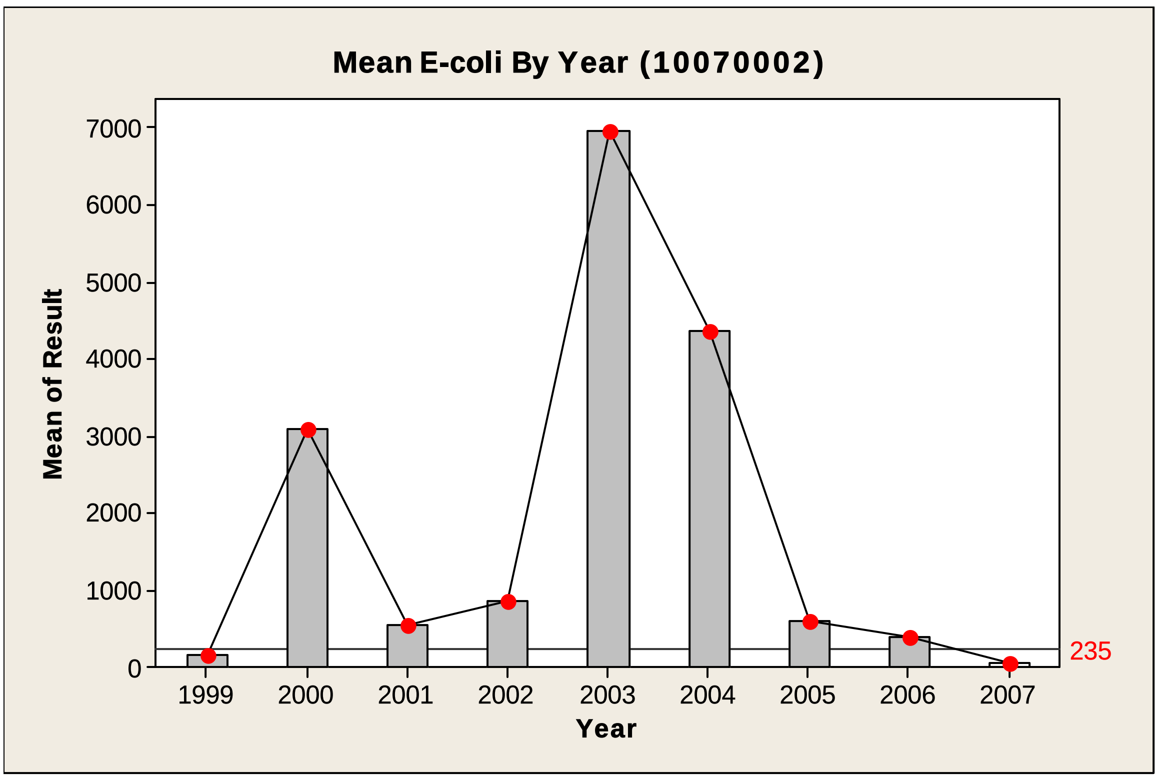


SITE 10070002

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	158.3	81.4	27.0	104.3	151.8	241.9	250.0
	2000	24	3080	7791	9	32	156	793	30360
	2001	24	547	743	9	92	317	692	2852
	2002	32	867	1934	9	10	150	723	10120
	2003	49	6952	12742	9	109	607	8312	47000
	2004	31	4347	6237	9	120	331	8924	25760
	2005	12	610	1113	10	46	275	570	4000
	2006	12	388	500	10	27	195	668	1700
	2007	2	60.0	70.7	10.0	*	60.0	*	110.0

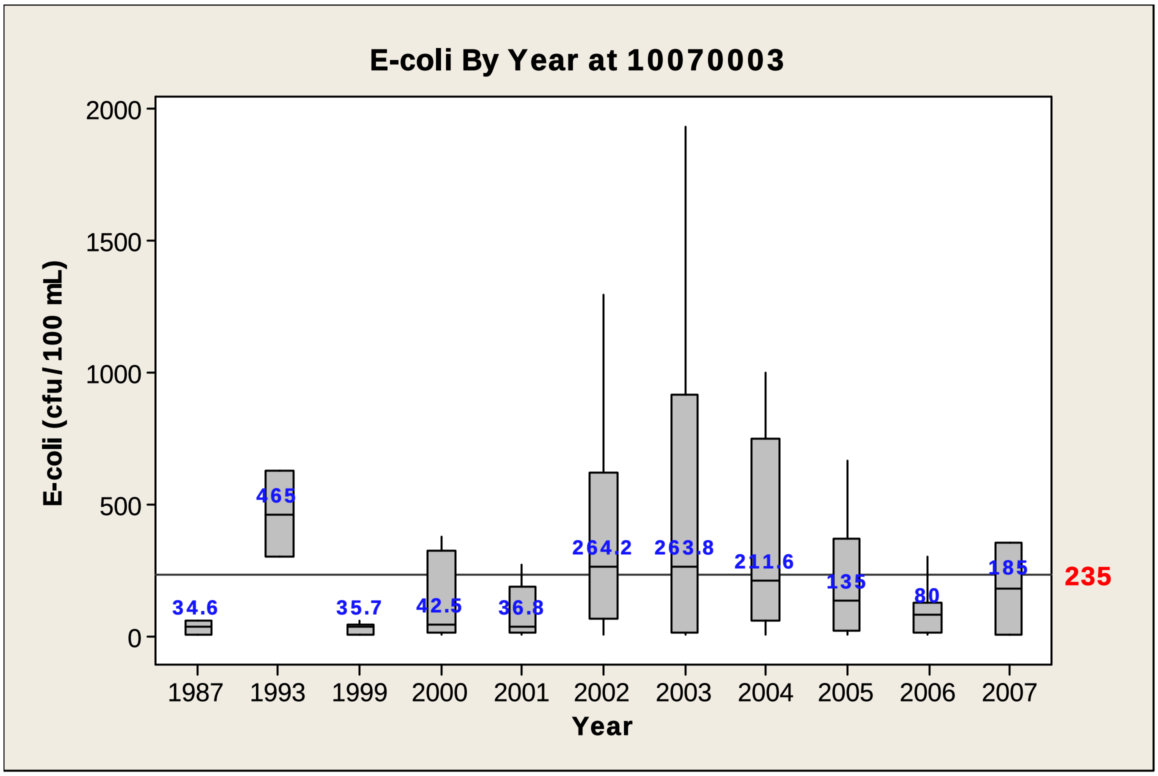

E-coli By Year at 10070002
E-coli (cfu/100 mL)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
151.8
156.4
316.8
150
607.2
331.2
275
195
60
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

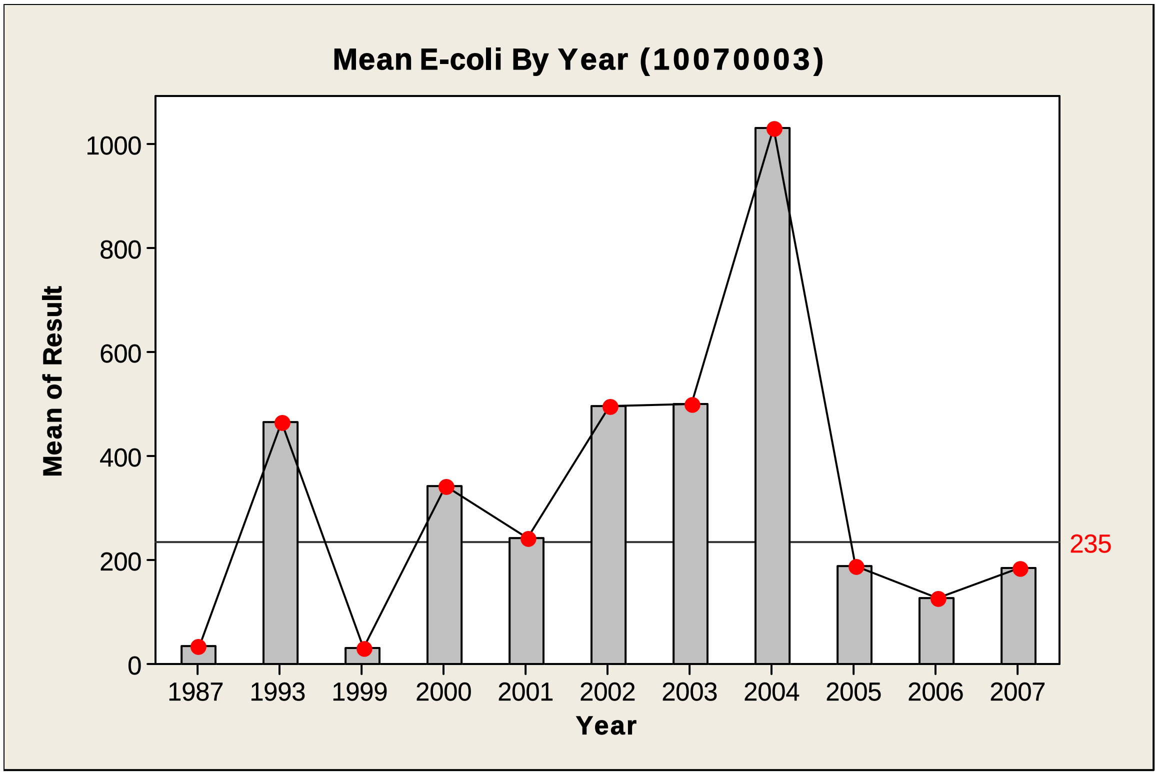

Mean E-coli By Year (10070002)
Mean of Result
7000
6000
5000
4000
3000
2000
1000
0
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

SITE 10070003

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1987	2	34.6	35.9	9.2	*	34.6	*	60.0
	1993	2	465	233	300	*	465	*	630
	1999	6	32.55	19.75	10.00	10.00	35.70	48.47	58.88
	2000	24	344	596	9	18	43	323	2000
	2001	24	243	542	10	19	37	189	2000
	2002	52	497.6	608.5	9.2	68.6	264.2	623.3	2500.0
	2003	44	501.3	589.6	9.2	18.8	263.8	920.0	1932.0
	2004	41	1032	1982	10	58	212	754	8000
	2005	12	190.6	218.6	10.0	21.8	135.0	370.0	670.0
	2006	12	128.3	178.2	10.0	12.5	80.0	127.5	630.0
	2007	2	185	247	10	*	185	*	360

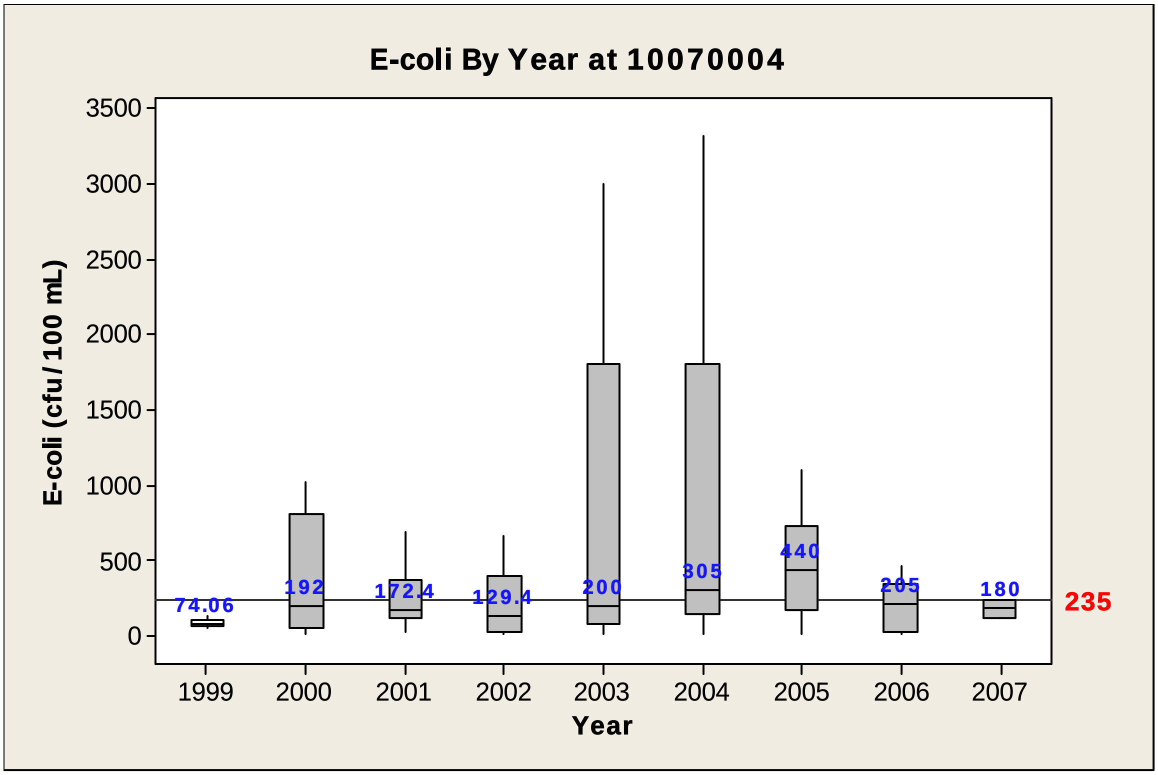


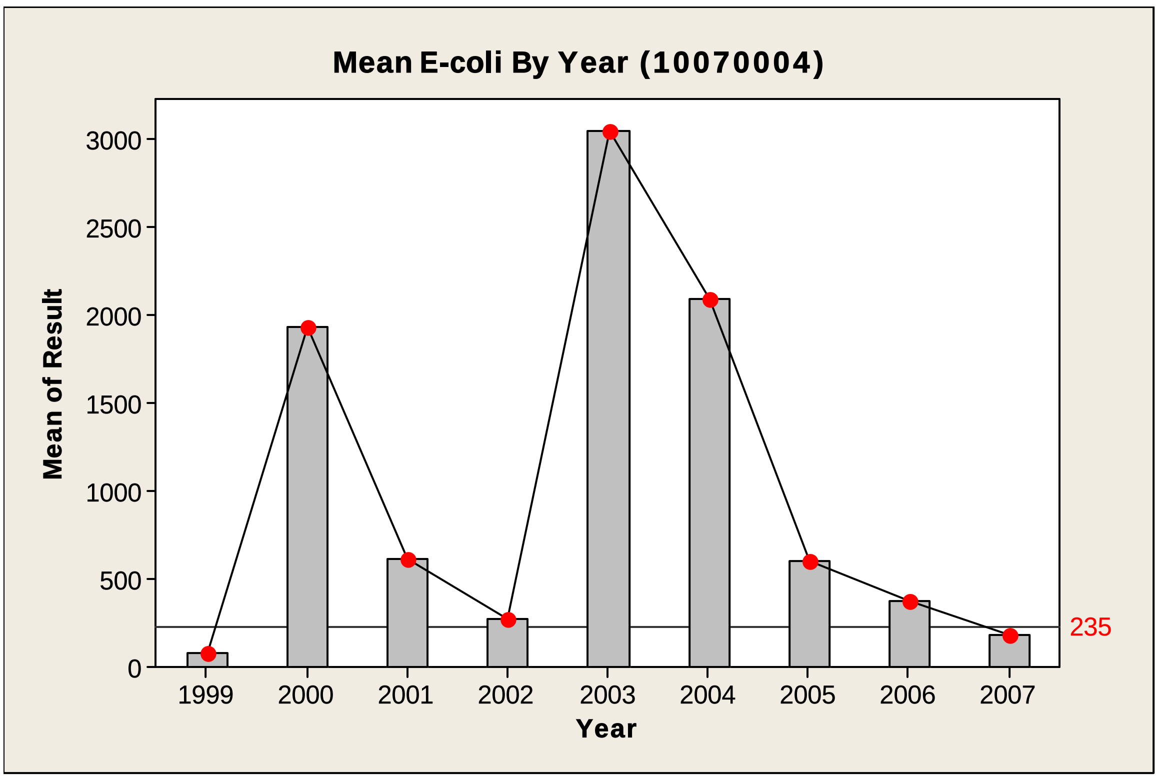


SITE 10070004

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	82.8	28.1	55.0	62.1	74.1	106.8	130.0
	2000	24	1938	4638	10	48	192	804	18400
	2001	24	618	1368	18	110	172	370	5244
	2002	28	269.1	327.2	9.2	28.2	129.4	390.0	1300.0
	2003	64	3049	8266	9	76	200	1805	47840
	2004	52	2091	4374	9	140	305	1805	23000
	2005	35	603	667	10	170	440	720	3000
	2006	12	372	658	10	18	205	345	2400
	2007	2	180.0	84.9	120.0	*	180.0	*	240.0

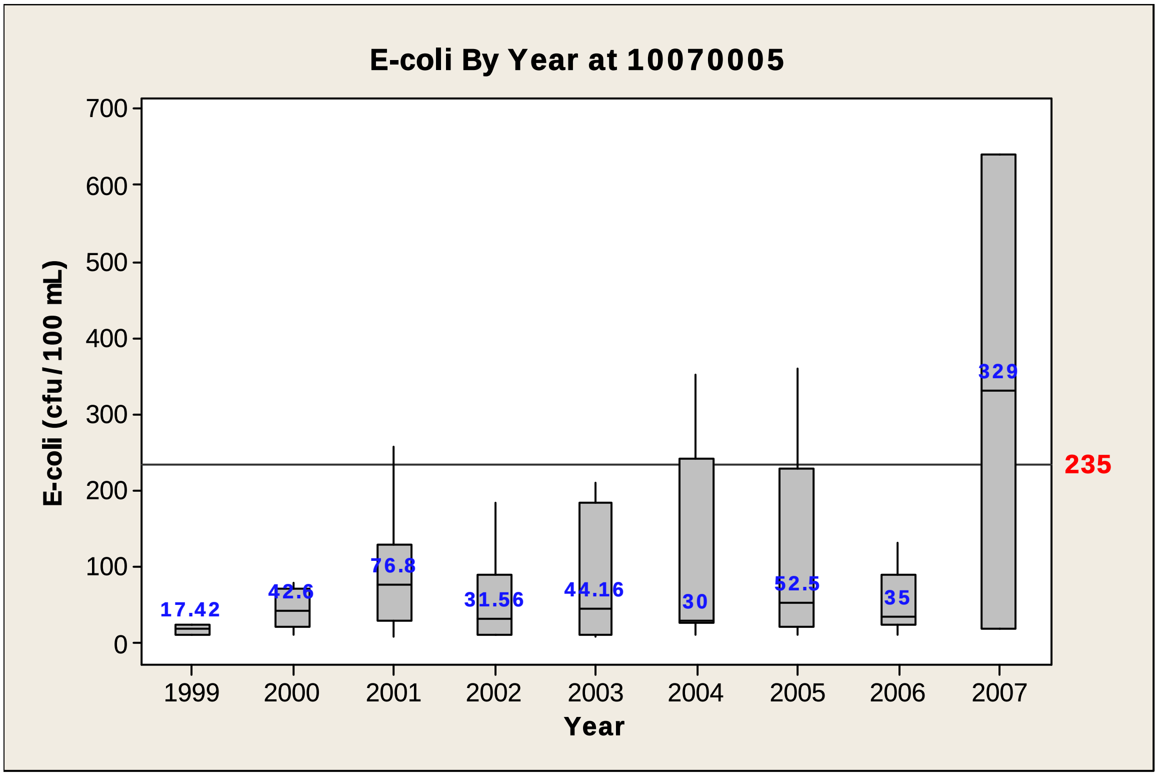

E-coli By Year at 10070004
E-coli (cfu/100 mL)
3500
3000
2500
2000
1500
1000
500
0
74.06
192
172.4
129.4
200
305
440
205
180
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

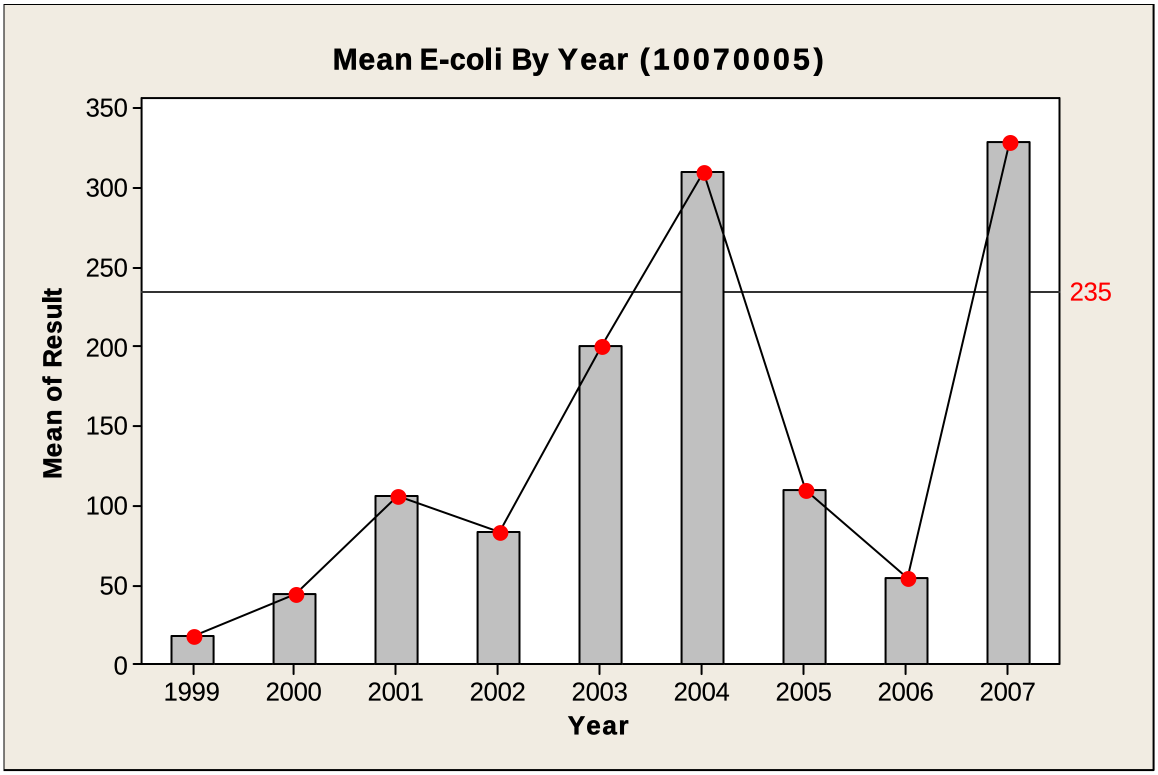

Mean E-coli By Year (10070004)
Mean of Result
3000
2500
2000
1500
1000
500
0
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

SITE 10070005

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	2	17.42	10.49	10.00	*	17.42	*	24.84
	2000	8	44.35	26.26	10.00	20.70	42.60	70.20	80.00
	2001	24	106.5	110.0	9.2	30.0	76.8	129.7	410.0
	2002	24	83.3	116.8	10.0	10.0	31.6	88.8	414.0
	2003	24	200.8	447.2	9.2	10.0	44.2	184.0	1700.0
	2004	19	310	678	10	28	30	240	2300
	2005	12	109.6	123.9	10.0	20.0	52.5	227.5	360.0
	2006	12	53.6	41.8	10.0	22.5	35.0	90.3	130.0
	2007	2	329	440	18	*	329	*	640

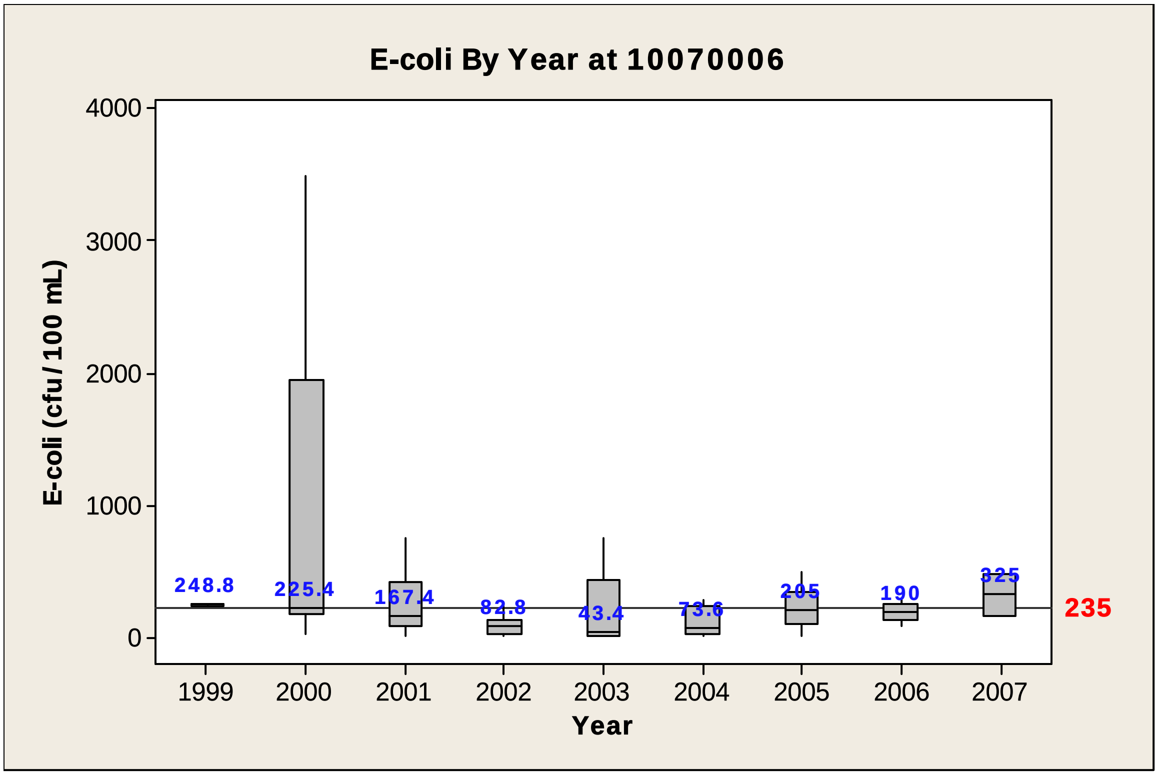


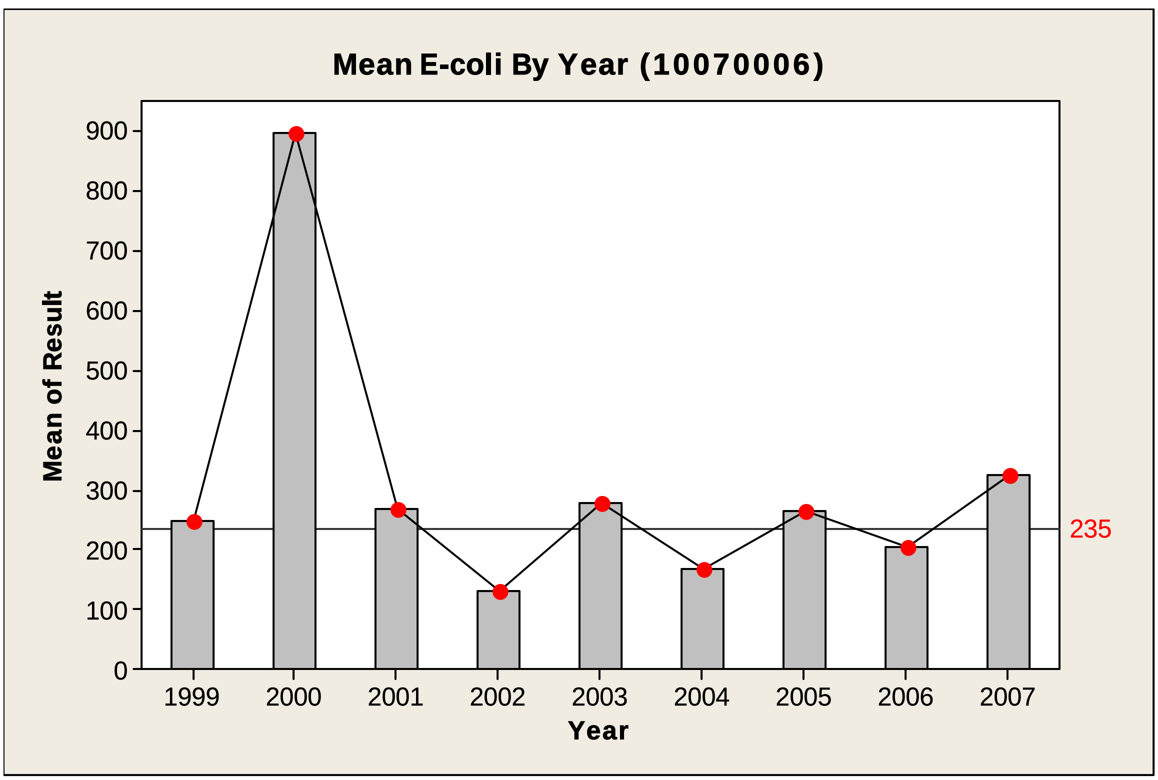


SITE 10070006

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	2	248.80	12.45	240.00	*	248.80	*	257.60
	2000	8	895	1327	30	173	225	1953	3496
	2001	24	268.5	228.3	10.0	92.5	167.4	421.4	754.4
	2002	24	131.1	175.1	10.0	23.0	82.8	136.0	671.6
	2003	24	277.4	486.6	10.0	10.0	43.4	441.6	1748.0
	2004	19	168.5	201.9	9.2	27.6	73.6	239.2	708.4
	2005	12	264.6	221.0	10.0	102.5	205.0	340.0	820.0
	2006	12	203.3	105.3	90.0	130.0	190.0	255.0	470.0
	2007	2	325	219	170	*	325	*	480

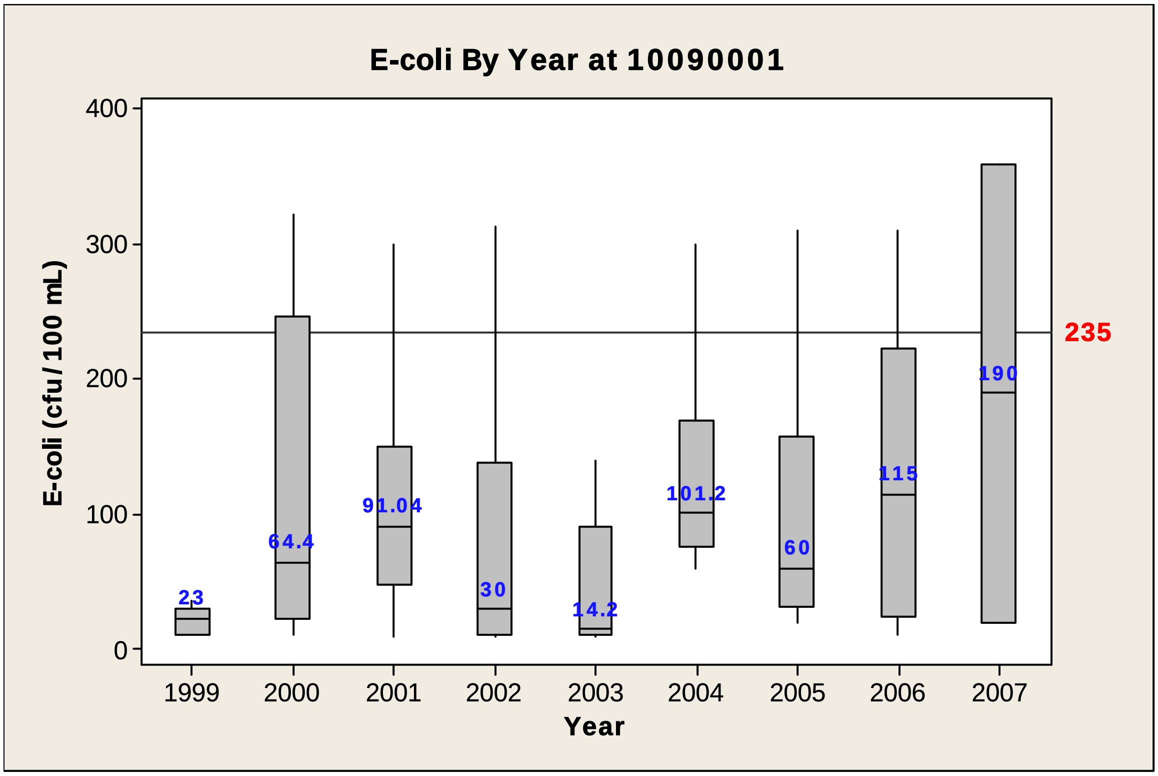

E-coli By Year at 10070006
E-coli (cfu/ 100 mL)
4000
3000
2000
1000
0
248.8
225.4
167.4
82.8
43.4
73.6
205
190
325
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

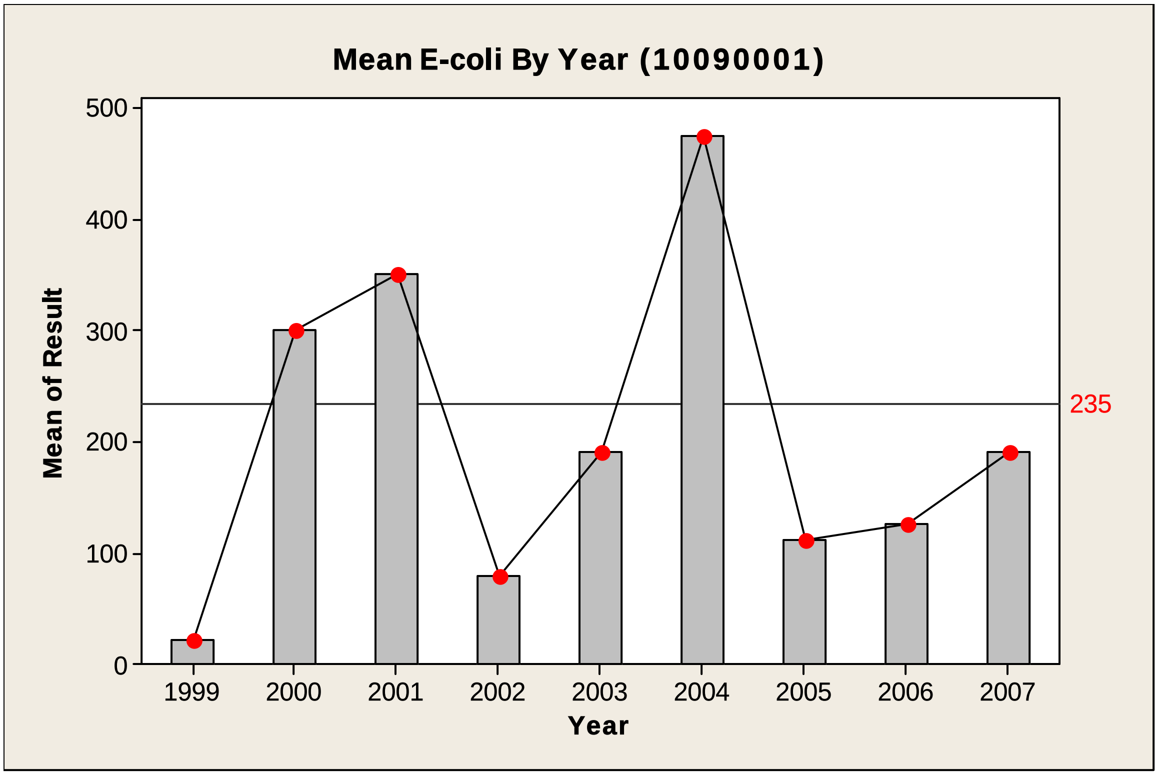

Mean E-coli By Year (10070006)
Mean of Result
900
800
700
600
500
400
300
200
100
0
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

SITE 10090001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	21.60	10.57	10.00	10.00	23.00	29.70	36.00
	2000	24	300	519	10	22	64	247	1656
	2001	24	350	826	9	47	91	150	3036
	2002	24	78.5	85.6	9.2	10.0	30.0	138.0	312.8
	2003	24	192	518	9	10	14	90	1932
	2004	19	474	1054	60	75	101	170	3600
	2005	12	112.3	119.0	20.0	31.5	60.0	157.5	380.0
	2006	12	125.5	99.6	10.0	24.0	115.0	222.5	310.0
	2007	2	190	240	20	*	190	*	360

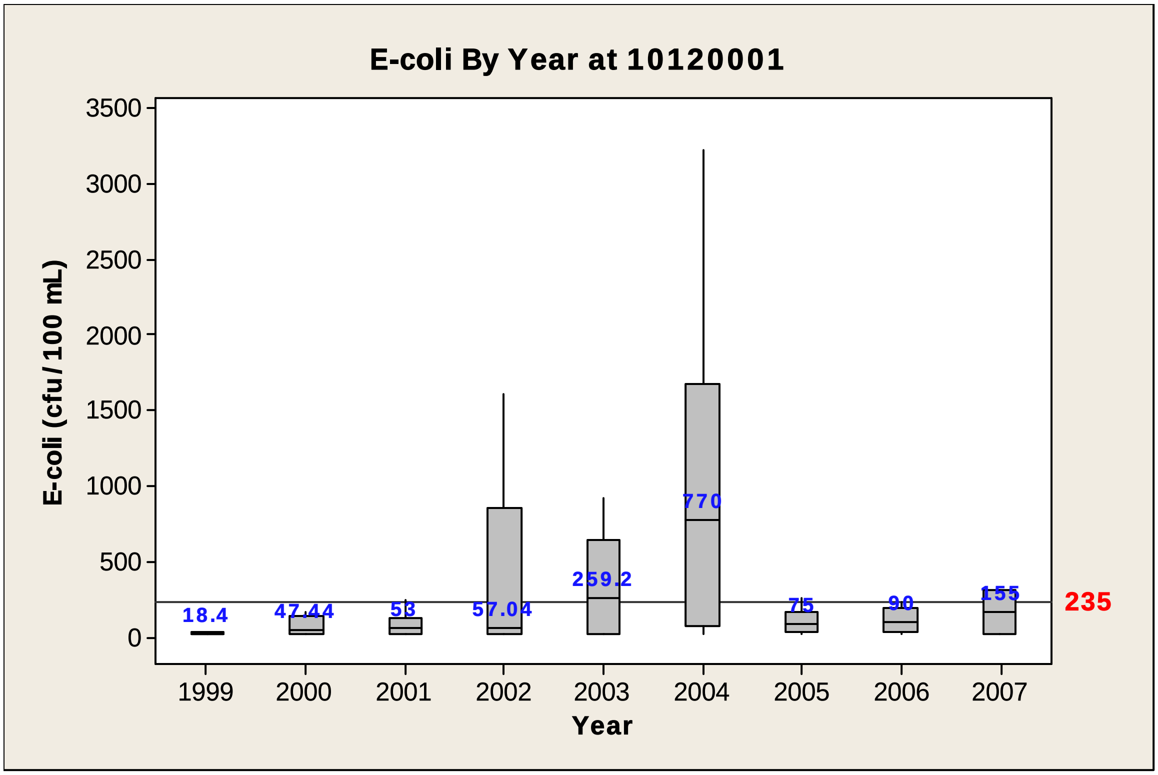


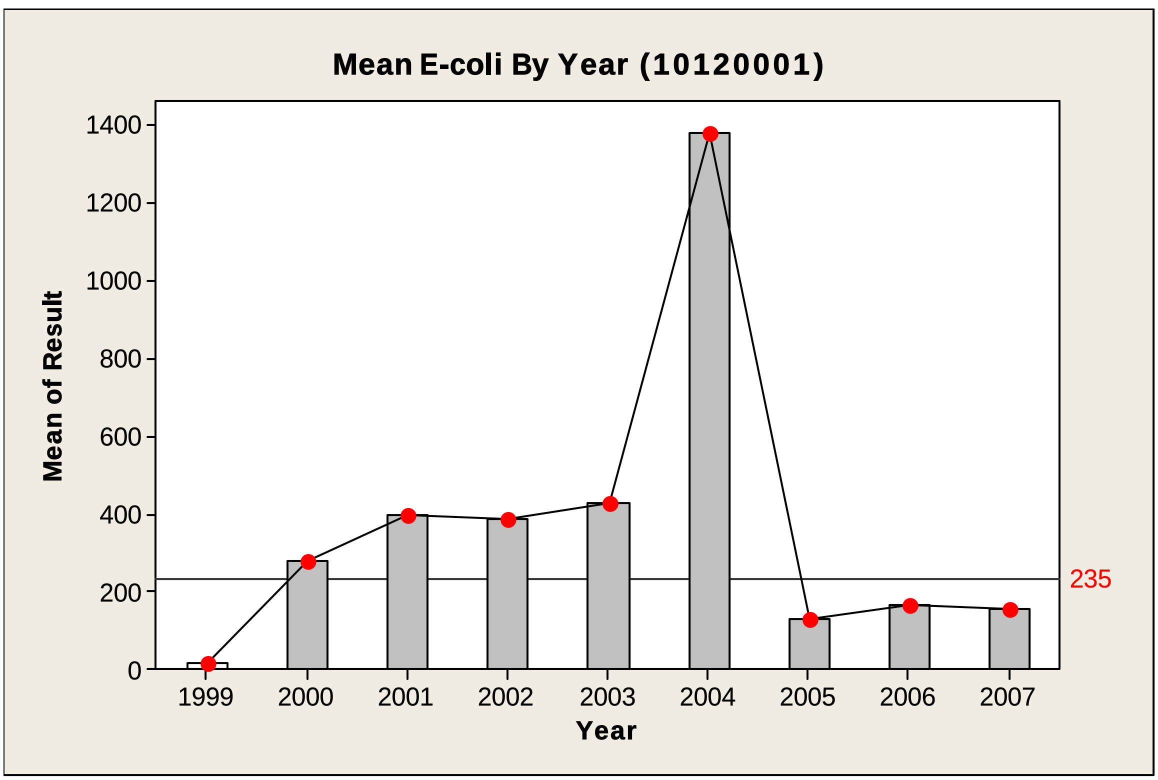


SITE 10120001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	17.67	7.60	9.20	9.80	18.40	22.50	30.00
	2000	24	278	729	9	18	47	134	2700
	2001	24	394	1013	9	14	53	127	3800
	2002	48	384.9	501.2	9.2	10.0	57.0	844.1	1600.0
	2003	46	429.0	560.0	9.2	10.0	259.2	637.1	2100.0
	2004	45	1378	2041	9	62	770	1674	9200
	2005	12	130.0	172.9	10.0	22.5	75.0	160.0	630.0
	2006	12	162.5	264.6	10.0	25.0	90.0	190.0	970.0
	2007	2	155	205	10	*	155	*	300

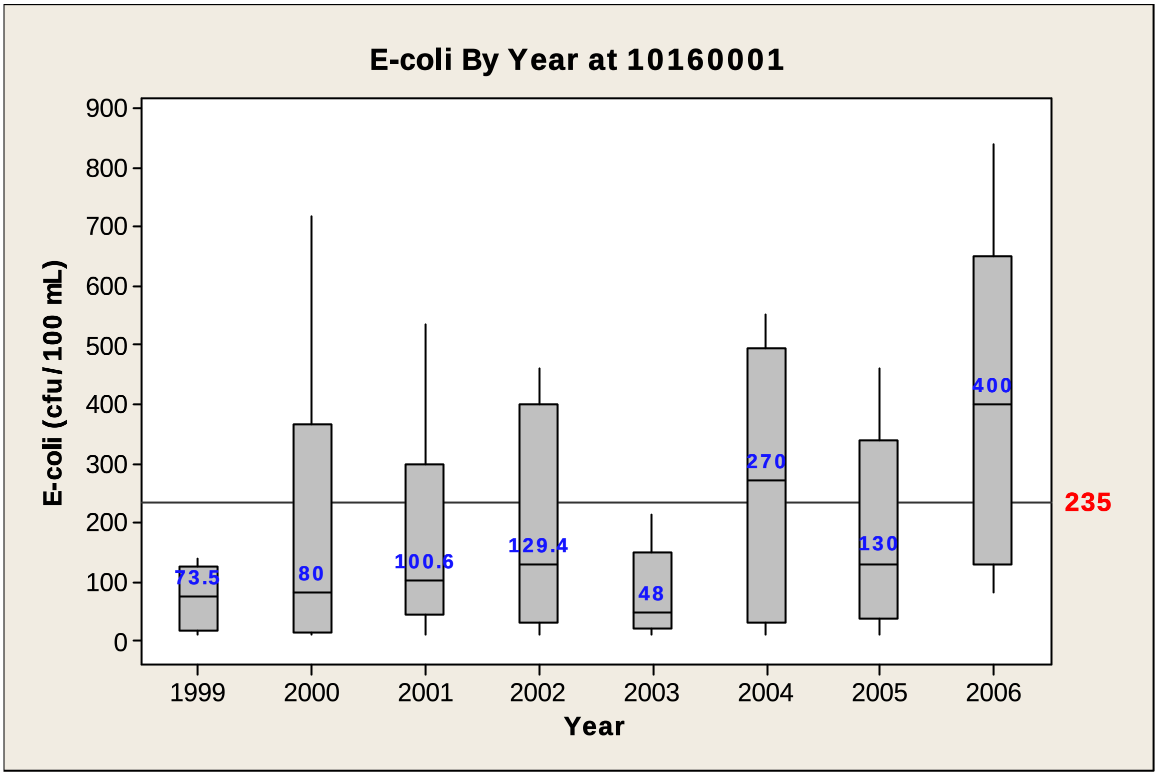

E-coli By Year at 10120001
E-coli (cfu/100 mL)
3500
3000
2500
2000
1500
1000
500
0
18.4
47.44
53
57.04
259.2
770
75
90
155
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

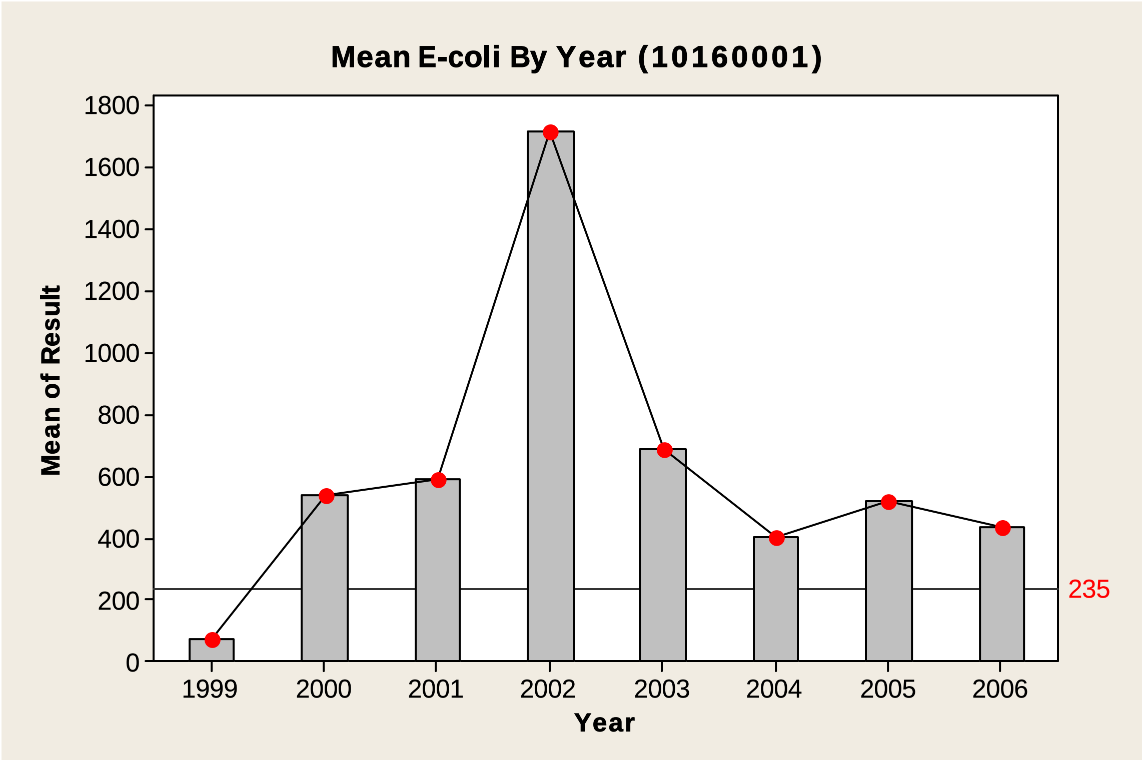

Mean E-coli By Year (10120001)
Mean of Result
1400
1200
1000
800
600
400
200
0
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

SITE 10160001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	72.6	53.3	9.2	17.3	73.5	124.7	140.0
	2000	24	540	1326	9	12	80	366	5000
	2001	24	588	1082	10	43	101	297	3588
	2002	24	1721	5242	10	31	129	400	23000
	2003	24	689	2081	9	19	48	150	8832
	2004	21	399	806	10	29	270	493	3800
	2005	12	521	1261	10	39	130	338	4500
	2006	7	433	283	80	130	400	650	840

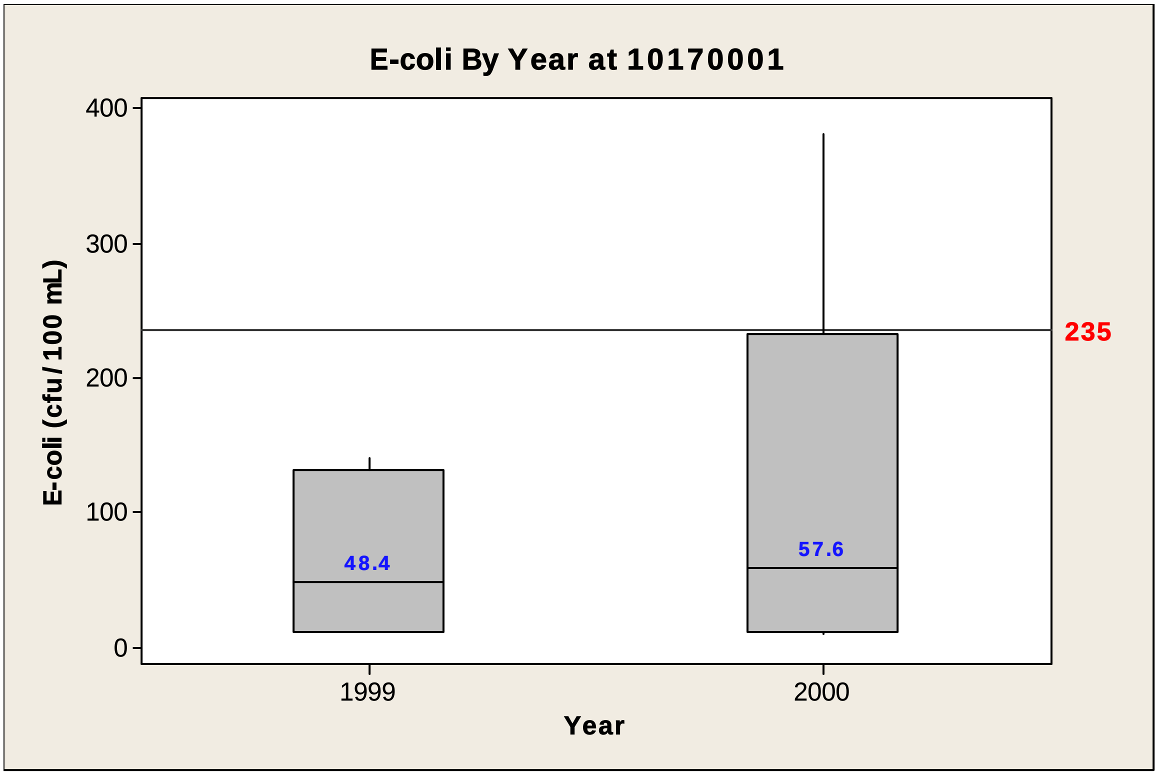


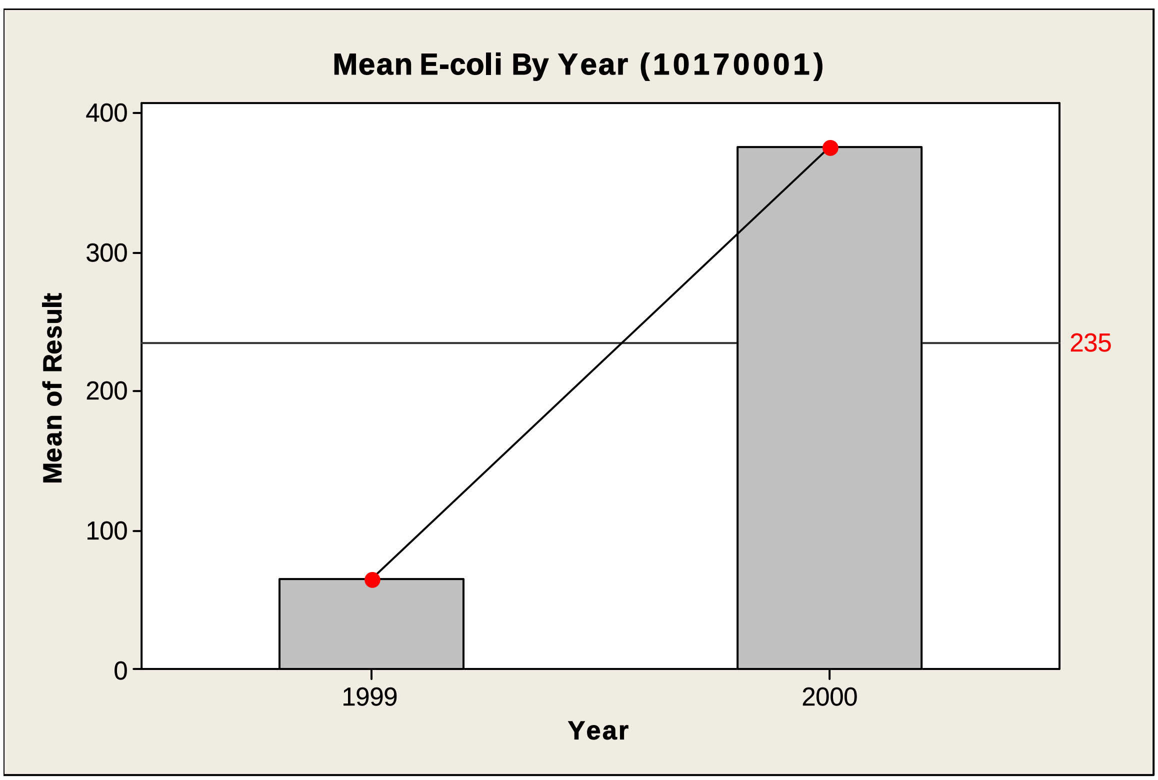


SITE 10170001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	64.3	57.6	10.0	10.0	48.4	131.6	140.0
	2000	18	375	814	9	10	58	232	2700

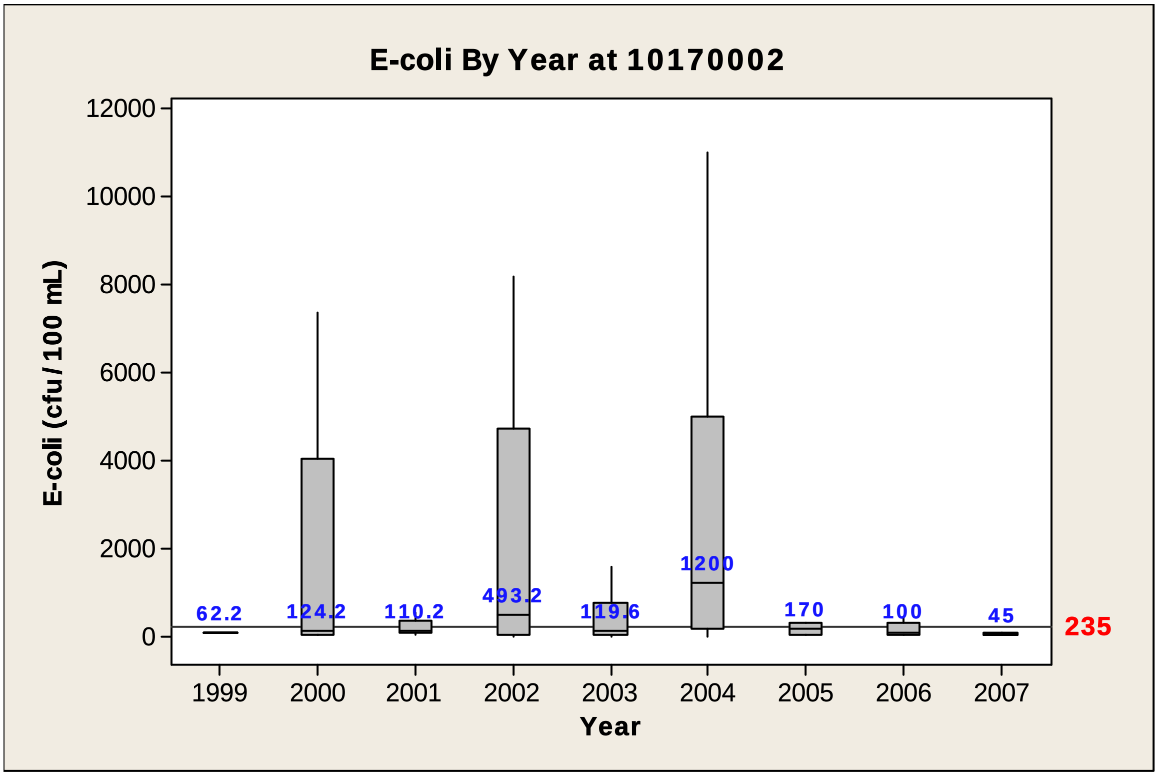

E-coli By Year at 10170001
E-coli (cfu/100 mL)
400
300
200
100
0
235
48.4
57.6
1999
2000
Year

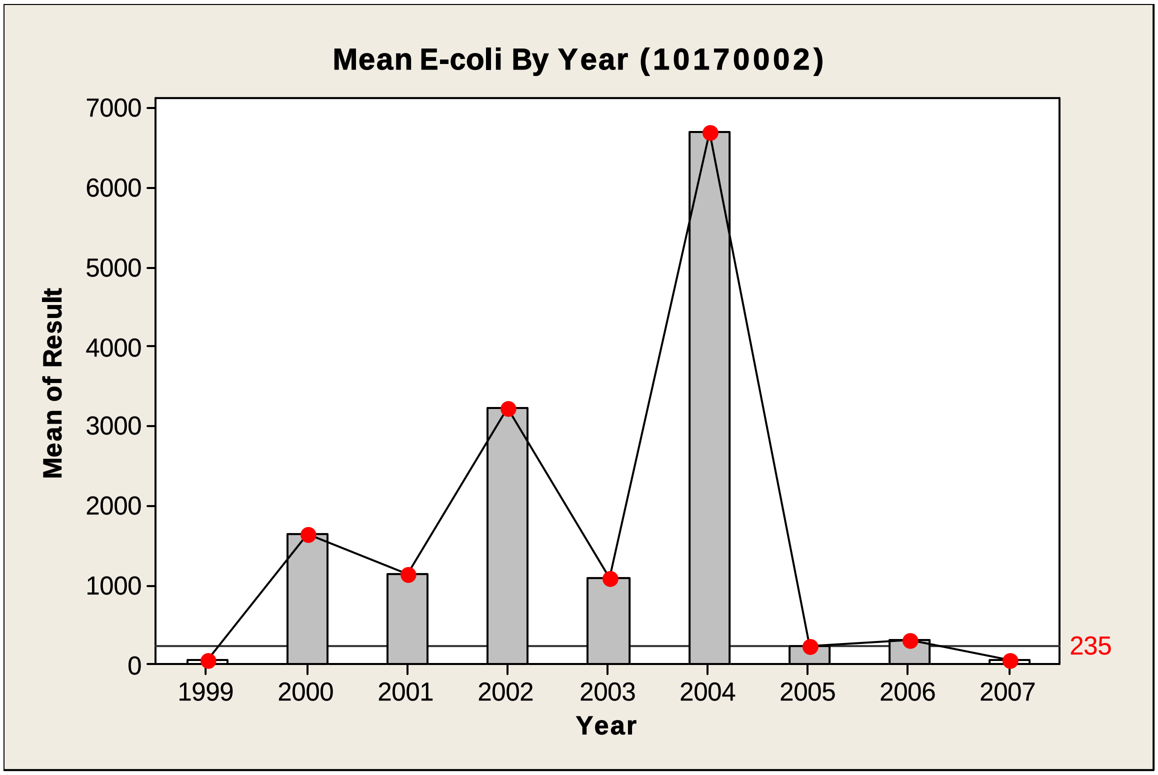

Mean E-coli By Year (10170001)
Mean of Result
400
300
200
100
0
235
1999
2000
Year

SITE 10170002

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	2	62.20	3.11	60.00	*	62.20	*	64.40
	2000	8	1647	2943	10	28	124	4018	7360
	2001	24	1142	3364	10	55	110	364	13800
	2002	40	3224	6703	9	41	493	4713	32200
	2003	36	1089	2290	9	10	120	745	11040
	2004	39	6705	15391	9	150	1200	4968	80040
	2005	12	234.3	260.5	10.0	30.0	170.0	285.0	790.0
	2006	12	294	585	10	13	100	295	2100
	2007	2	45.0	21.2	30.0	*	45.0	*	60.0

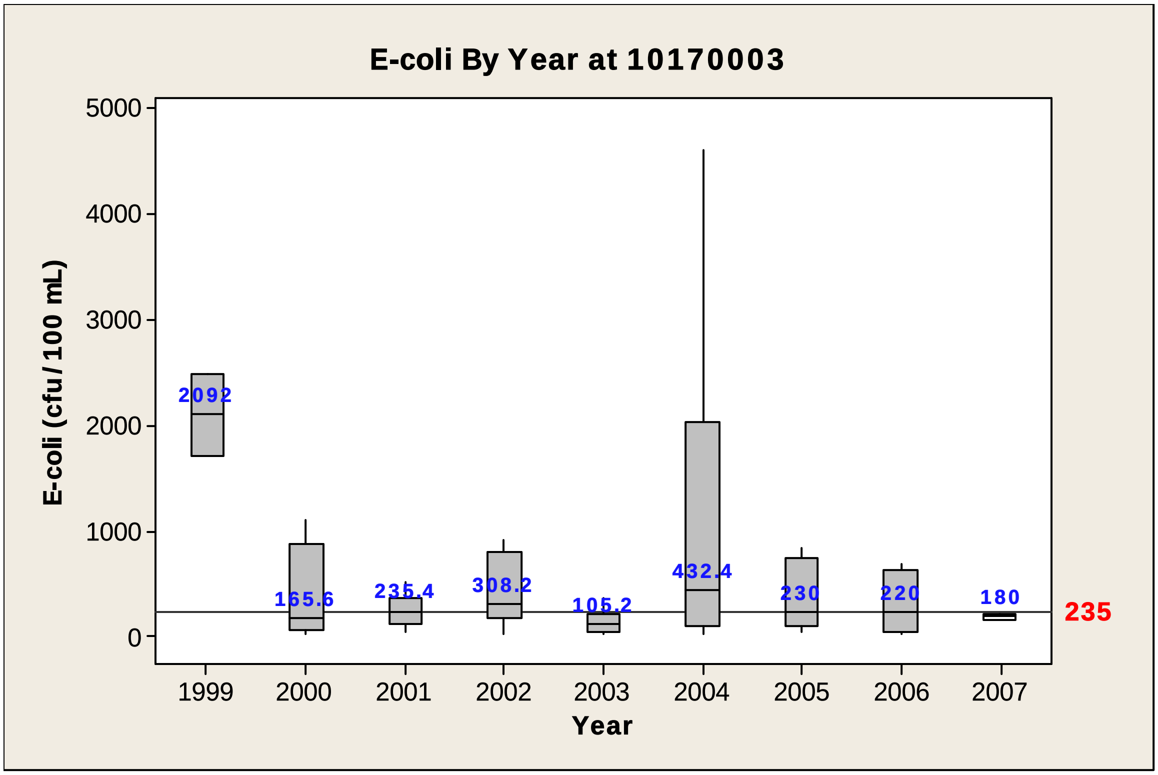


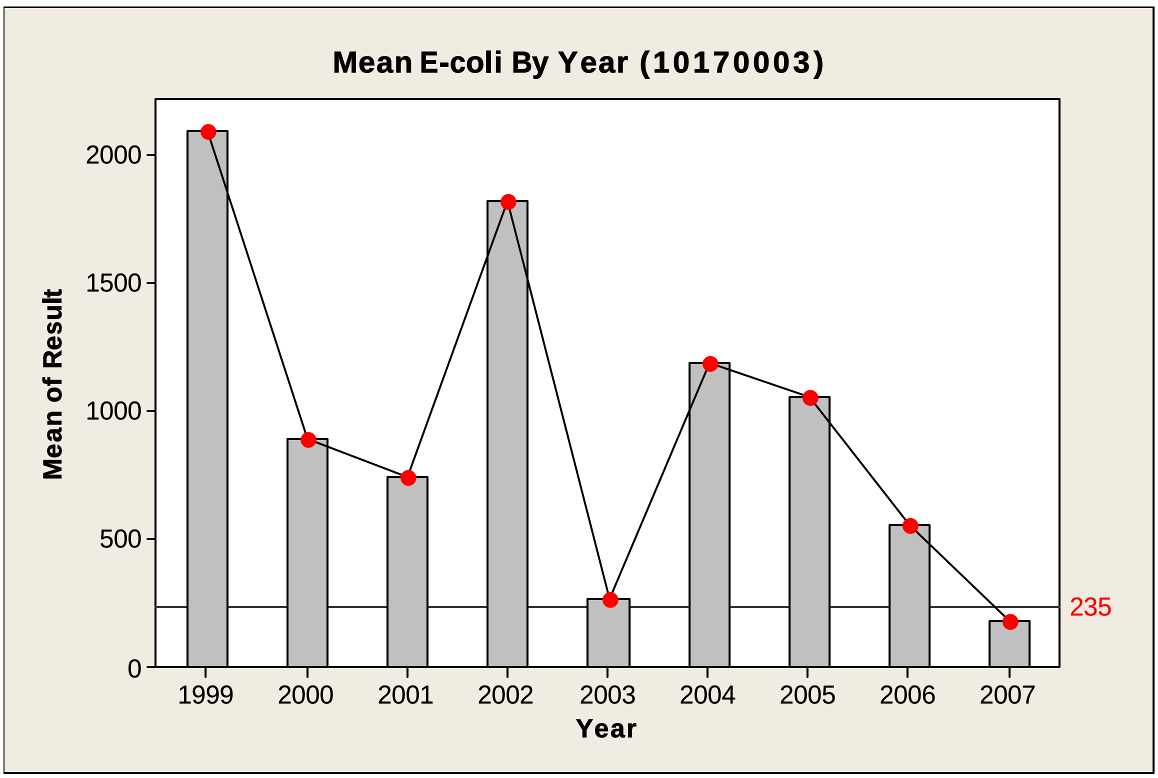


SITE 10170003

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	2	2092	554	1700	*	2092	*	2484
	2000	8	890	1816	10	63	166	878	5300
	2001	24	739	1744	36	112	235	365	7084
	2002	24	1817	3432	9	174	308	796	11040
	2003	24	262.0	427.5	9.2	42.5	105.2	211.6	1656.0
	2004	19	1183	1501	10	100	432	2024	5000
	2005	12	1056	2611	40	84	230	730	9300
	2006	12	557	994	10	32	220	633	3600
	2007	2	180.0	42.4	150.0	*	180.0	*	210.0

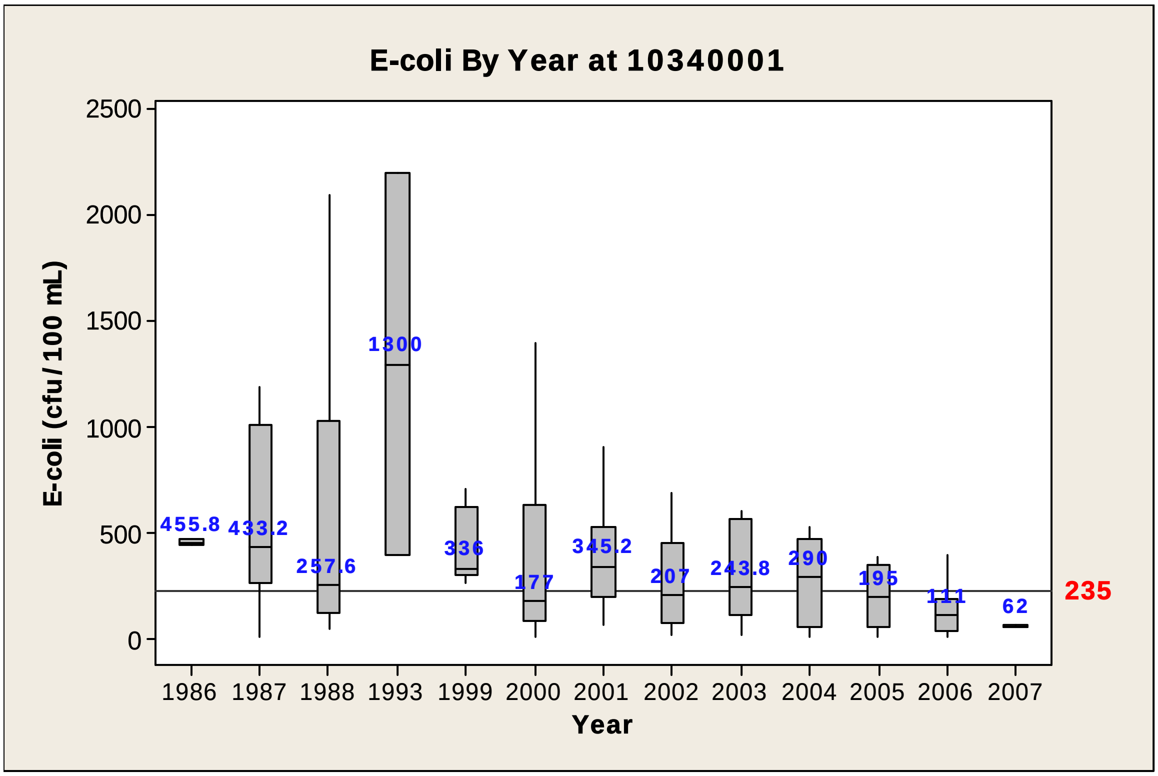

E-coli By Year at 10170003
E-coli (cfu/100 mL)
5000
4000
3000
2000
1000
0
2092
165.6
235.4
308.2
105.2
432.4
230
220
180
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

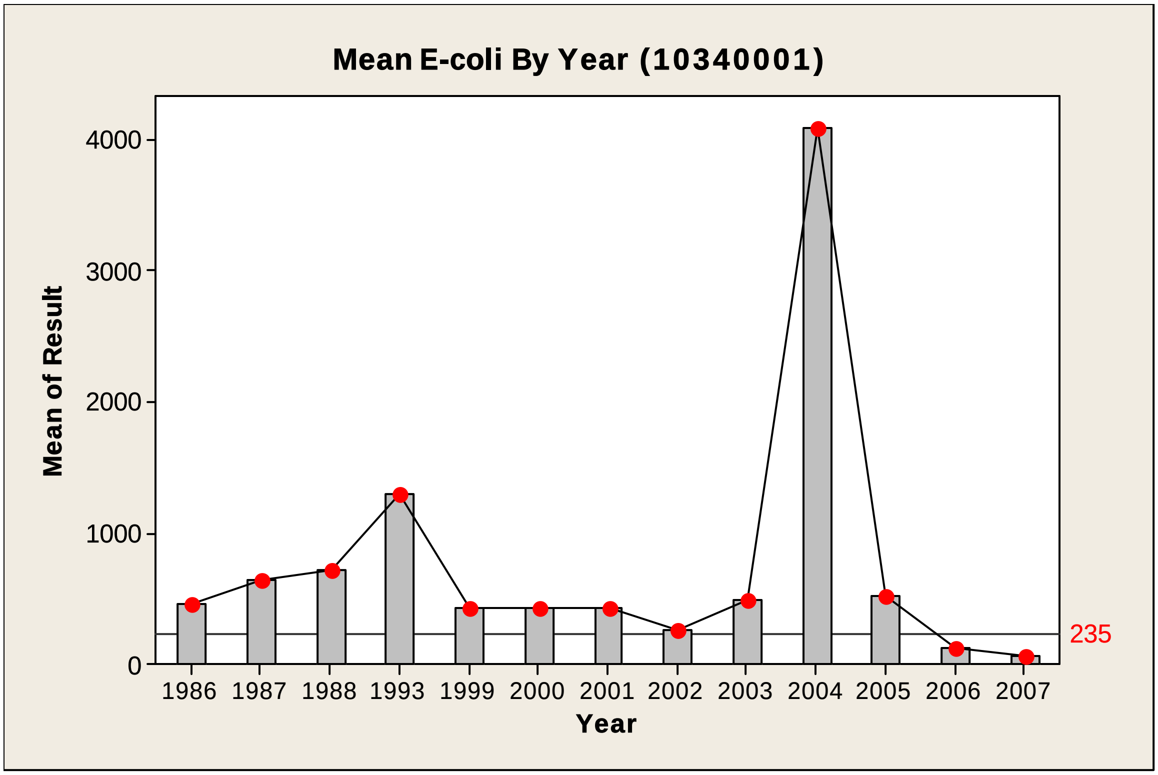

Mean E-coli By Year (10170003)
Mean of Result
2000
1500
1000
500
0
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

SITE 10340001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1986	2	455.8	20.1	441.6	*	455.8	*	470.0
	1987	12	640	606	10	269	433	1013	2200
	1988	14	719	968	46	121	258	1029	3300
	1993	2	1300	1273	400	*	1300	*	2200
	1999	6	426.2	181.9	266.8	299.2	336.0	627.1	708.4
	2000	24	425	506	9	83	177	630	2024
	2001	24	425.7	300.8	70.0	202.9	345.2	526.3	1380.0
	2002	24	259.8	202.8	18.4	81.0	207.0	453.1	690.0
	2003	24	484	599	20	113	244	565	2100
	2004	19	4085	11576	10	55	290	470	40480
	2005	12	520	1166	10	58	195	350	4200
	2006	12	129.1	110.6	10.0	35.3	111.0	192.5	400.0
	2007	2	62.00	2.83	60.00	*	62.00	*	64.00

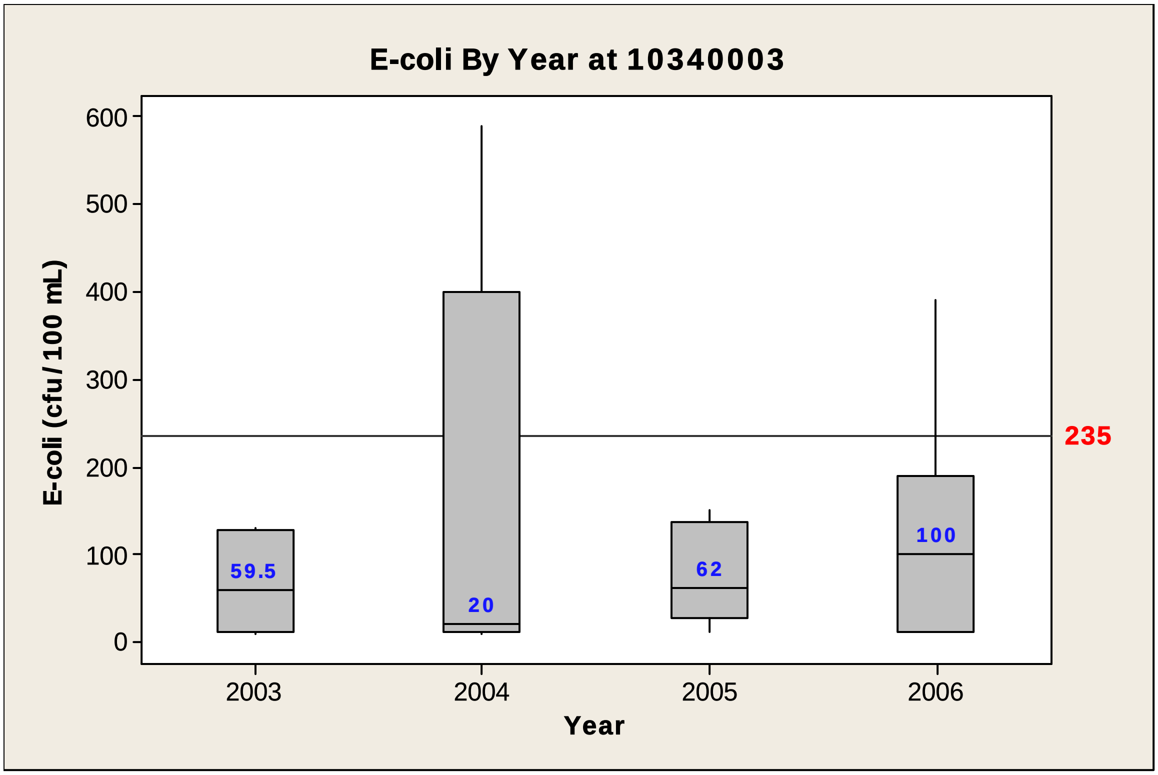


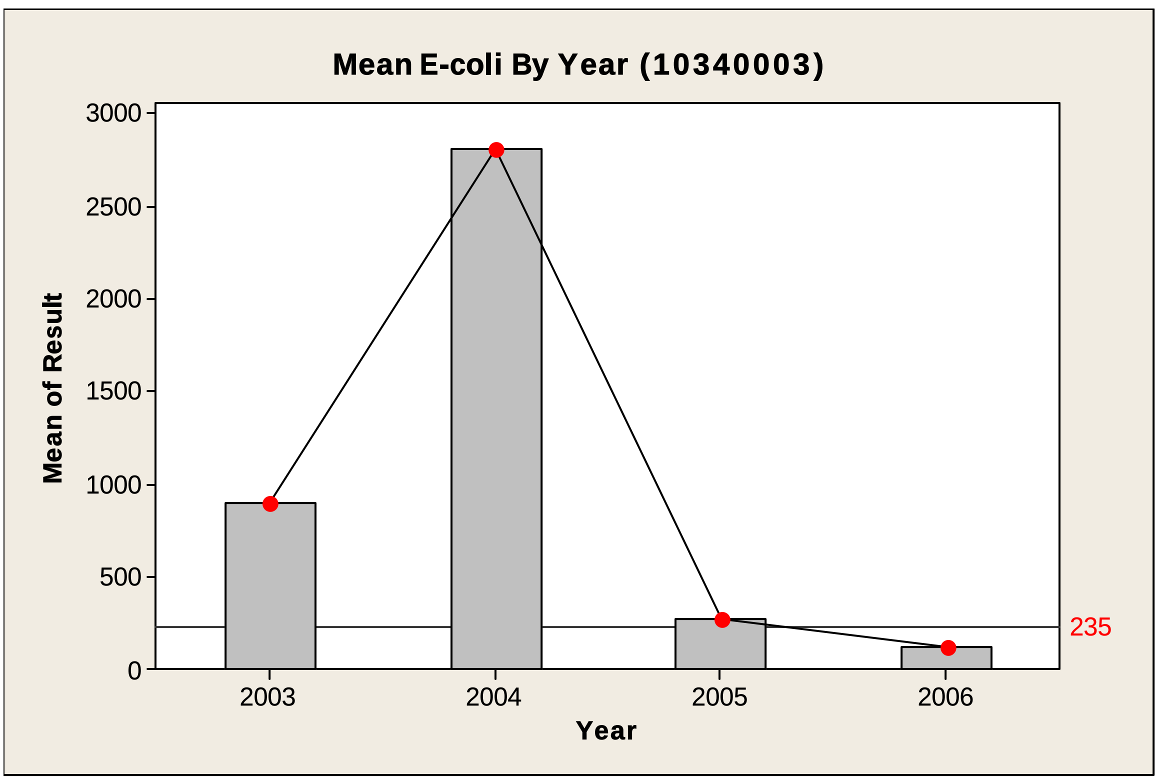


SITE 10340003

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	2003	12	892	1959	9	10	60	127	5200
	2004	19	2803	7967	9	10	20	400	27600
	2005	12	269	645	10	28	62	138	2300
	2006	11	121.3	114.3	10.0	10.0	100.0	190.0	390.0

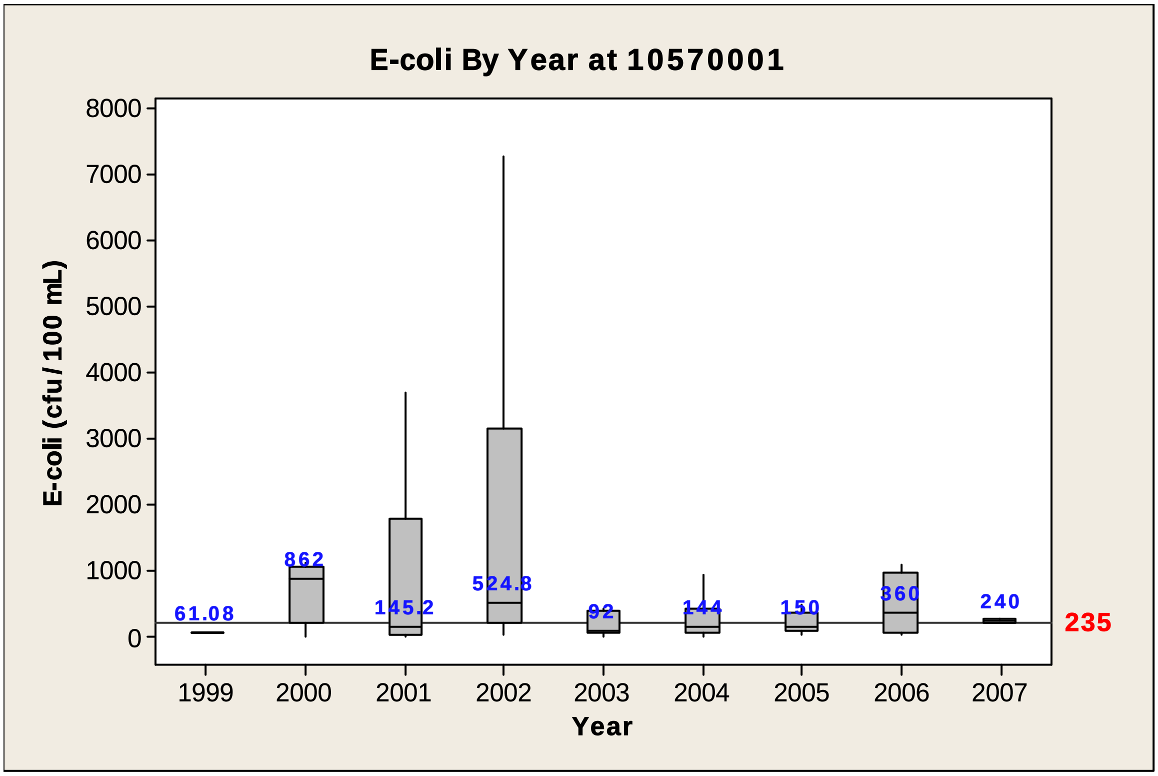

E-coli By Year at 10340003
E-coli (cfu/100 mL)
600
500
400
300
200
100
0
59.5
20
62
100
235
2003
2004
2005
2006
Year

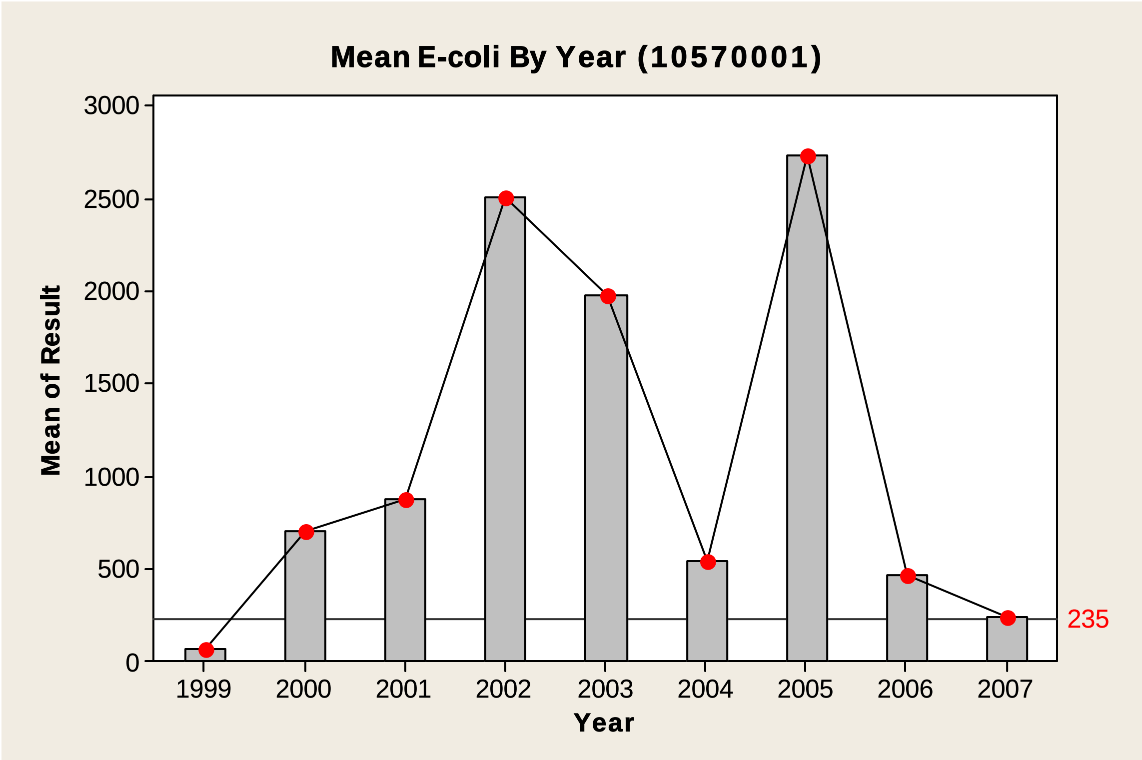

Mean E-coli By Year (10340003)
Mean of Result
3000
2500
2000
1500
1000
500
0
235
2003
2004
2005
2006
Year

SITE 10570001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	2	61.08	8.60	55.00	*	61.08	*	67.16
	2000	8	705	444	10	203	862	1056	1104
	2001	24	870	1322	10	37	145	1794	4508
	2002	24	2507	4025	40	210	525	3147	14720
	2003	41	1977	6436	10	55	92	389	31280
	2004	42	536	1143	10	69	144	425	5900
	2005	35	2726	13813	20	80	150	360	82000
	2006	12	466	439	20	56	360	963	1100
	2007	2	240.0	56.6	200.0	*	240.0	*	280.0

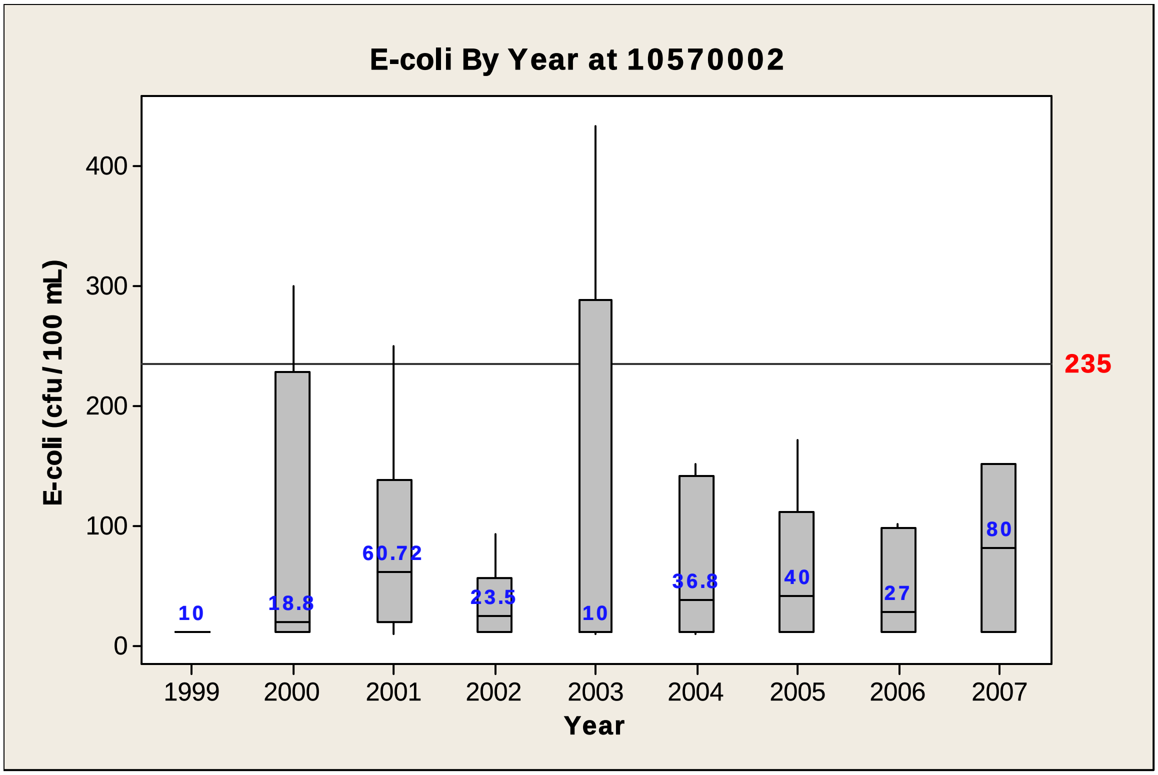


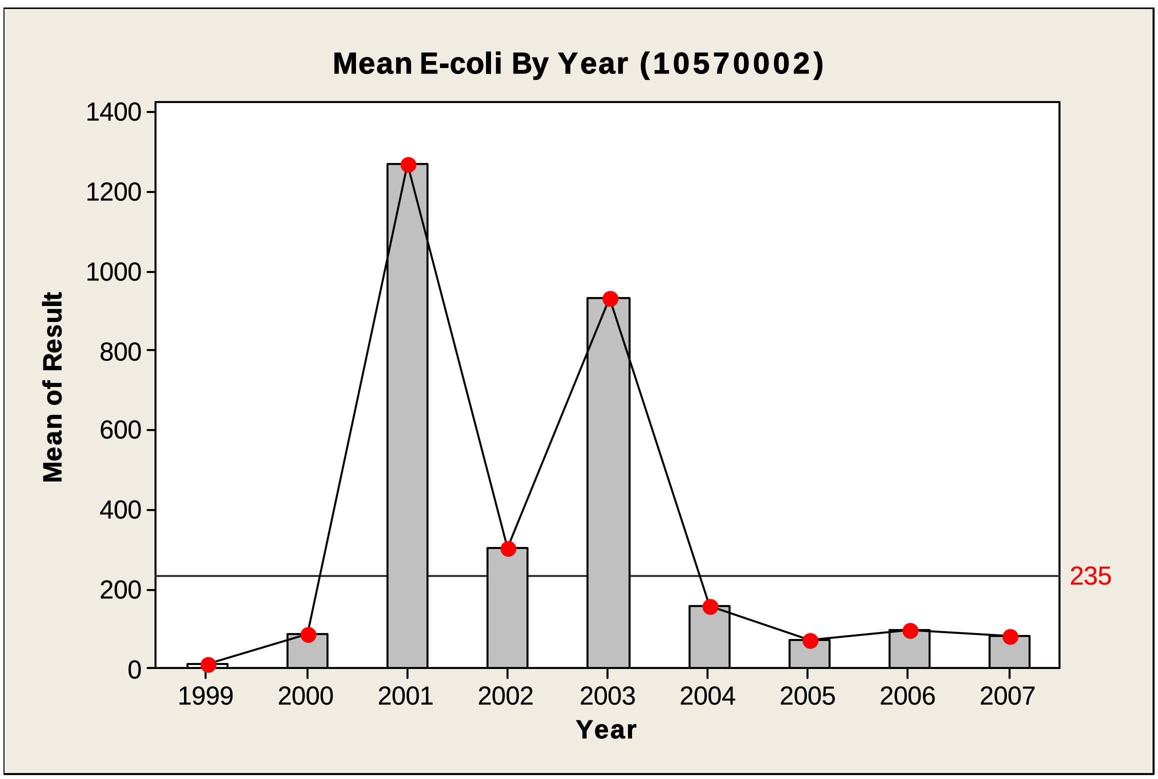


SITE 10570002

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	2	10.000	0.000000	10.000	*	10.000	*	10.000
	2000	8	86.5	130.3	10.0	10.0	18.8	228.3	300.0
	2001	24	1267	4065	9	18	61	137	16560
	2002	24	304	960	10	10	24	55	4140
	2003	24	931	2020	9	10	10	288	6000
	2004	19	155.3	243.9	9.2	10.0	36.8	140.0	730.0
	2005	12	69.2	81.6	10.0	10.0	40.0	110.0	270.0
	2006	12	96.2	158.4	10.0	10.0	27.0	97.5	530.0
	2007	2	80.0	99.0	10.0	*	80.0	*	150.0

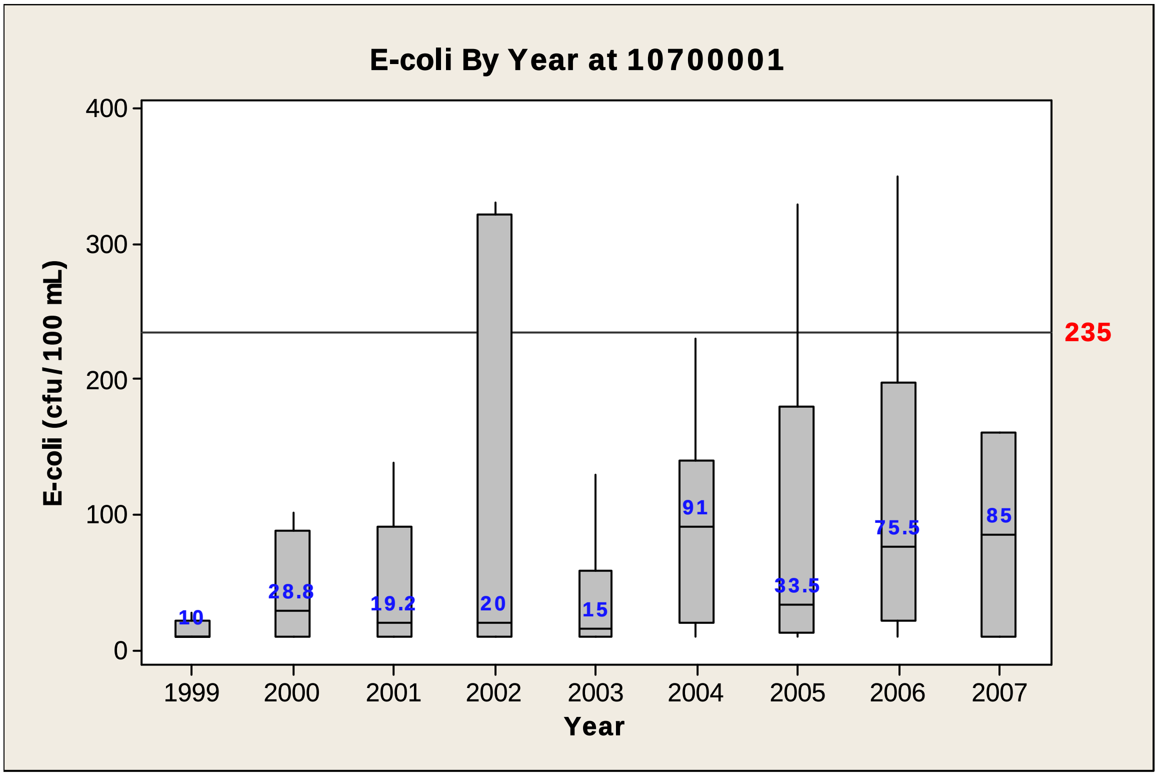

E-coli By Year at 10570002
E-coli (cfu/100 mL)
400
300
200
100
0
235
10
18.8
60.72
23.5
10
36.8
40
27
80
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

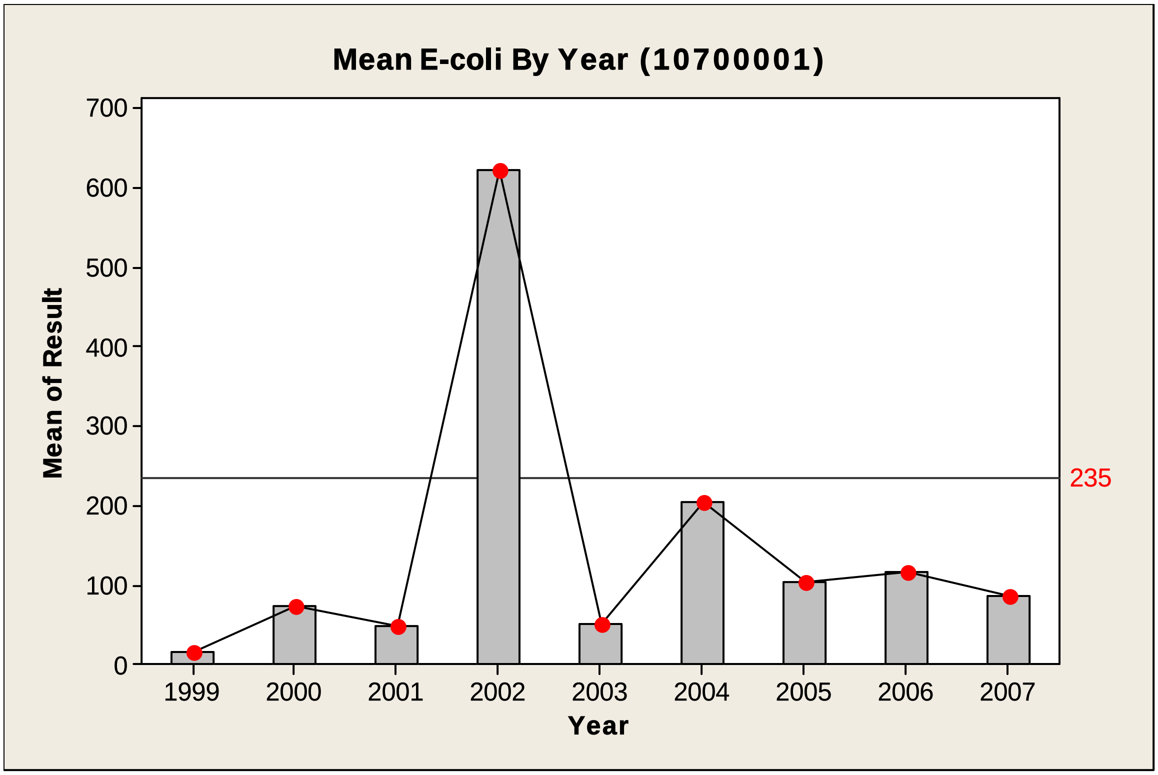

Mean E-coli By Year (10570002)
Mean of Result
1400
1200
1000
800
600
400
200
0
235
1999
2000
2001
2002
2003
2004
2005
2006
2007
Year

SITE 10700001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1999	6	14.20	7.42	9.20	9.80	10.00	20.70	27.60
	2000	24	74.1	108.7	9.2	10.0	28.8	88.8	386.4
	2001	24	48.8	56.8	9.2	10.0	19.2	91.6	220.8
	2002	24	621	1497	9	10	20	322	5980
	2003	24	50.5	65.0	9.2	10.0	15.0	58.8	240.0
	2004	19	203.8	347.0	9.2	20.0	91.0	140.0	1200.0
	2005	12	102.5	145.8	10.0	12.0	33.5	180.0	440.0
	2006	12	114.8	115.4	10.0	21.8	75.5	197.5	350.0
	2007	2	85.0	106.1	10.0	*	85.0	*	160.0

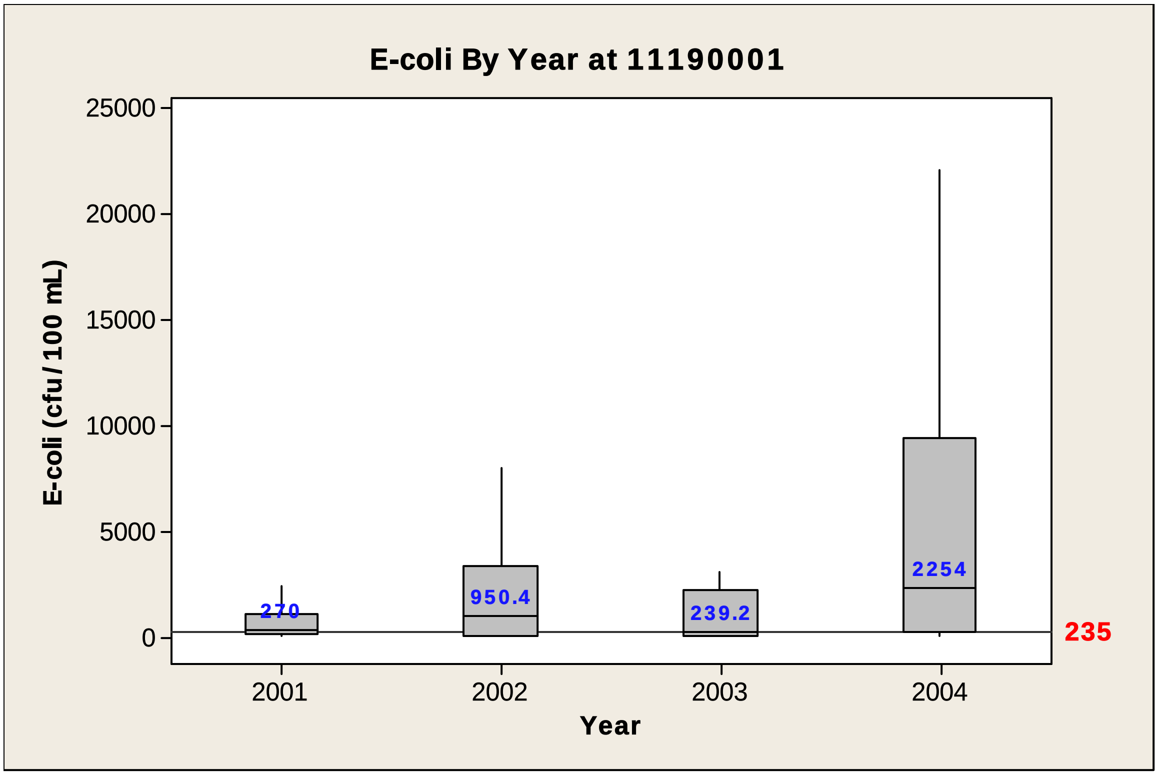


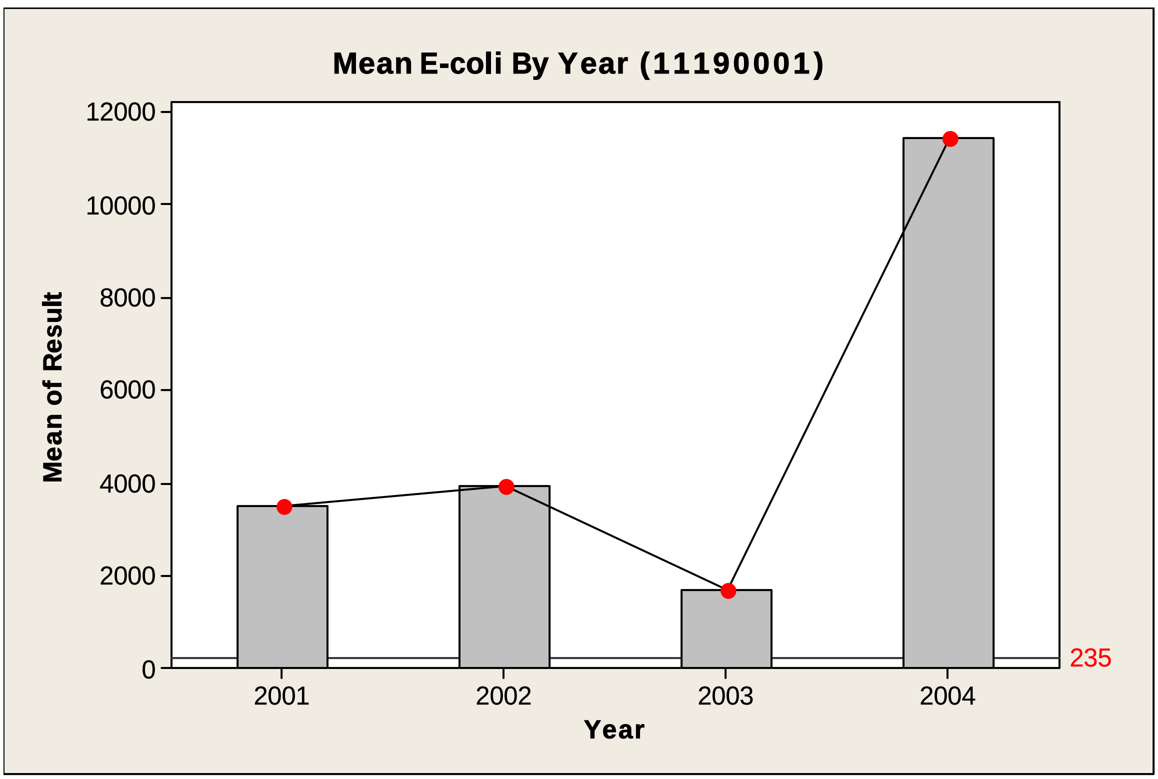


SITE 11190001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	2001	18	3493	9307	10	66	270	1074	36800
	2002	46	3952	12472	9	49	950	3350	80960
	2003	30	1694	3067	9	39	239	2200	11960
	2004	38	11450	24007	10	159	2254	9400	110400

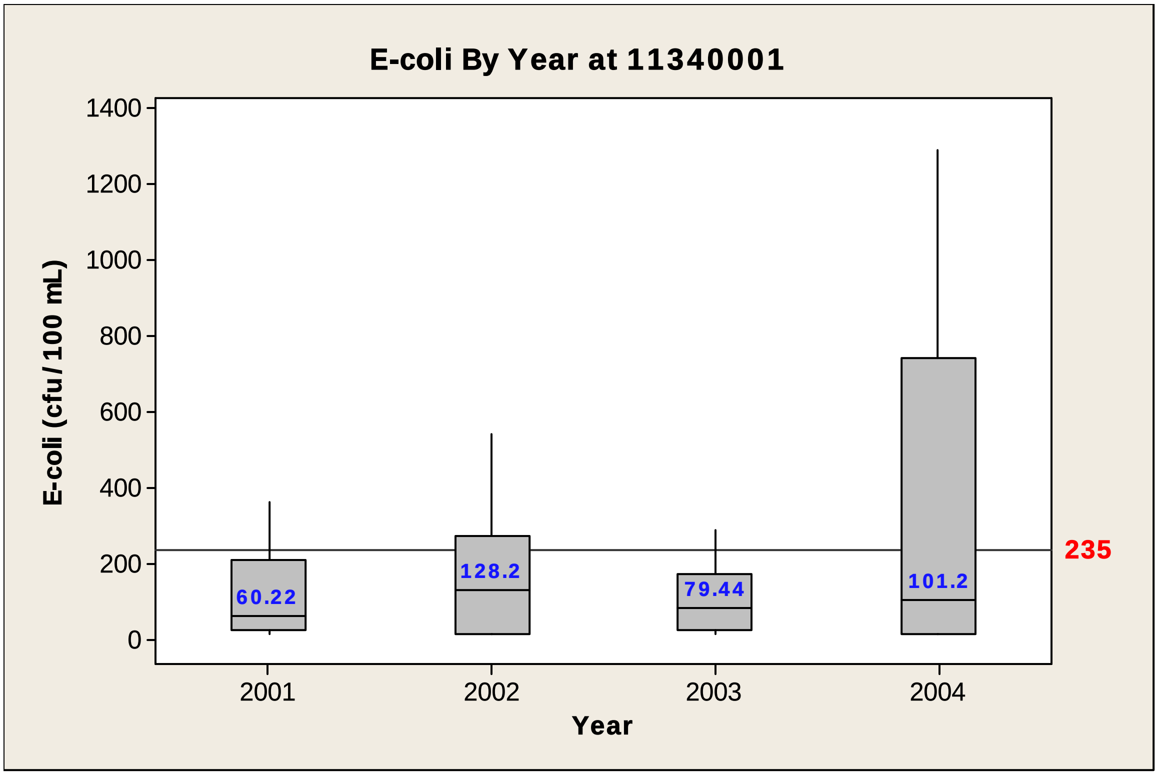

E-coli By Year at 11190001
25000
20000
15000
10000
5000
0
E-coli (cfu/100 mL)
270
950.4
239.2
2254
235
2001
2002
2003
2004
Year

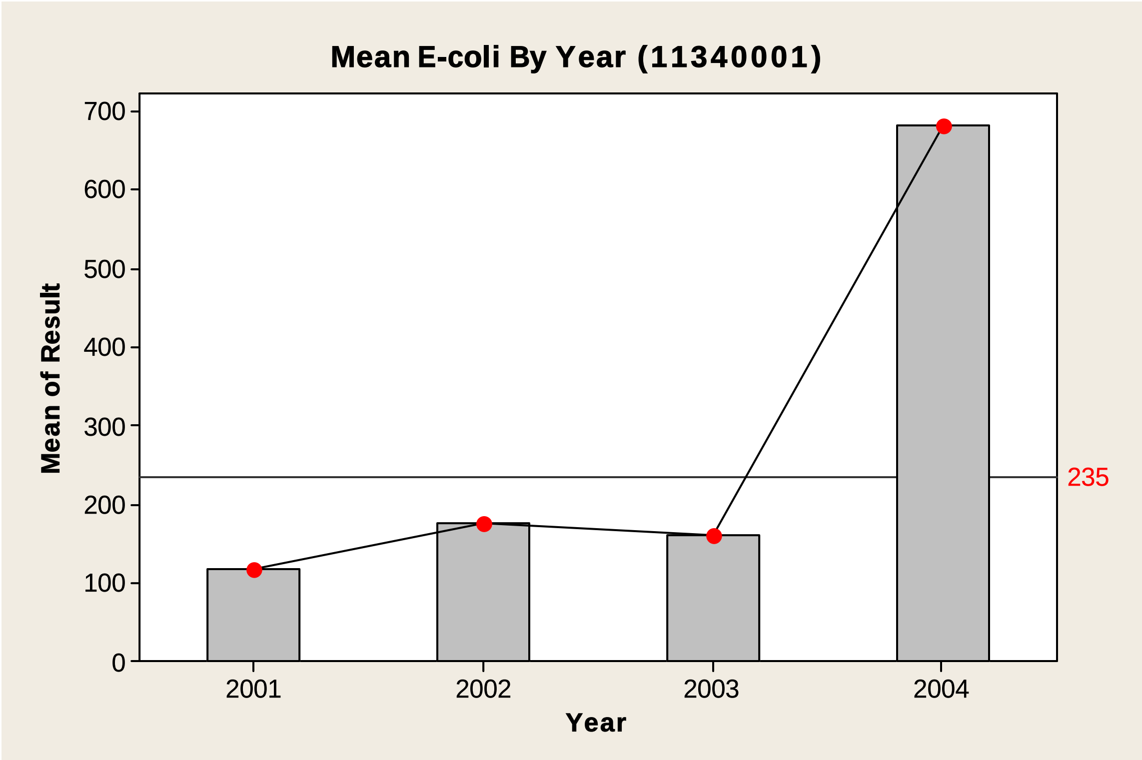

Mean E-coli By Year (11190001)
12000
10000
8000
6000
4000
2000
0
Mean of Result
235
2001
2002
2003
2004
Year

SITE 11340001

Descriptive Statistics: Result

Variable	Year	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	2001	18	117.3	118.1	10.0	19.6	60.2	205.2	358.8
	2002	22	174.7	195.3	10.0	10.0	128.2	271.5	763.6
	2003	24	161.5	272.3	9.2	20.0	79.4	169.5	1104.0
	2004	16	682	1298	9	14	101	740	4048

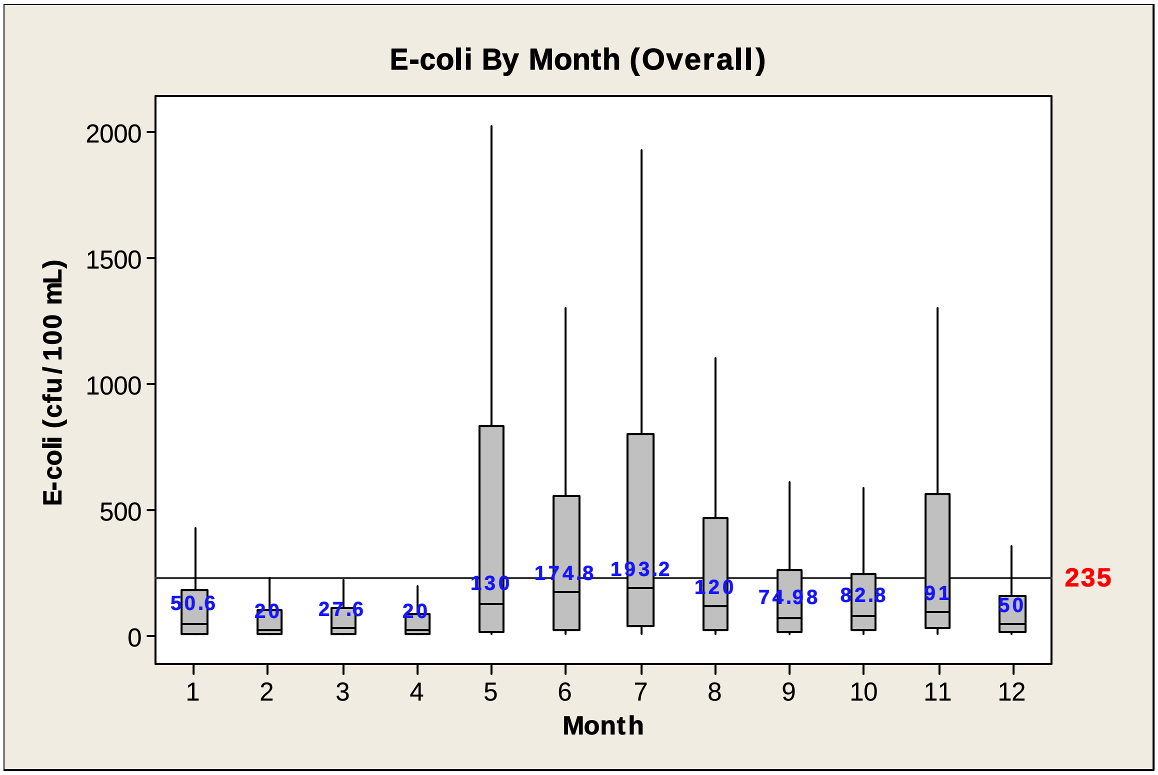


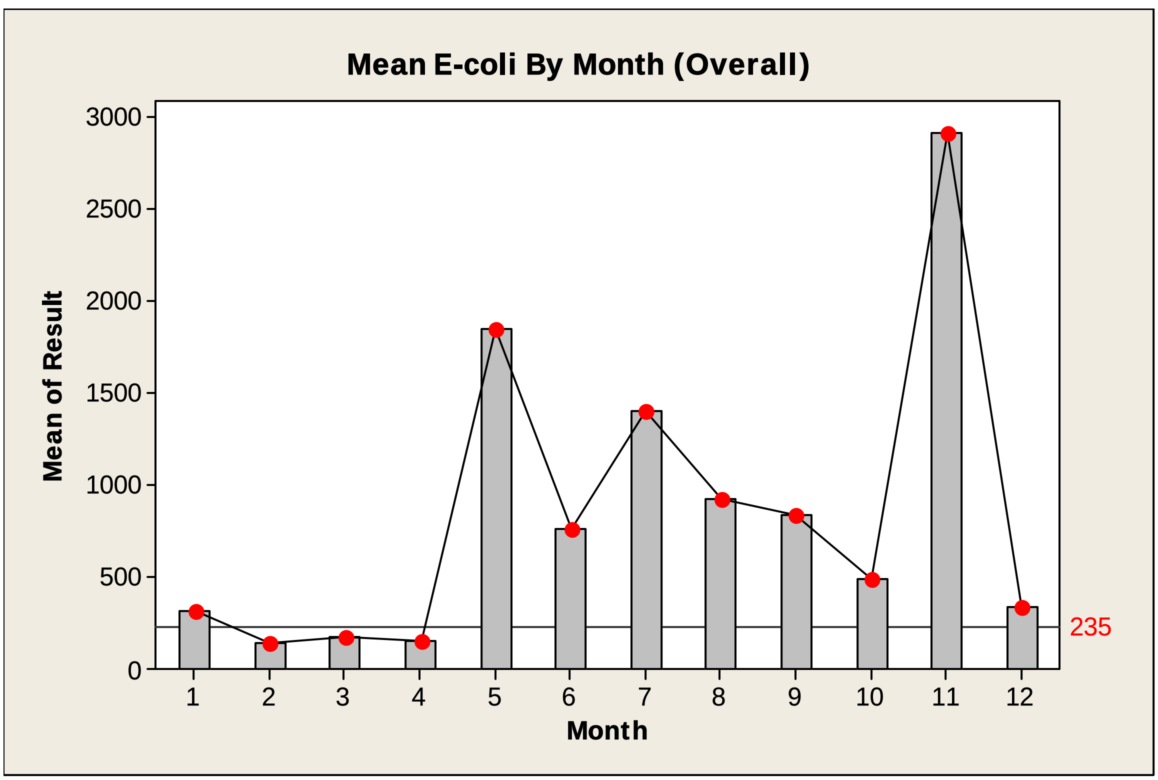


OVERALL STATISTICS BY MONTH

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	211	319.7	1403.4	9.2	10.0	50.6	180.0	14720.0
	2	200	144.4	375.0	9.2	10.0	20.0	101.2	3000.0
	3	201	175.8	458.3	9.2	10.0	27.6	110.4	3588.0
	4	330	154.1	599.5	9.2	10.0	20.0	90.0	8464.0
	5	585	1849	7842	9	18	130	837	110400
	6	751	762.9	1927.1	9.2	27.0	174.8	552.0	25760.0
	7	803	1399	4223	9	37	193	800	54280
	8	646	925	2988	9	20	120	470	36800
	9	494	834	5816	9	15	75	258	80960
	10	411	484	2523	9	20	83	248	32200
	11	265	2906	8231	9	29	91	567	47840
	12	218	340	1480	9	18	50	160	16560


E-coli By Month (Overall)
E-coli (cfu/100 mL)
2000
1500
1000
500
0
50.6
20
27.6
20
130
174.8
193.2
120
74.98
82.8
91
50
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

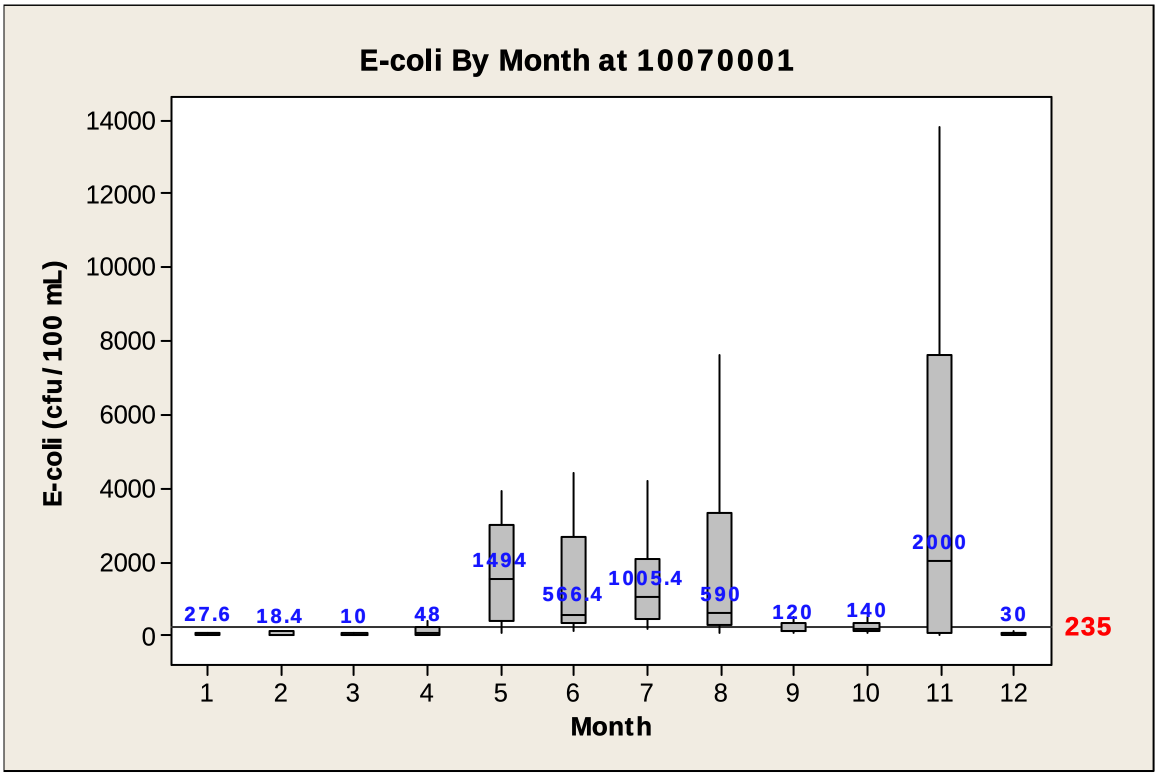

Mean E-coli By Month (Overall)
Mean of Result
3000
2500
2000
1500
1000
500
0
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

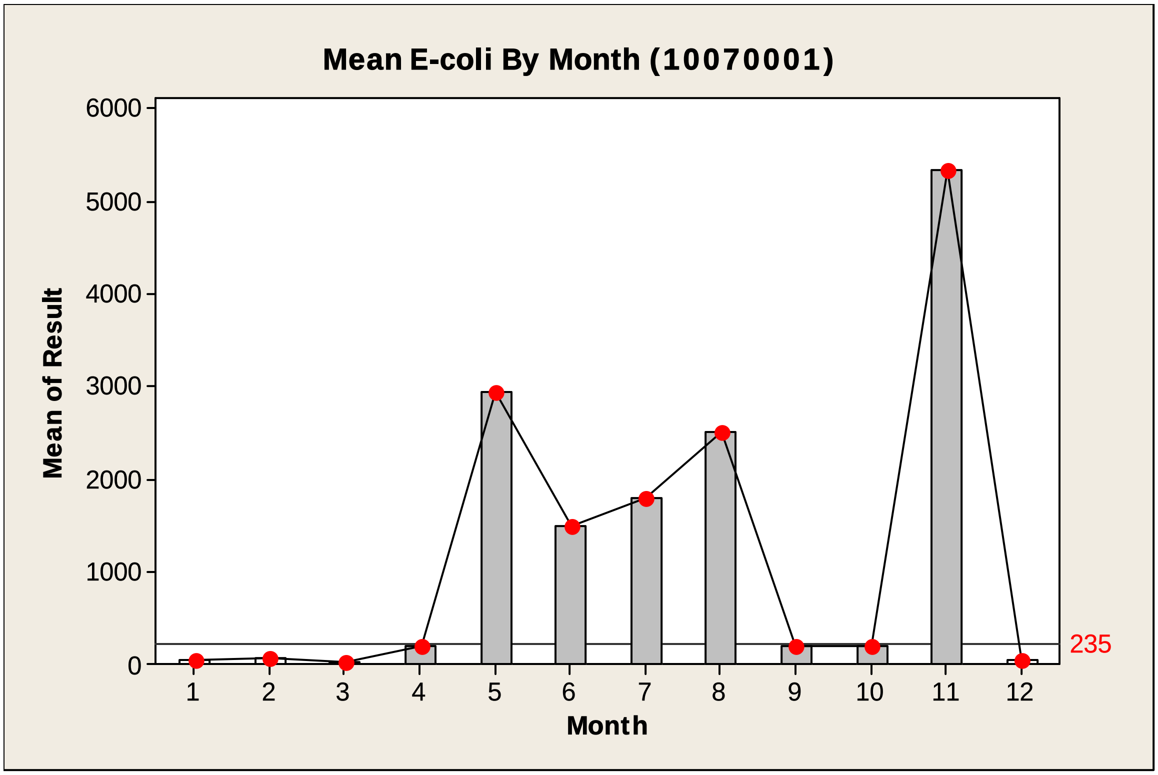
STATISTICS BY MONTH BY SITE

SITE 10070001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	48.3	71.1	10.0	18.2	27.6	48.0	280.0
	2	13	74.0	145.9	9.2	10.0	18.4	80.0	540.0
	3	12	28.10	30.72	10.00	10.00	10.00	35.10	92.00
	4	20	184.3	288.5	9.2	10.0	48.0	215.6	1012.0
	5	34	2928	4435	50	404	1494	3000	17480
	6	24	1491	1691	110	308	566	2650	6348
	7	20	1787	2131	138	421	1005	2058	7360
	8	19	2498	3163	50	290	590	3312	8500
	9	11	197.2	142.9	74.5	110.0	120.0	330.0	490.0
	10	13	199.3	141.3	46.0	82.0	140.0	315.0	460.0
	11	19	5334	7574	10	40	2000	7636	23920
	12	13	41.99	34.39	10.00	10.00	30.00	65.94	119.60

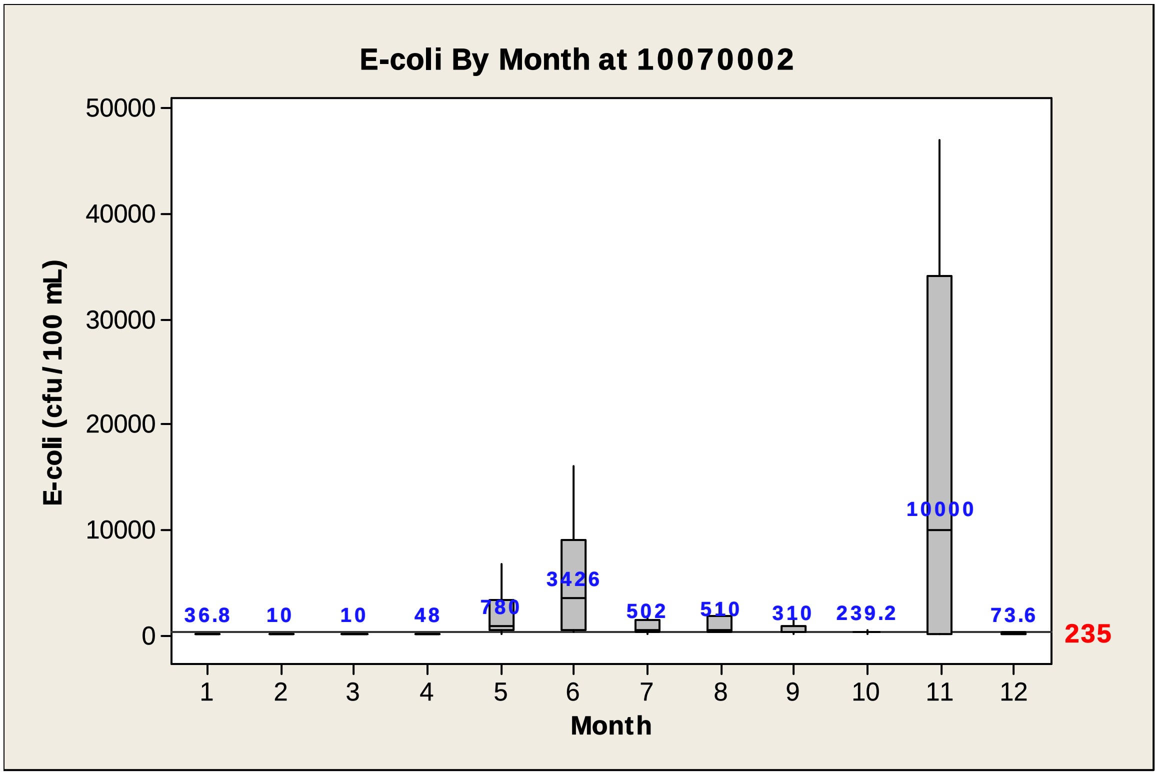


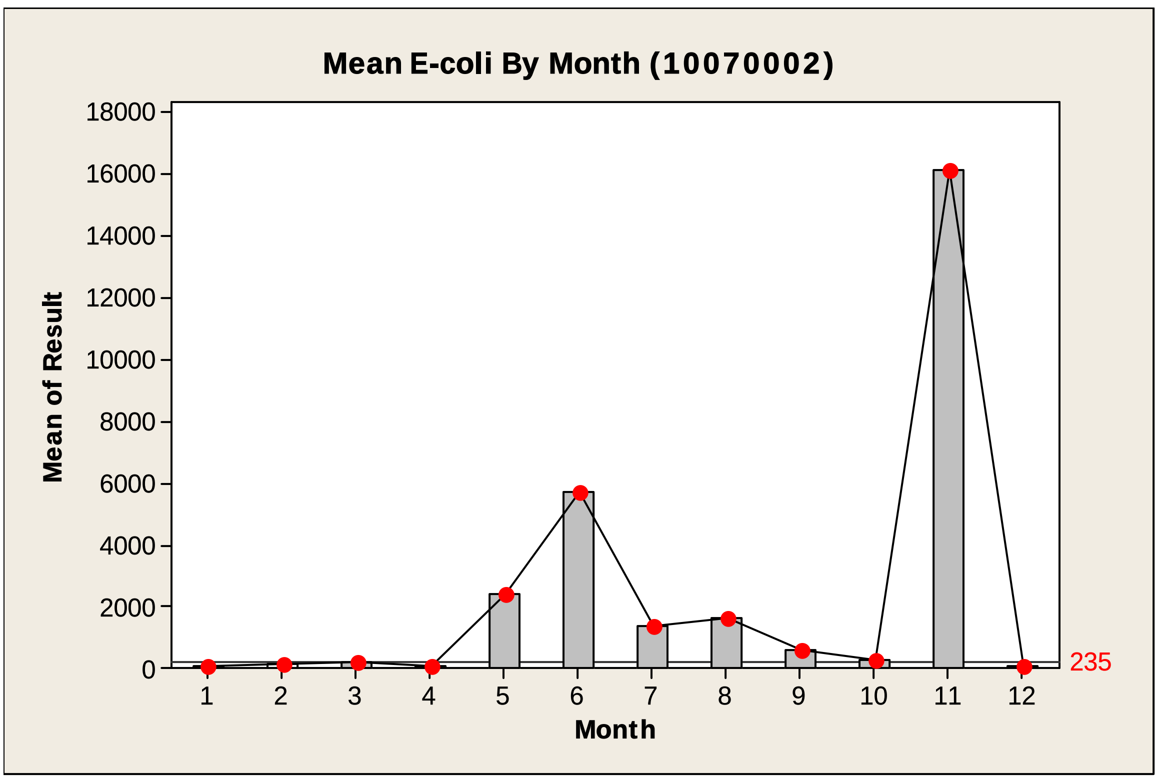


SITE 10070002

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	68.5	88.8	9.2	14.0	36.8	87.0	266.8
	2	13	107.0	300.1	9.2	10.0	10.0	51.0	1100.0
	3	14	208	480	9	10	10	50	1380
	4	12	44.87	23.49	10.00	27.75	48.00	59.72	92.00
	5	35	2400	3150	9	400	780	3220	10120
	6	22	5708	6515	160	500	3426	8943	25760
	7	12	1380	2082	120	255	502	1430	6072
	8	13	1630	2817	138	305	510	1802	10120
	9	11	590	453	120	270	310	770	1472
	10	13	257.0	151.4	27.0	167.4	239.2	320.0	670.0
	11	21	16151	17151	9	130	10000	33980	47000
	12	13	88.5	81.7	10.0	18.5	73.6	173.2	250.0

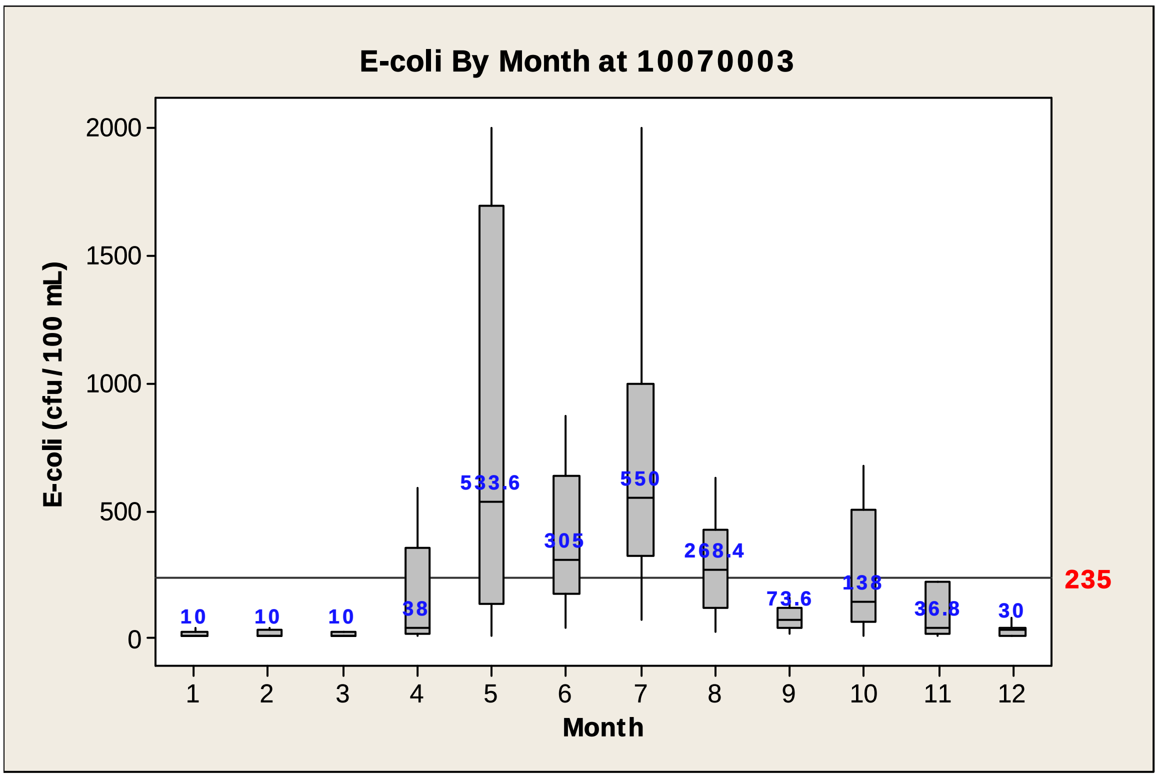

E-coli By Month at 10070002
E-coli (cfu/100 mL)
50000
40000
30000
20000
10000
0
36.8
10
10
48
780
3426
502
510
310
239.2
10000
73.6
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

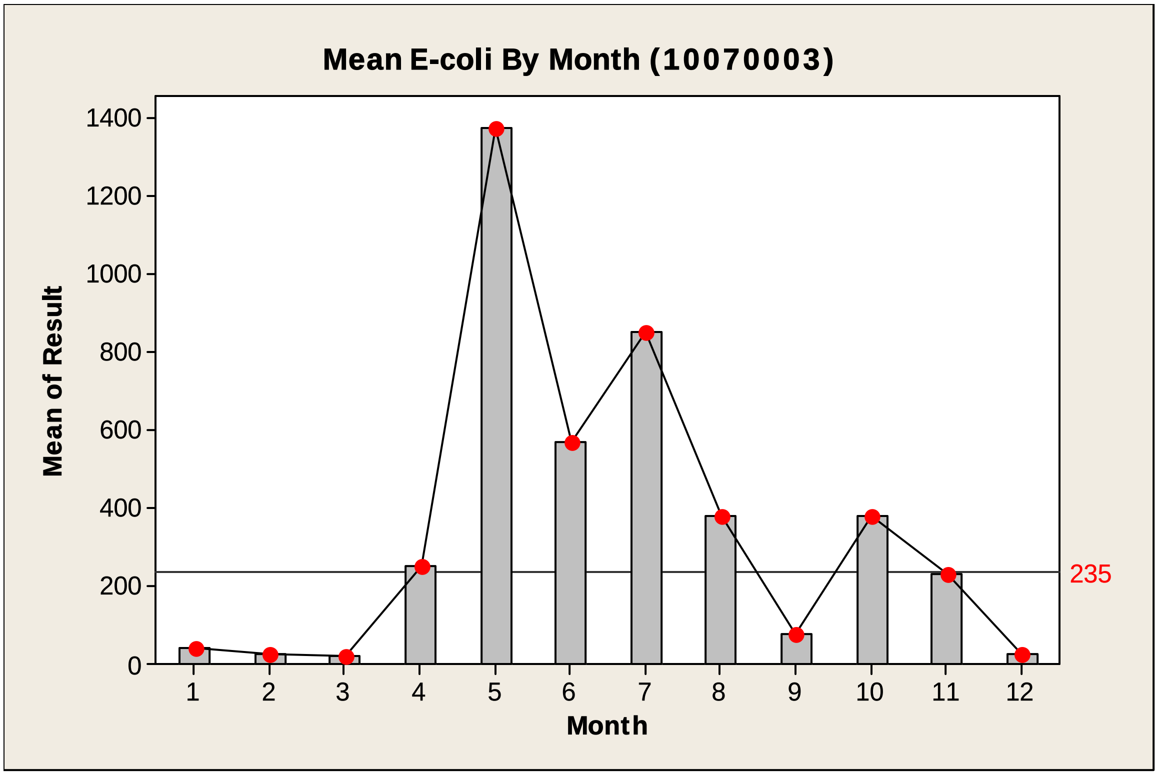

Mean E-coli By Month (10070002)
Mean of Result
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

SITE 10070003

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	42.8	95.8	10.0	10.0	10.0	23.8	360.0
	2	13	27.2	38.3	10.0	10.0	10.0	28.4	150.0
	3	12	20.67	21.56	9.20	10.00	10.00	19.60	75.44
	4	20	250.7	382.2	10.0	18.1	38.0	349.6	1300.0
	5	34	1371	2042	10	133	534	1692	8000
	6	18	566	708	37	173	305	639	2500
	7	31	851	808	67	322	550	1000	3400
	8	16	378	429	20	120	268	423	1500
	9	11	75.1	47.7	18.4	41.4	73.6	120.0	160.0
	10	27	376.4	490.0	9.2	58.9	138.0	506.0	1656.0
	11	13	229	415	10	15	37	216	1196
	12	13	28.14	19.58	9.20	10.00	30.00	38.40	80.00

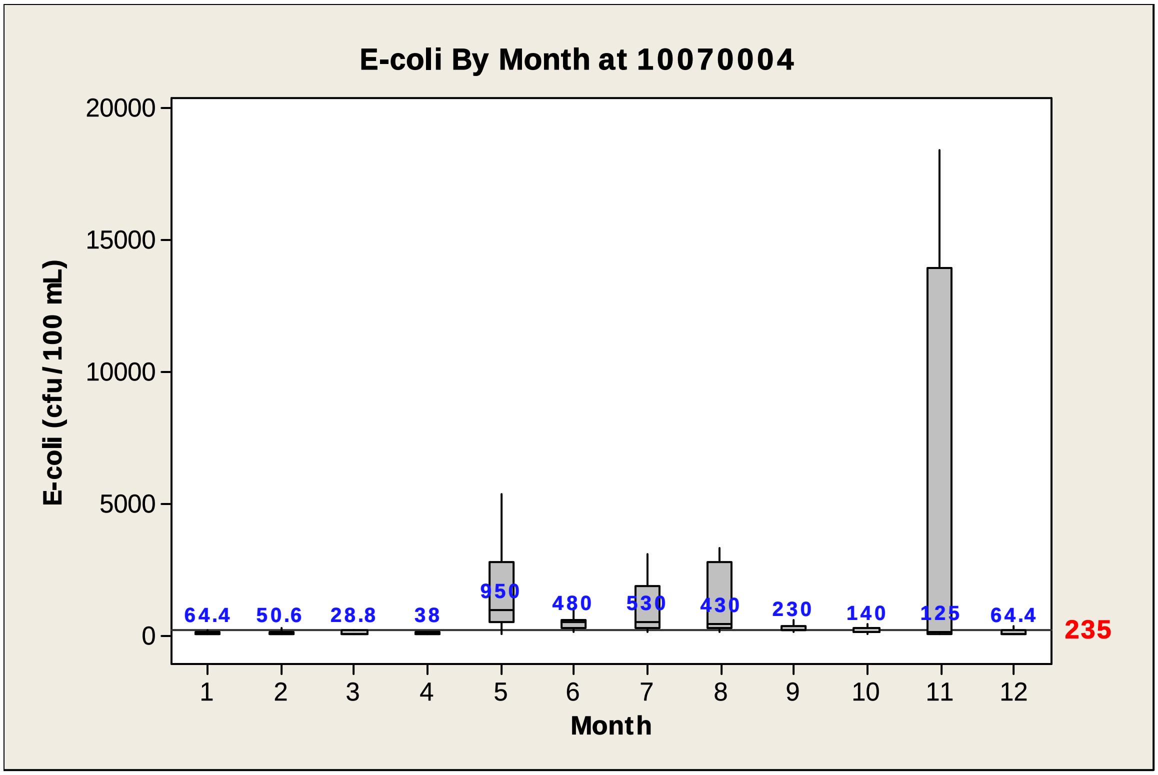


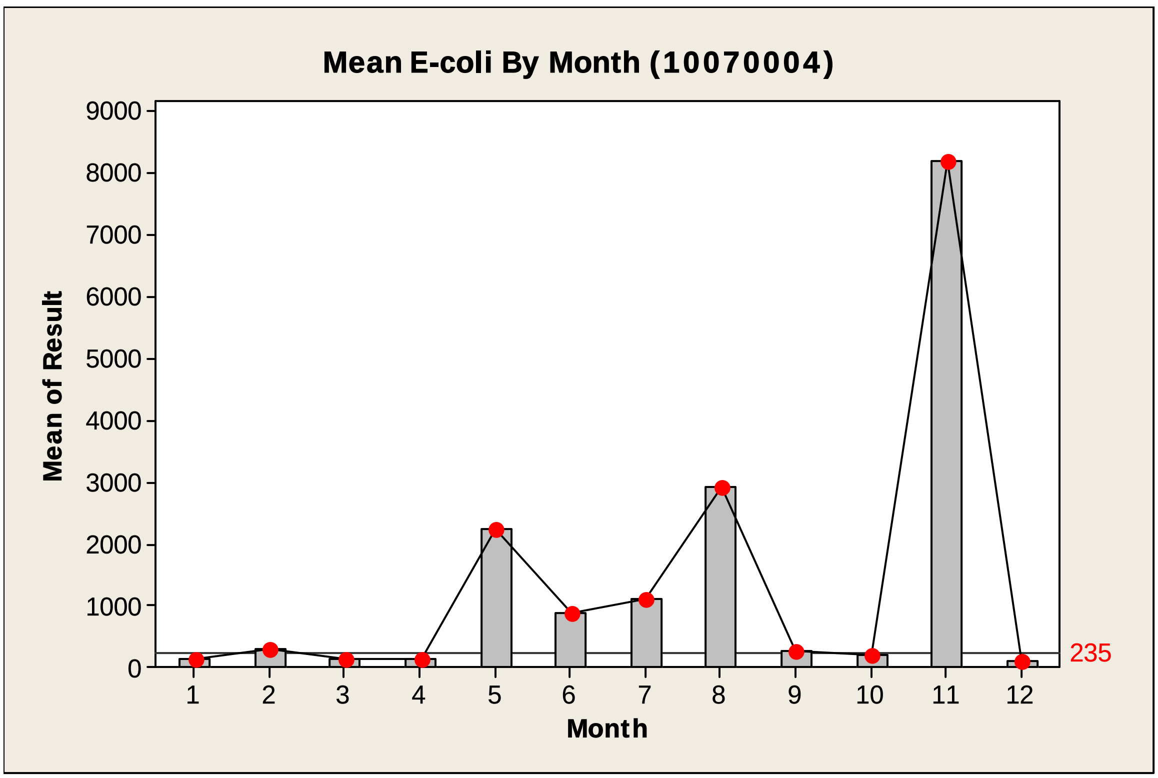


SITE 10070004

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	133.6	236.2	9.2	10.0	64.4	147.4	890.0
	2	13	291	816	10	19	51	115	3000
	3	14	136.2	217.1	9.2	10.0	28.8	197.4	690.0
	4	18	139.4	236.8	9.2	16.3	38.0	140.0	930.0
	5	40	2250	2897	59	480	950	2802	11040
	6	19	876	1279	140	240	480	590	5500
	7	23	1114	1385	110	300	530	1840	6164
	8	28	2922	5480	100	305	430	2800	23000
	9	23	263.8	122.2	119.6	170.0	230.0	360.0	580.0
	10	23	183.5	115.4	64.4	99.0	140.0	248.4	420.0
	11	20	8176	14015	18	65	125	13950	47840
	12	13	103.2	92.2	9.2	33.4	64.4	177.0	322.0

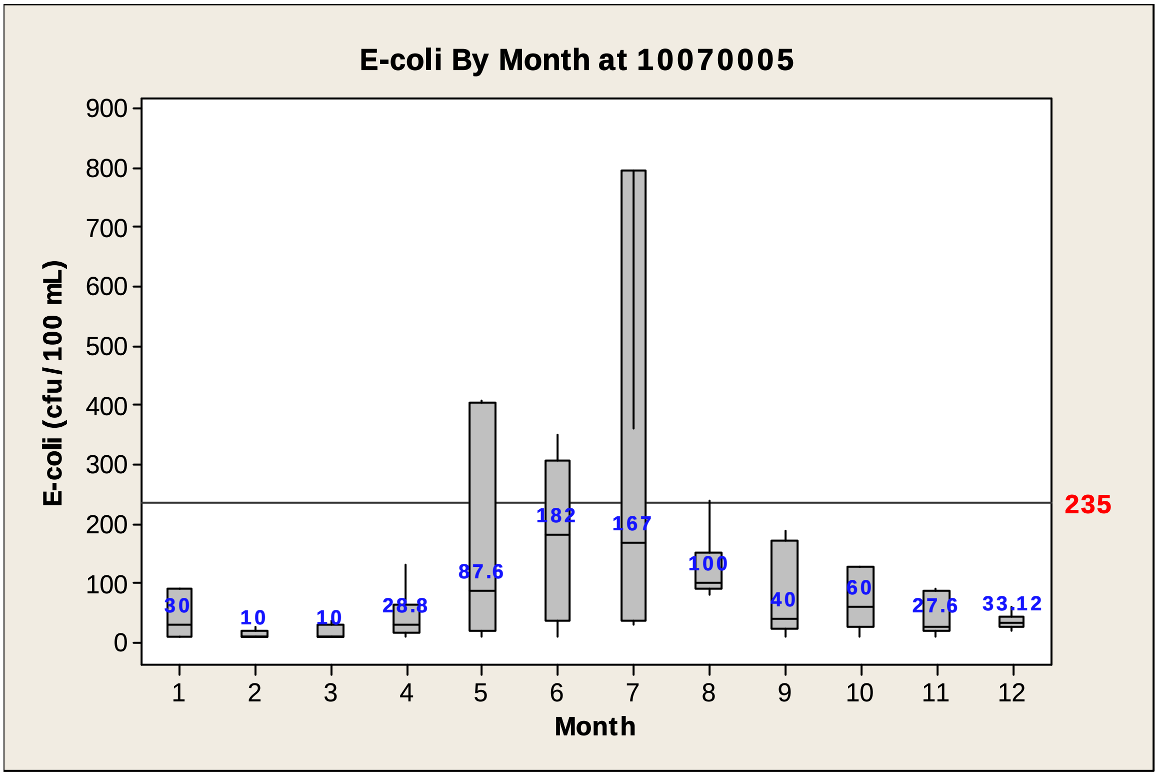

E-coli By Month at 10070004
E-coli (cfu/100 mL)
20000
15000
10000
5000
0
64.4
50.6
28.8
38
950
480
530
430
230
140
125
64.4
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

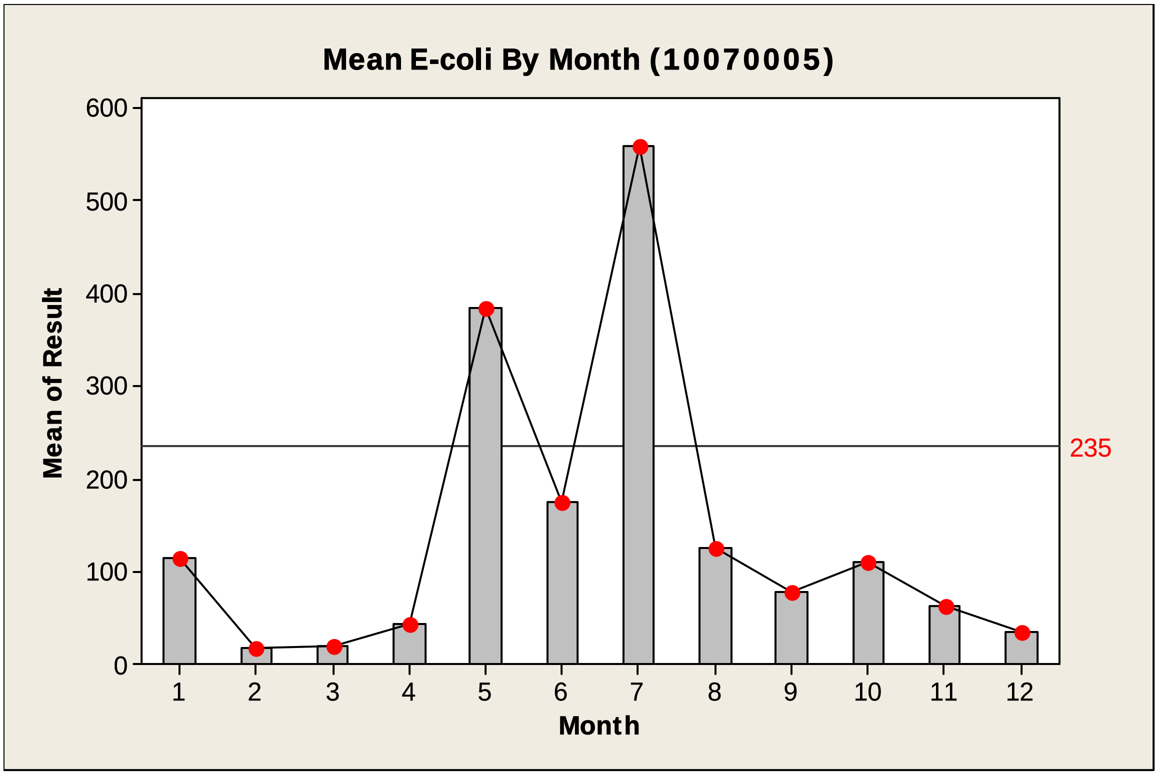

Mean E-coli By Month (10070004)
Mean of Result
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

SITE 10070005

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	11	113.5	192.8	10.0	10.0	30.0	92.0	640.0
	2	11	16.80	15.38	9.20	10.00	10.00	18.00	60.00
	3	10	18.36	11.20	9.20	10.00	10.00	30.00	36.80
	4	10	43.6	37.4	10.0	17.5	28.8	63.4	130.0
	5	12	385	601	10	19	88	404	1700
	6	10	174.0	134.2	9.2	36.3	182.0	305.5	350.0
	7	10	560	876	30	35	167	799	2300
	8	9	125.0	52.9	80.0	91.0	100.0	152.0	240.0
	9	9	78.7	75.6	10.0	24.2	40.0	172.0	190.0
	10	11	110.4	127.9	9.2	27.0	60.0	128.8	414.0
	11	13	62.5	67.4	10.0	19.0	27.6	85.5	210.0
	12	11	35.59	10.96	20.00	27.60	33.12	41.40	60.00

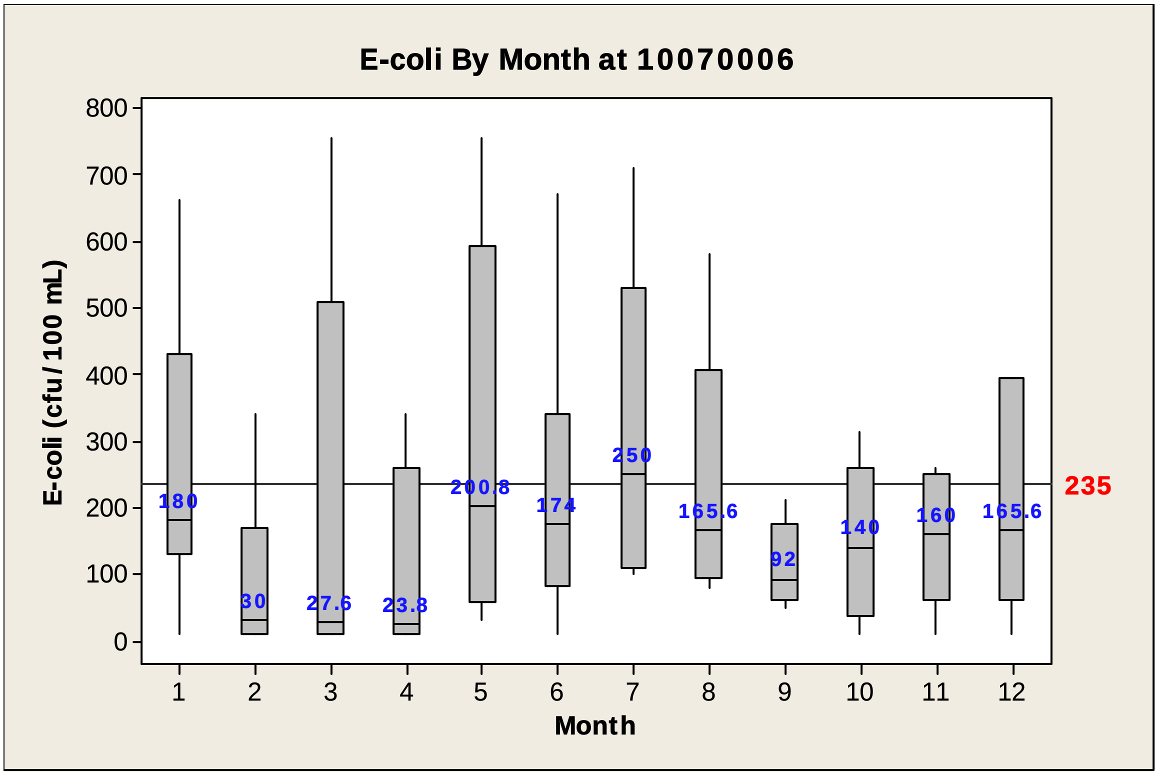


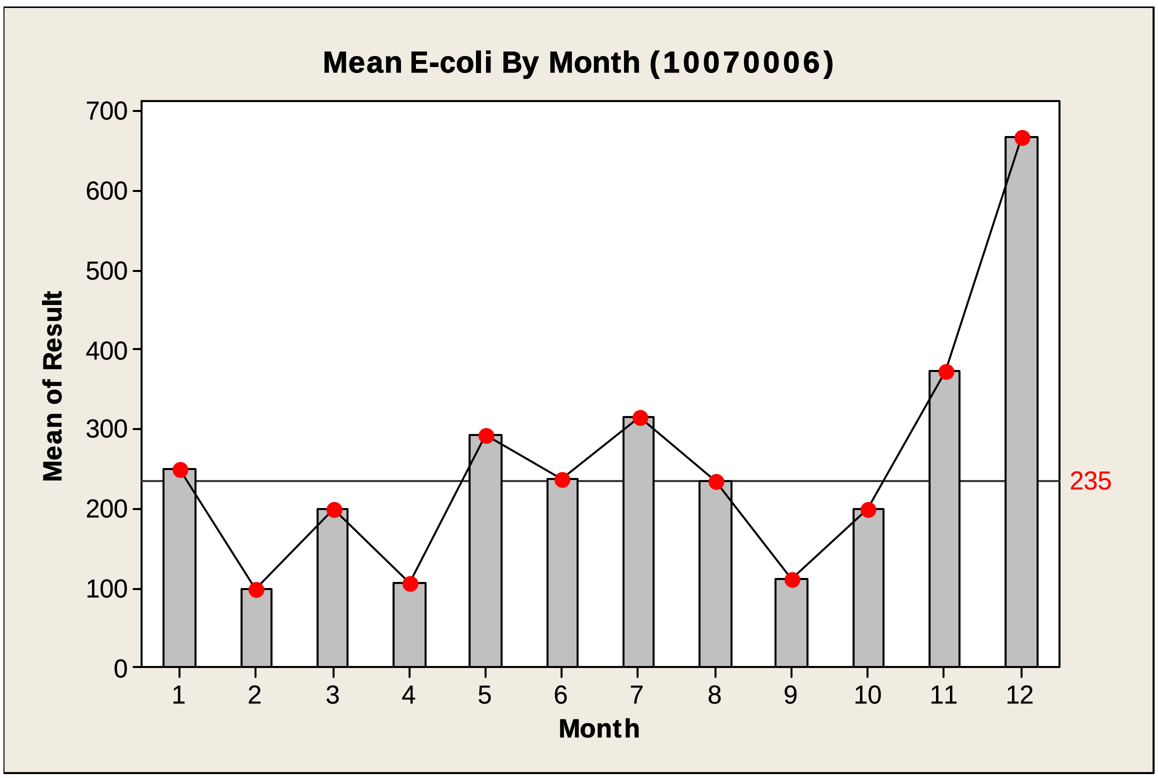


SITE 10070006

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	11	248.8	203.4	10.0	130.0	180.0	430.0	662.4
	2	11	97.4	107.4	10.0	10.0	30.0	170.0	340.0
	3	10	197.9	295.6	9.2	10.0	27.6	507.5	754.4
	4	10	107.0	135.9	10.0	10.0	23.8	258.2	340.0
	5	12	293.5	271.5	30.0	58.0	200.8	592.6	754.4
	6	10	236.6	233.9	10.0	81.9	174.0	339.4	671.6
	7	10	314.8	231.2	101.2	110.0	250.0	530.0	708.4
	8	9	233.8	193.7	80.0	95.0	165.6	406.8	580.0
	9	9	111.2	60.6	50.0	59.5	92.0	173.6	210.0
	10	11	198.3	230.9	10.0	36.8	140.0	257.6	820.0
	11	13	372	584	10	62	160	249	1748
	12	11	669	1178	10	60	166	396	3496

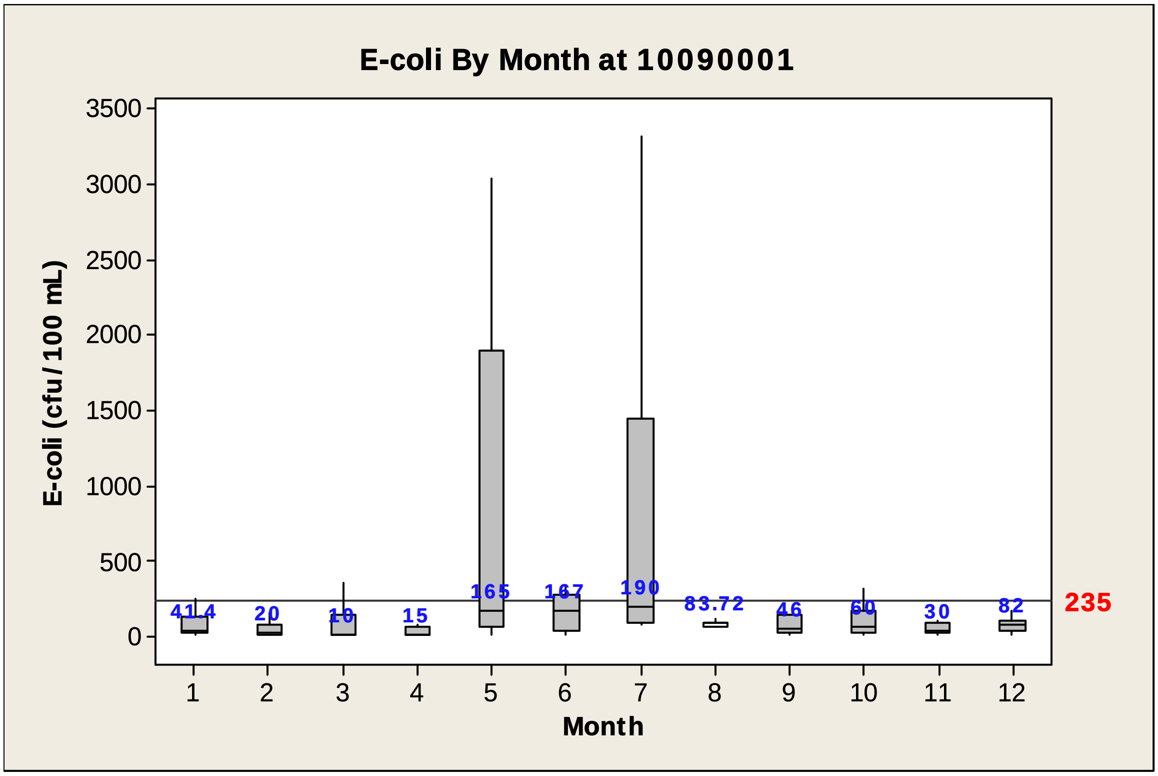

E-coli By Month at 10070006
E-coli (cfu/ 100 mL)
800
700
600
500
400
300
200
100
0
180
30
27.6
23.8
200.8
174
250
165.6
92
140
160
165.6
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

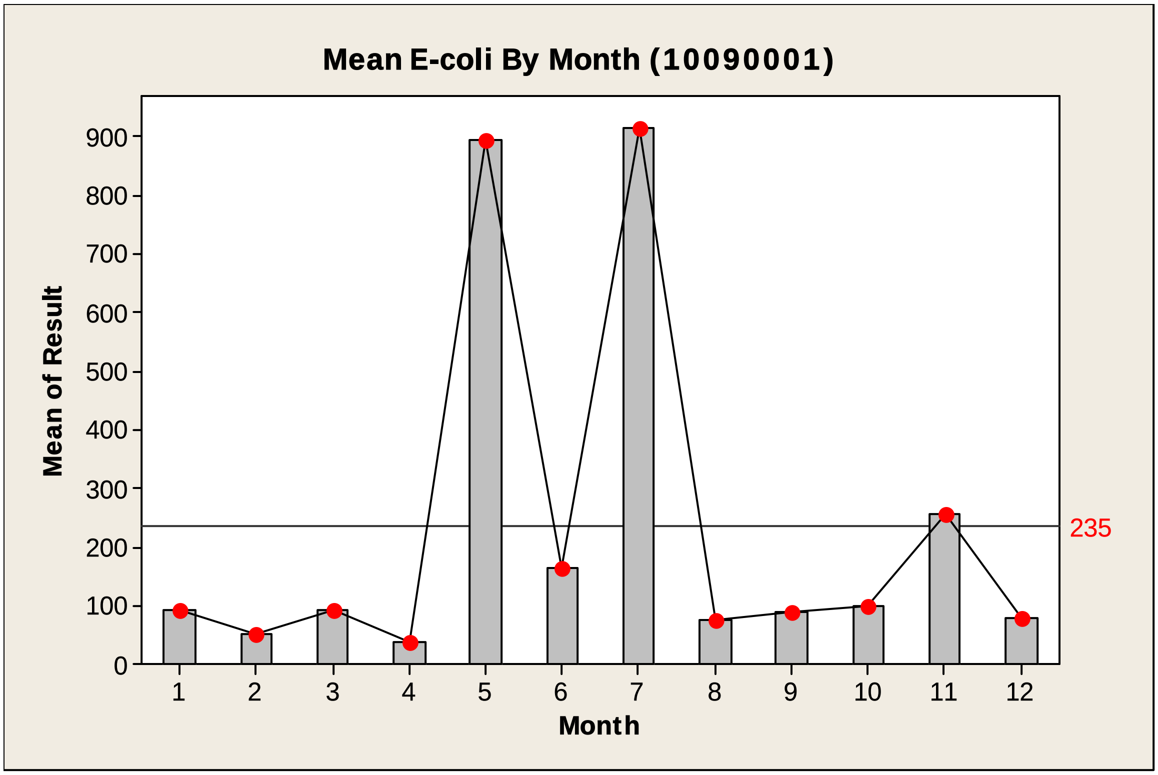

Mean E-coli By Month (10070006)
Mean of Result
700
600
500
400
300
200
100
0
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

SITE 10090001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	91.5	105.2	10.0	18.3	41.4	125.6	360.0
	2	13	49.5	47.5	9.2	10.0	20.0	79.6	150.0
	3	12	91.5	126.4	9.2	10.0	10.0	147.2	349.6
	4	12	38.0	47.4	9.2	10.0	15.0	58.0	170.0
	5	12	895	1197	10	66	165	1899	3036
	6	12	162.5	116.7	10.0	36.0	167.0	279.0	322.0
	7	12	914	1282	83	96	190	1447	3600
	8	11	76.0	38.5	9.2	60.0	83.7	91.1	138.0
	9	11	88.3	88.2	10.0	27.0	46.0	140.0	310.0
	10	13	98.6	96.1	9.2	27.2	60.0	164.8	312.8
	11	13	256	529	10	24	30	96	1656
	12	13	78.5	46.4	10.0	40.0	82.0	105.0	174.8

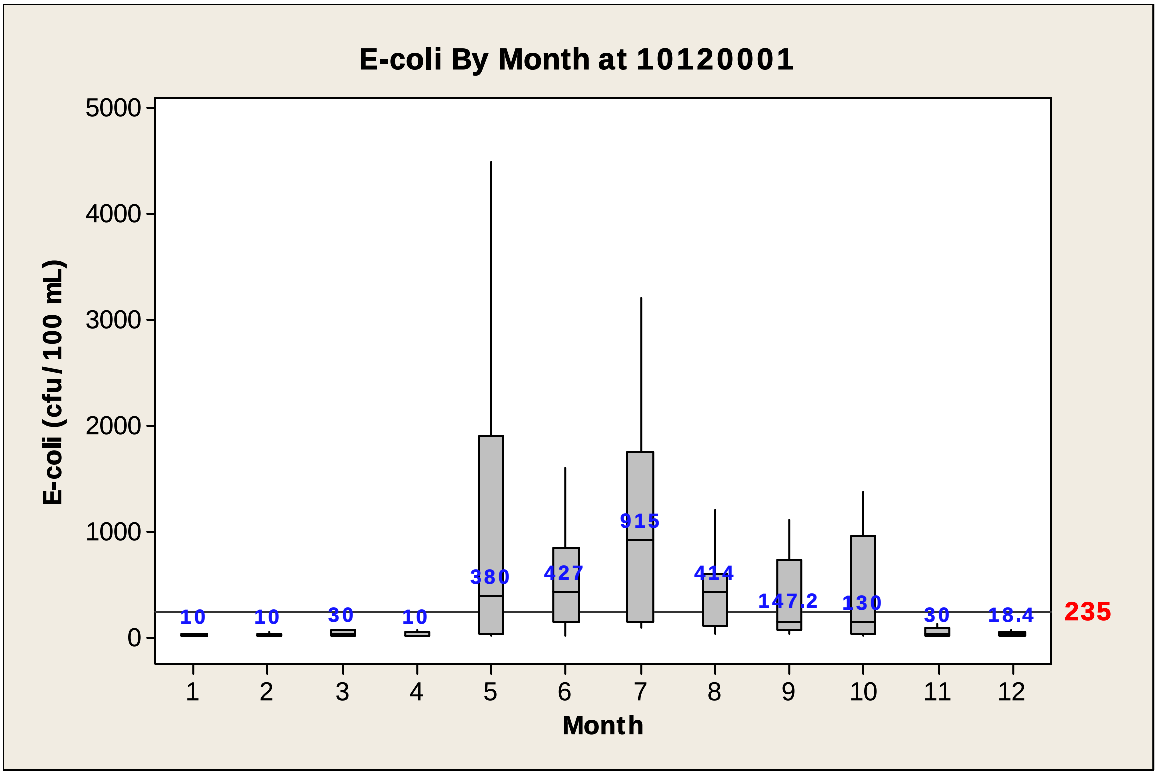


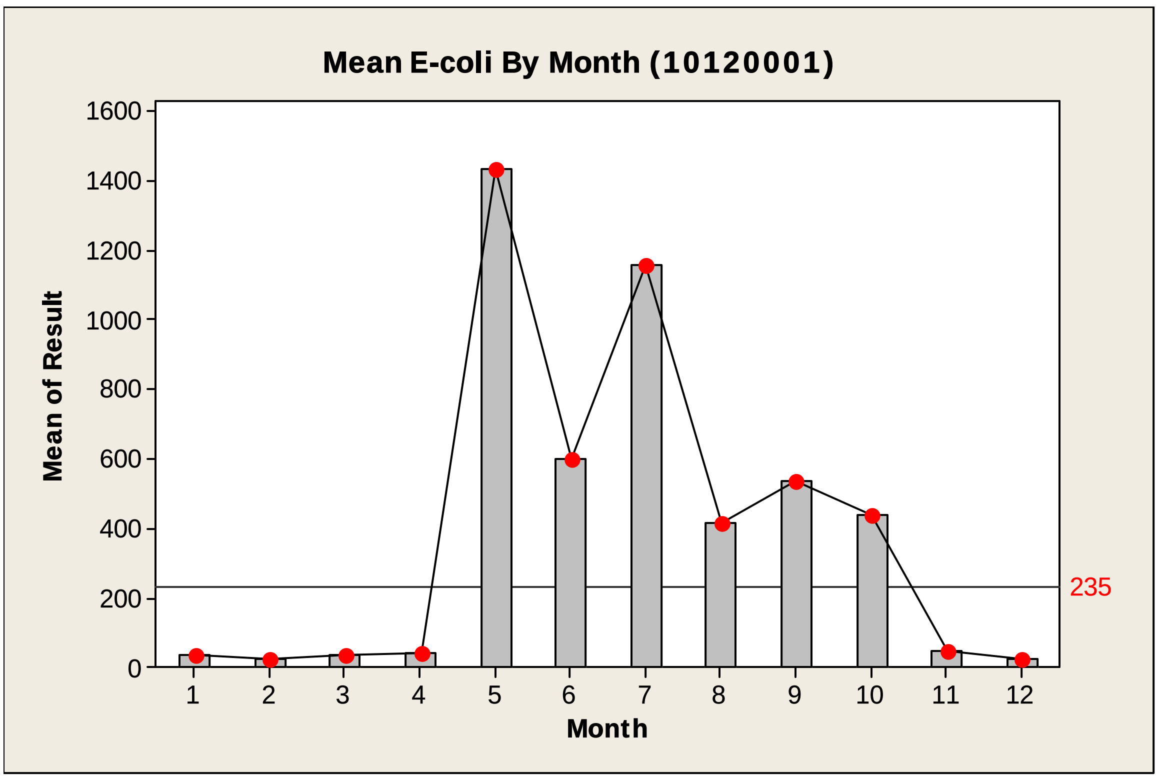


SITE 10120001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	35.7	79.6	9.2	9.6	10.0	20.0	300.0
	2	13	21.17	20.33	9.20	10.00	10.00	28.80	80.00
	3	12	32.90	23.75	9.20	10.00	30.00	53.90	70.00
	4	14	39.8	64.0	9.2	10.0	10.0	37.5	239.2
	5	34	1431	2378	9	26	380	1908	9200
	6	30	600	566	10	138	427	840	2100
	7	22	1154	968	90	143	915	1748	3220
	8	15	417.0	353.2	20.0	99.0	414.0	600.0	1196.0
	9	19	535	692	20	60	147	730	2300
	10	21	437	507	9	24	130	960	1380
	11	13	44.9	40.5	9.2	10.0	30.0	76.8	120.0
	12	13	24.24	17.92	10.00	10.00	18.40	34.56	70.00

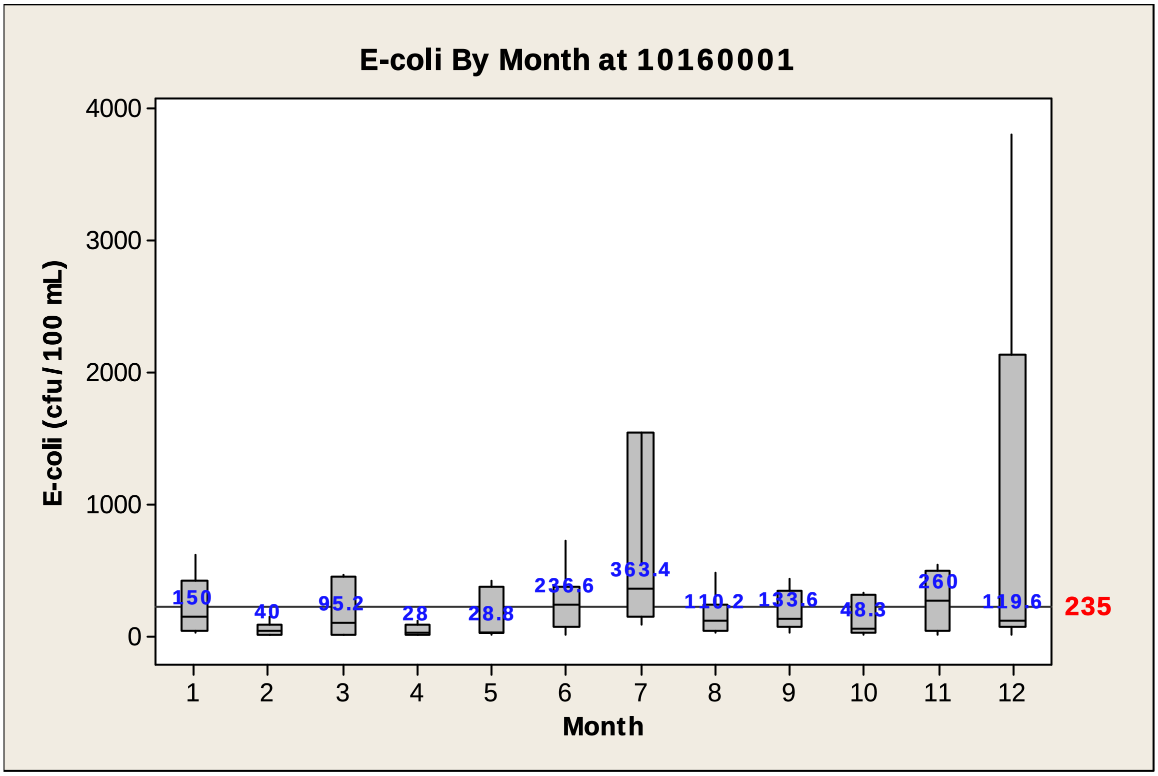

E-coli By Month at 10120001
E-coli (cfu/100 mL)
5000
4000
3000
2000
1000
0
10
10
30
10
380
427
915
414
147.2
130
30
18.4
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

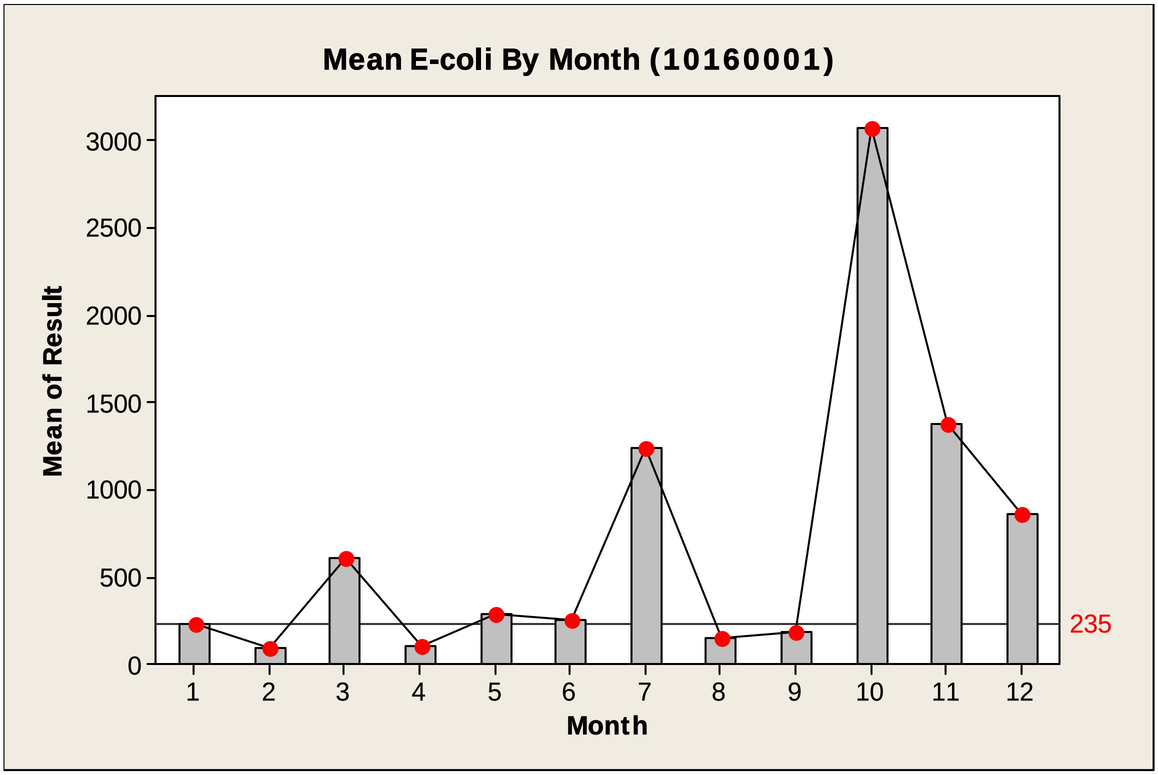

Mean E-coli By Month (10120001)
Mean of Result
1600
1400
1200
1000
800
600
400
200
0
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

SITE 10160001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	12	224.5	206.5	20.0	42.7	150.0	415.0	620.0
	2	12	95.2	179.7	9.2	10.0	40.0	87.4	650.0
	3	12	606	1154	9	10	95	445	3588
	4	12	104.0	234.3	10.0	10.0	28.0	81.5	840.0
	5	12	284	570	10	19	29	367	2024
	6	12	252.9	210.2	9.2	74.8	236.6	375.0	717.6
	7	14	1238	1886	92	153	363	1538	5000
	8	10	149.5	135.9	30.0	44.5	110.2	230.0	480.0
	9	10	183.2	149.7	18.4	73.3	133.6	341.2	430.0
	10	12	3072	7292	9	20	48	315	23000
	11	12	1372	2838	10	34	260	492	8832
	12	12	854	1406	10	68	120	2135	3800

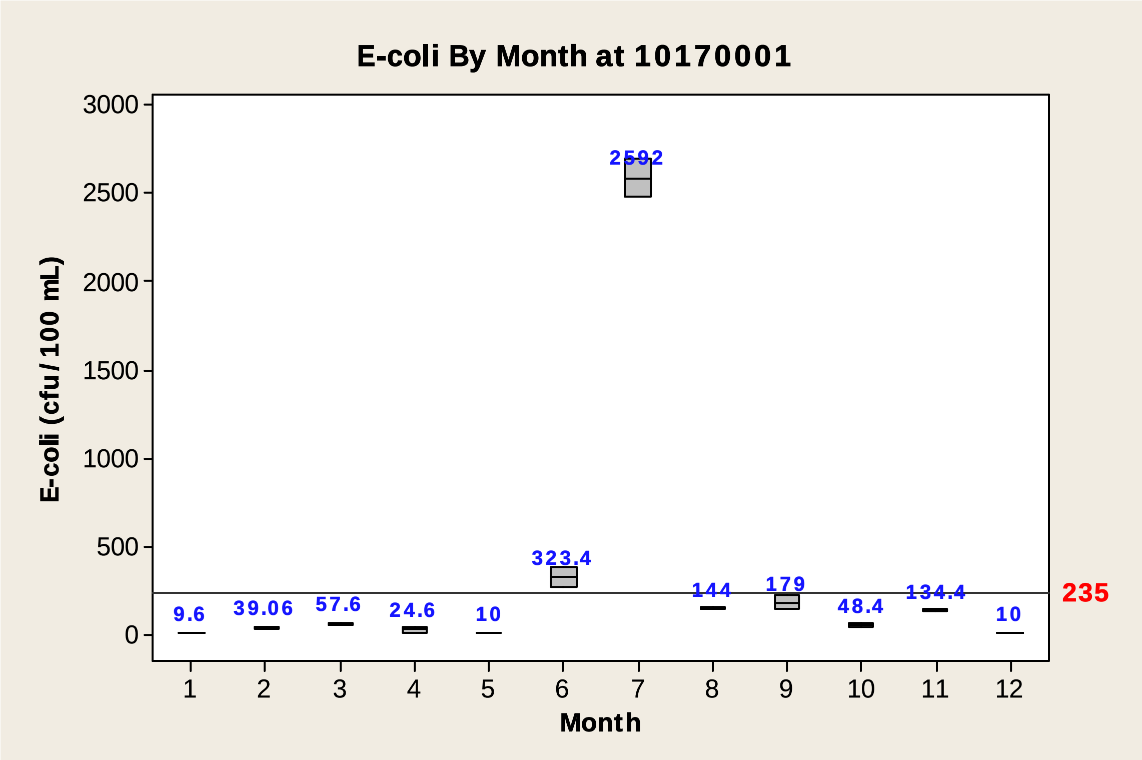


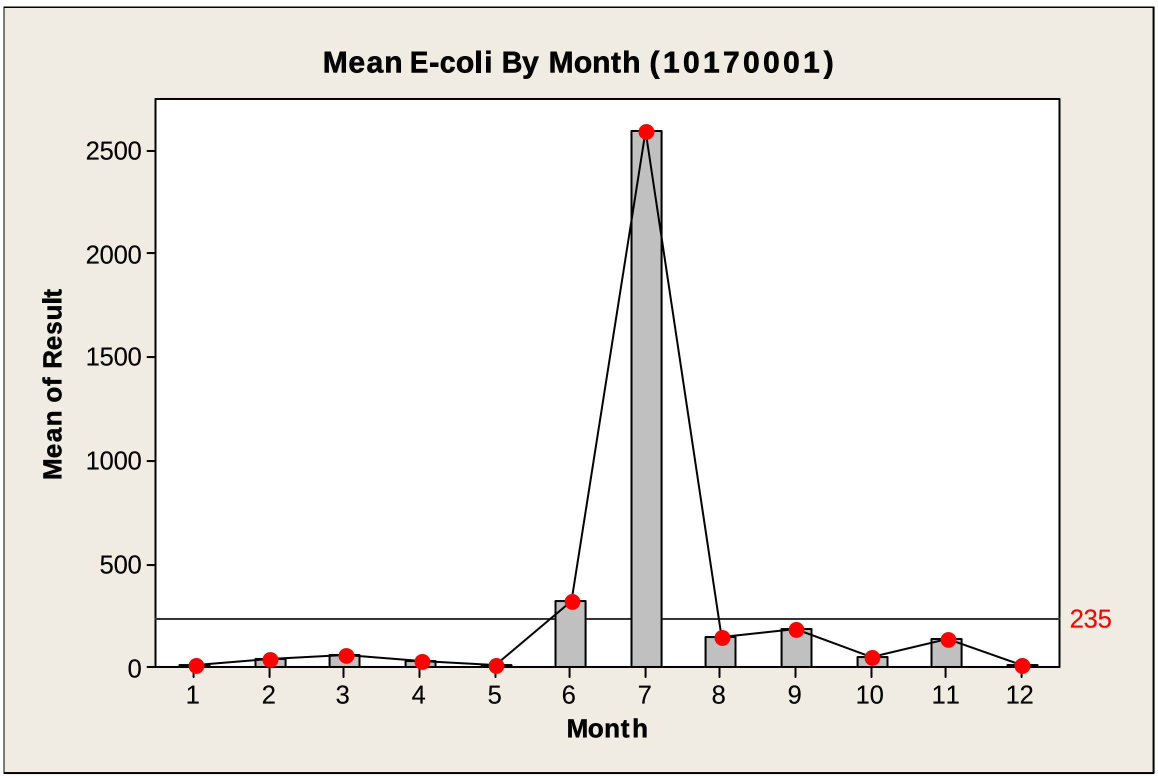


SITE 10170001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	2	9.600	0.566	9.200	*	9.600	*	10.000
	2	2	39.06	8.40	33.12	*	39.06	*	45.00
	3	2	57.60	3.39	55.20	*	57.60	*	60.00
	4	2	24.6	21.8	9.2	*	24.6	*	40.0
	5	2	10.000	0.000000	10.000	*	10.000	*	10.000
	6	2	323.4	80.0	266.8	*	323.4	*	380.0
	7	2	2592	153	2484	*	2592	*	2700
	8	2	144.00	8.49	138.00	*	144.00	*	150.00
	9	2	179.0	58.0	138.0	*	179.0	*	220.0
	10	2	48.4	16.4	36.8	*	48.4	*	60.0
	11	2	134.40	7.92	128.80	*	134.40	*	140.00
	12	2	10.000	0.000000	10.000	*	10.000	*	10.000

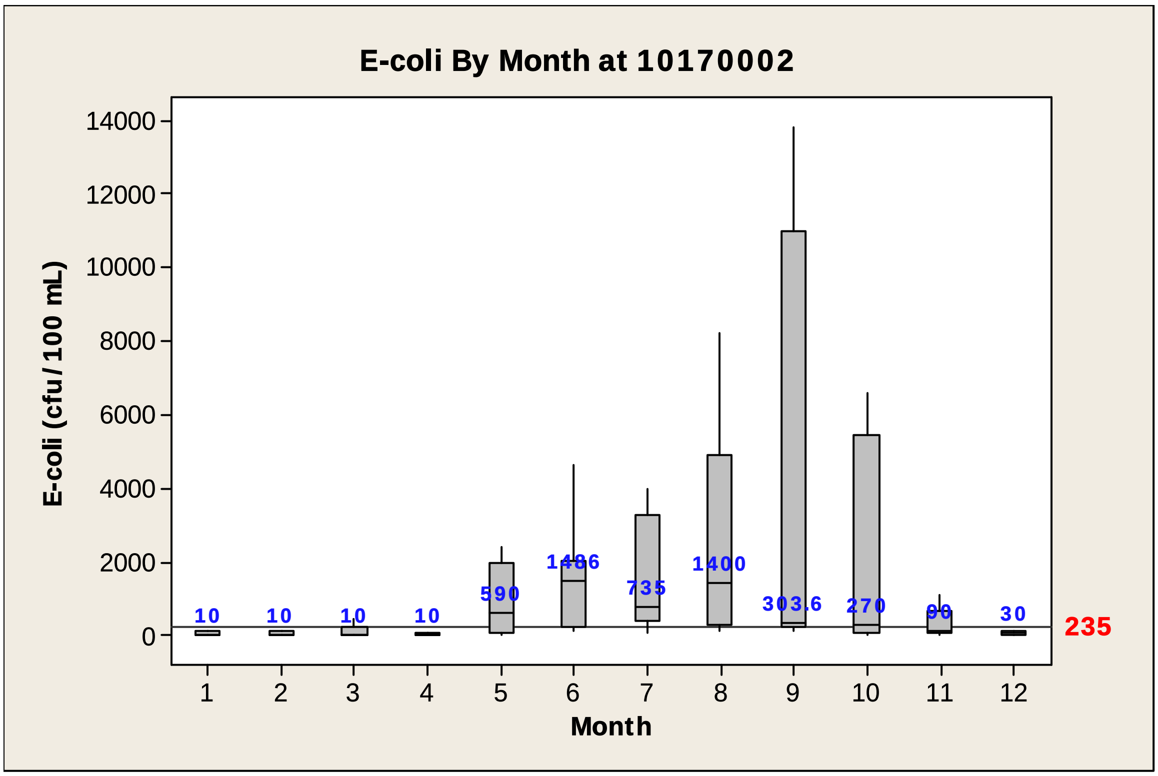

E-coli By Month at 10170001
E-coli (cfu/100 mL)
3000
2500
2000
1500
1000
500
0
2592
323.4
9.6
39.06
57.6
24.6
10
144
179
48.4
134.4
10
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

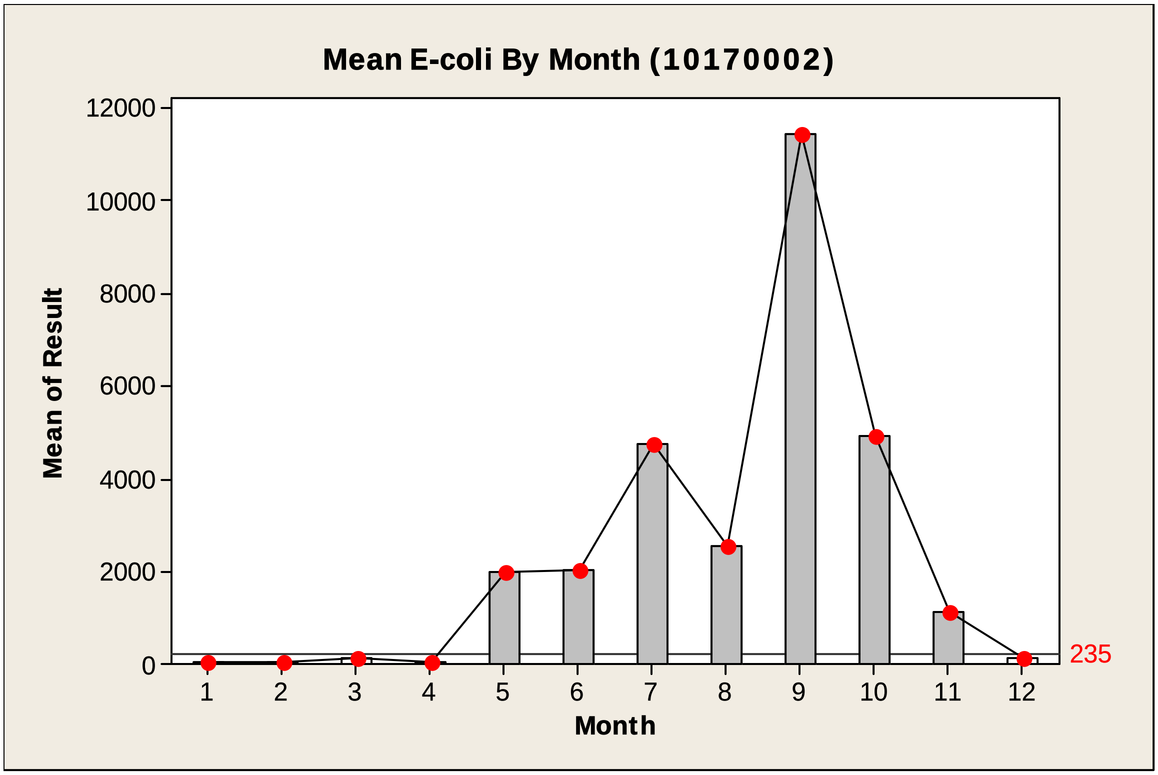

Mean E-coli By Month (10170001)
Mean of Result
2500
2000
1500
1000
500
0
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

SITE 10170002

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	11	40.0	40.0	9.2	10.0	10.0	90.0	110.0
	2	11	35.1	35.7	9.2	10.0	10.0	82.0	91.0
	3	10	122.6	187.9	10.0	10.0	10.0	197.2	506.0
	4	10	22.44	21.73	9.20	9.80	10.00	41.50	70.00
	5	22	1993	3560	10	54	590	1978	13800
	6	22	2017	2667	100	203	1486	2006	11040
	7	14	4765	8870	73	355	735	3239	28520
	8	19	2532	2469	90	290	1400	4876	8188
	9	15	11445	22945	99	190	304	11000	80040
	10	17	4940	9779	9	33	270	5428	32200
	11	13	1111	2372	10	43	90	625	7360
	12	11	123.9	182.8	18.4	20.0	30.0	92.0	533.6

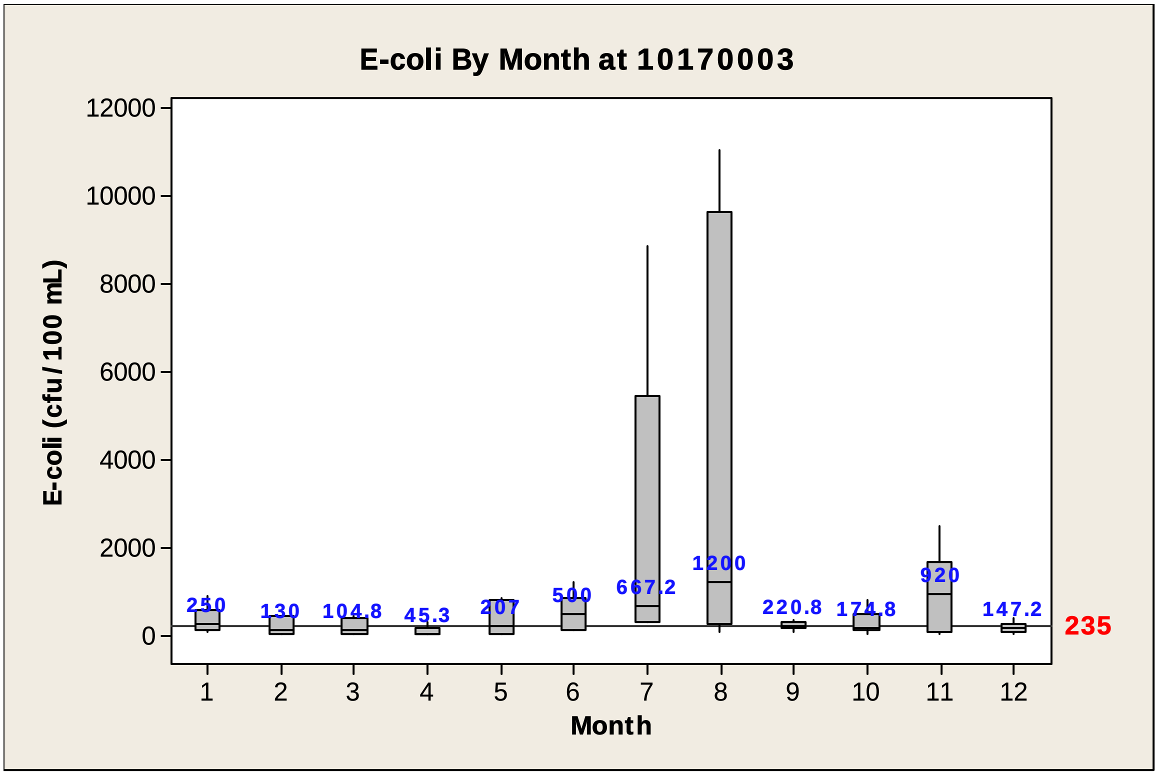


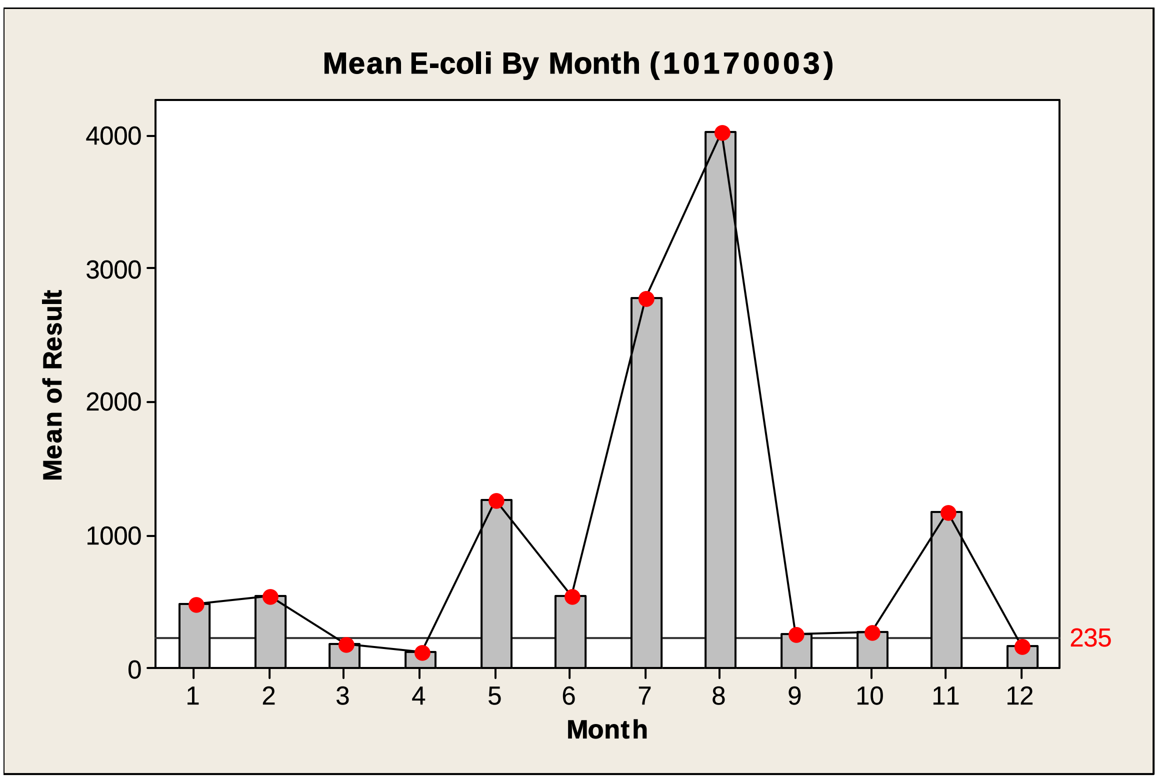


SITE 10170003

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	11	483	577	80	100	250	580	2024
	2	11	541	925	10	18	130	423	2576
	3	10	185.0	173.7	27.6	30.0	104.8	385.6	460.0
	4	10	119.8	181.2	9.2	23.2	45.3	153.8	580.0
	5	12	1256	2410	10	49	207	793	7084
	6	10	534	416	100	140	500	842	1200
	7	10	2785	3235	280	322	667	5450	8832
	8	9	4024	4709	91	252	1200	9650	11040
	9	9	251.0	132.5	90.0	165.0	220.8	308.8	540.0
	10	11	273.1	239.6	36.0	140.0	174.8	469.2	809.6
	11	13	1167	1488	20	75	920	1678	5300
	12	11	172.2	123.7	9.2	82.0	147.2	250.0	377.2

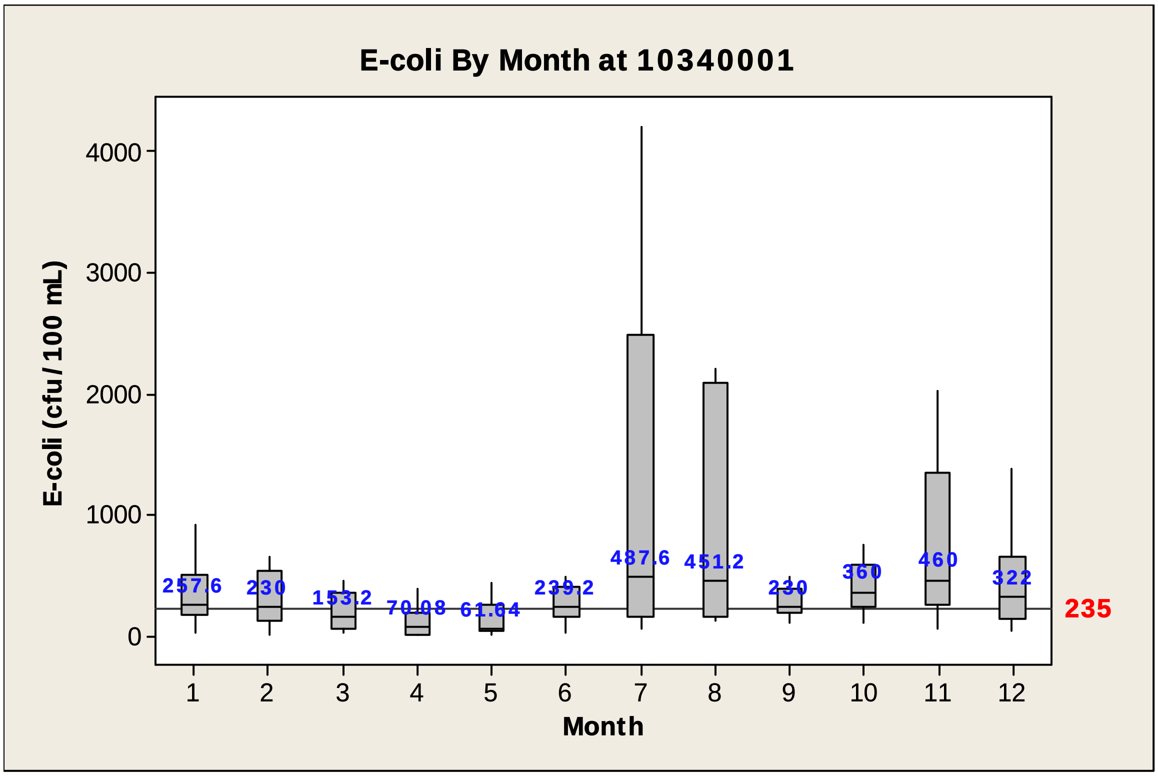

E-coli By Month at 10170003
E-coli (cfu/100 mL)
12000
10000
8000
6000
4000
2000
0
250
130
104.8
45.3
207
500
667.2
1200
220.8
171.8
920
147.2
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

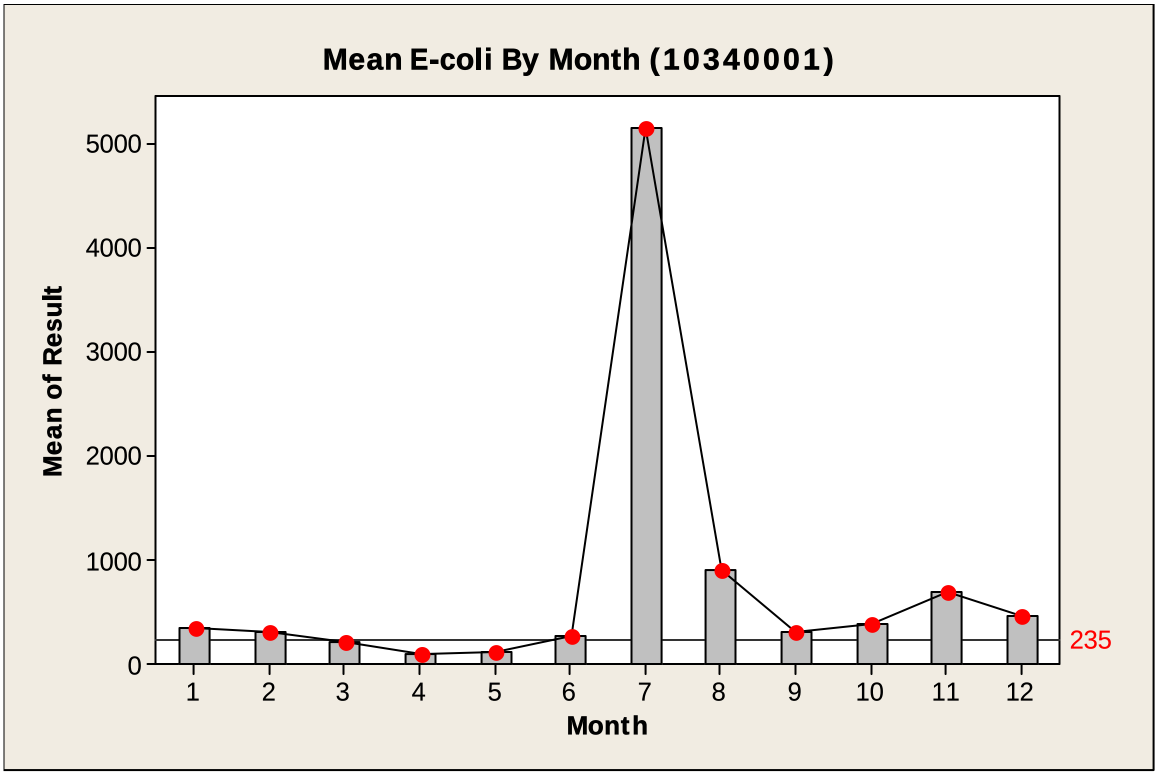

Mean E-coli By Month (10170003)
Mean of Result
4000
3000
2000
1000
0
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

SITE 10340001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	354.6	260.5	20.0	175.0	257.6	508.8	910.8
	2	13	313.1	217.3	10.0	114.6	230.0	531.8	653.2
	3	12	210.3	156.2	27.0	55.9	153.2	347.6	460.0
	4	16	101.5	106.2	10.0	12.1	70.1	187.5	386.4
	5	16	124.6	128.2	9.2	31.7	61.6	245.6	441.6
	6	16	260.5	150.3	20.0	148.5	239.2	408.0	480.0
	7	17	5153	12019	60	150	488	2478	40480
	8	16	911	884	120	163	451	2081	2200
	9	13	311.2	186.2	110.0	190.0	230.0	390.0	820.0
	10	19	391.3	193.3	100.0	230.0	360.0	588.8	750.0
	11	13	700	624	50	258	460	1340	2024
	12	13	452	386	36	135	322	653	1380

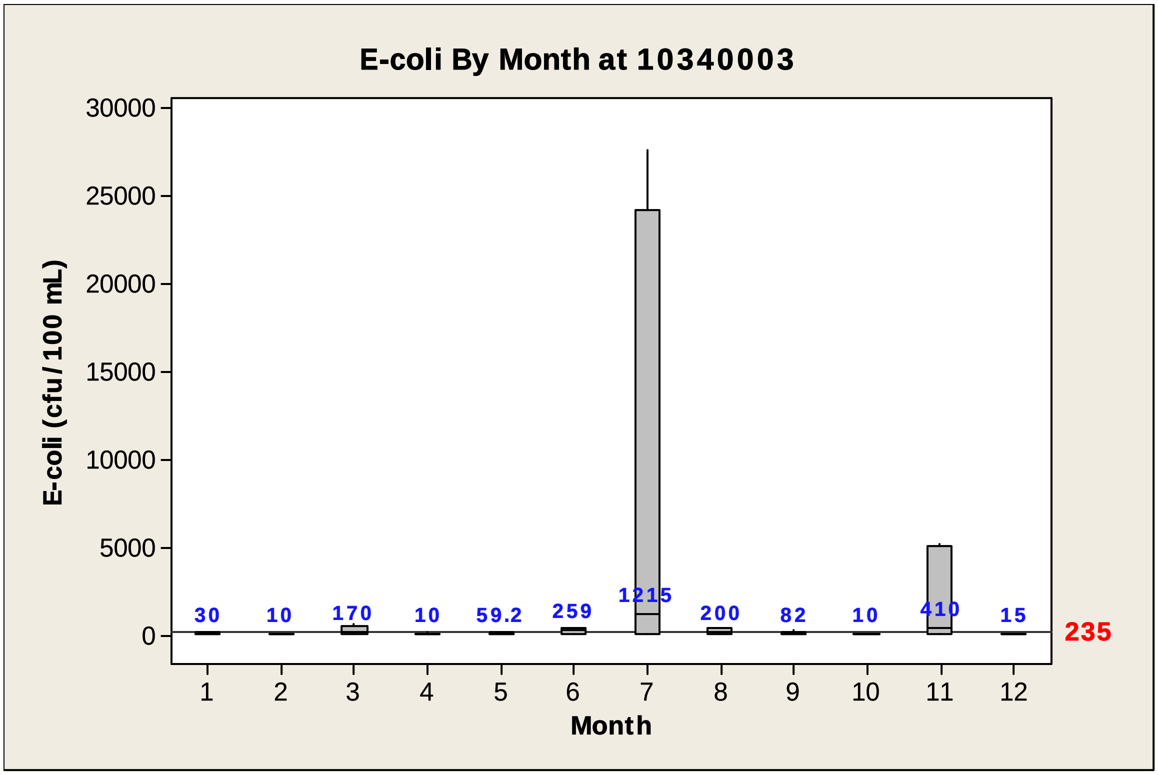


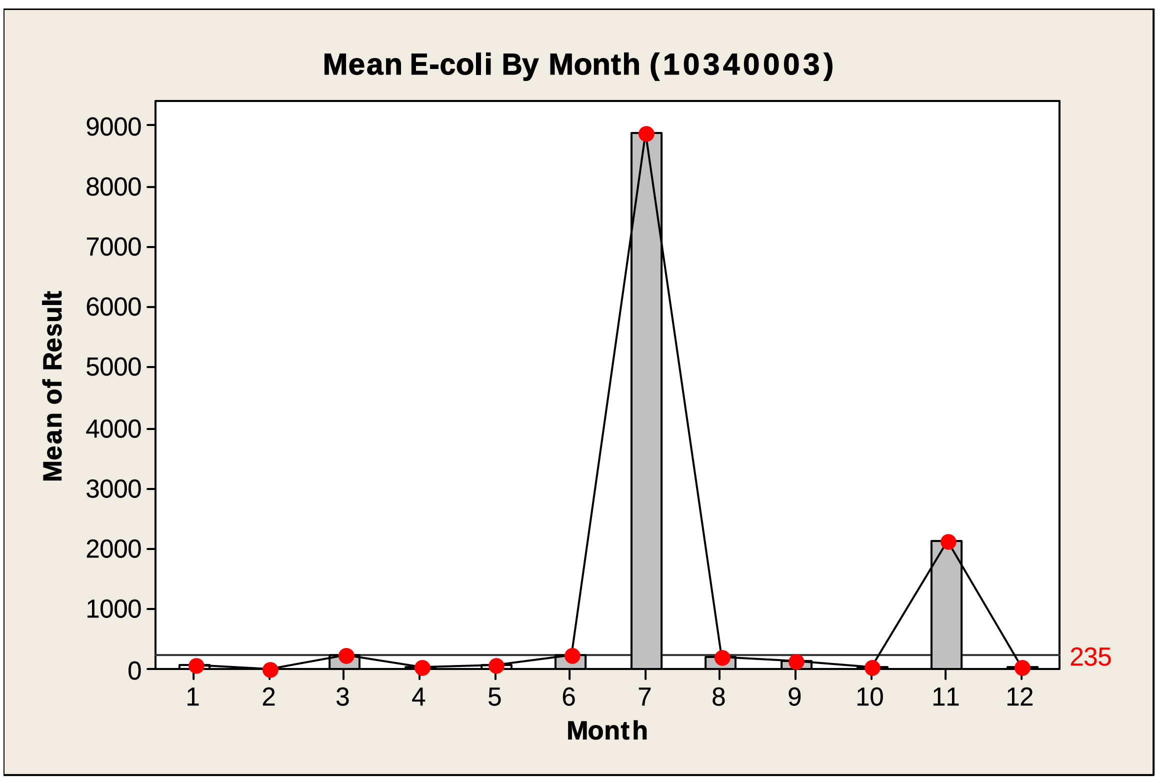


SITE 10340003

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	4	64.8	85.6	9.2	9.4	30.0	155.0	190.0
	2	4	12.50	5.00	10.00	10.00	10.00	17.50	20.00
	3	4	235	280	10	10	170	524	589
	4	4	42.5	65.0	10.0	10.0	10.0	107.5	140.0
	5	4	69.6	67.2	10.0	12.1	59.2	137.5	150.0
	6	4	245.5	164.3	64.0	85.5	259.0	392.0	400.0
	7	6	8875	12834	100	115	1215	24150	27600
	8	5	209.9	144.9	64.0	69.7	200.0	355.0	390.0
	9	5	127.5	90.4	50.6	52.8	82.0	225.0	240.0
	10	5	30.6	28.7	9.2	9.6	10.0	62.0	64.0
	11	5	2130	2703	10	35	410	5084	5200
	12	4	24.8	24.0	9.2	9.4	15.0	50.0	60.0

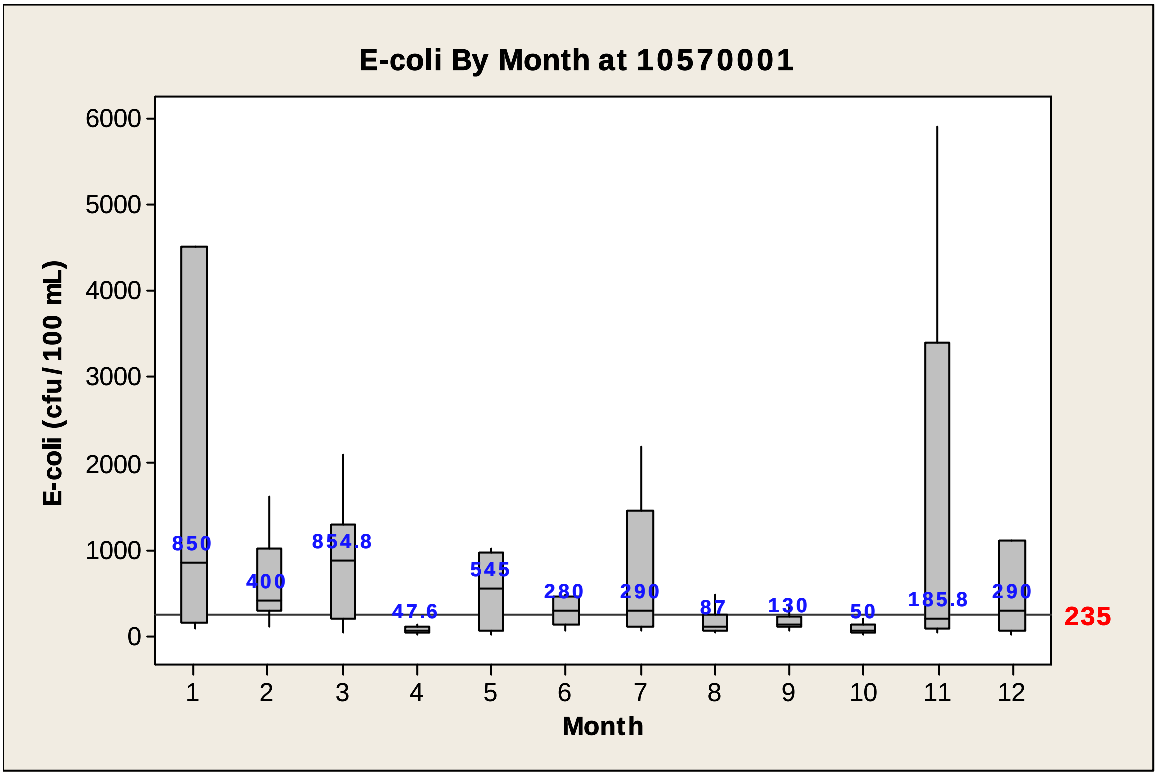

E-coli By Month at 10340003
E-coli (cfu/100 mL)
30000
25000
20000
15000
10000
5000
0
30
10
170
10
59.2
259
1215
200
82
10
410
15
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

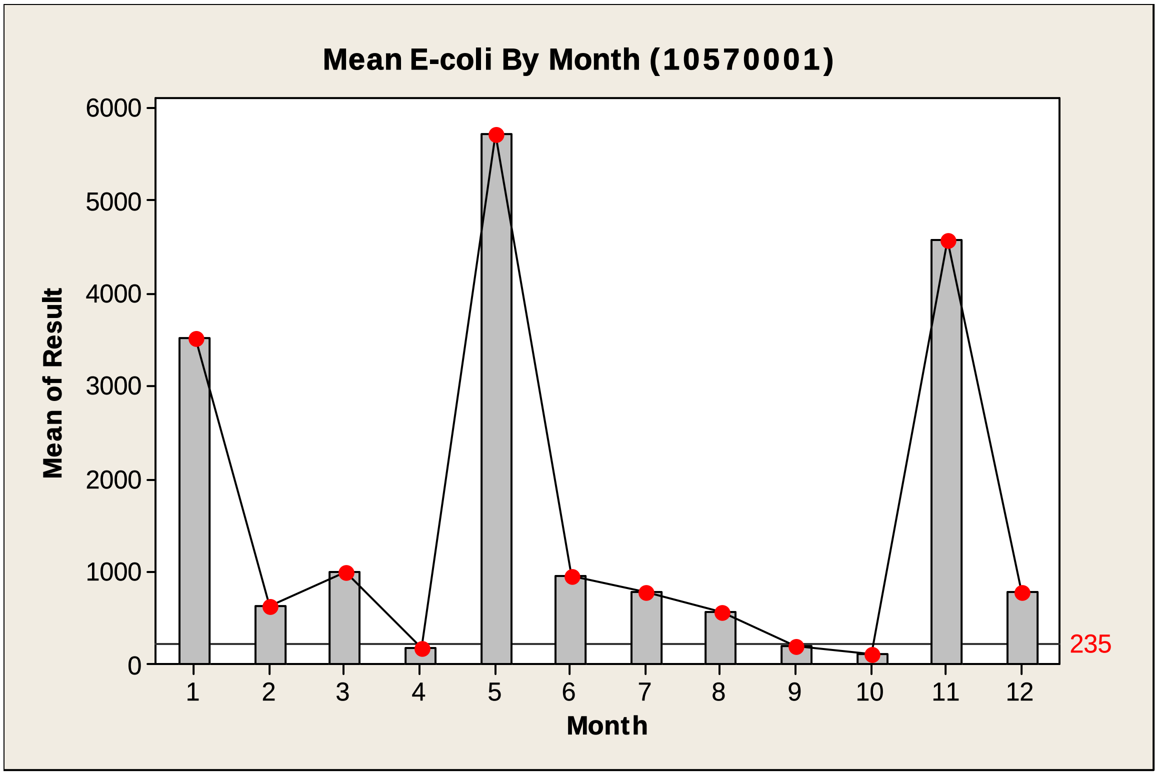

Mean E-coli By Month (10340003)
Mean of Result
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
235
1 2 3 4 5 6 7 8 9 10 11 12
Month

SITE 10570001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	11	3519	5322	70	138	850	4508	14720
	2	11	618	512	100	280	400	1000	1600
	3	10	986	1073	36	193	855	1275	3496
	4	16	168.0	301.6	10.0	20.0	47.6	107.8	1100.0
	5	18	5716	19165	10	47	545	951	82000
	6	17	948	1933	55	116	280	440	7268
	7	21	777	977	55	101	290	1450	3700
	8	18	569	1477	27	62	87	245	6164
	9	20	191.3	194.6	40.0	91.0	130.0	205.0	890.0
	10	21	116.2	203.4	10.0	19.2	50.0	114.4	910.0
	11	16	4585	9757	36	80	186	3385	31280
	12	11	785	1363	10	51	290	1100	4700

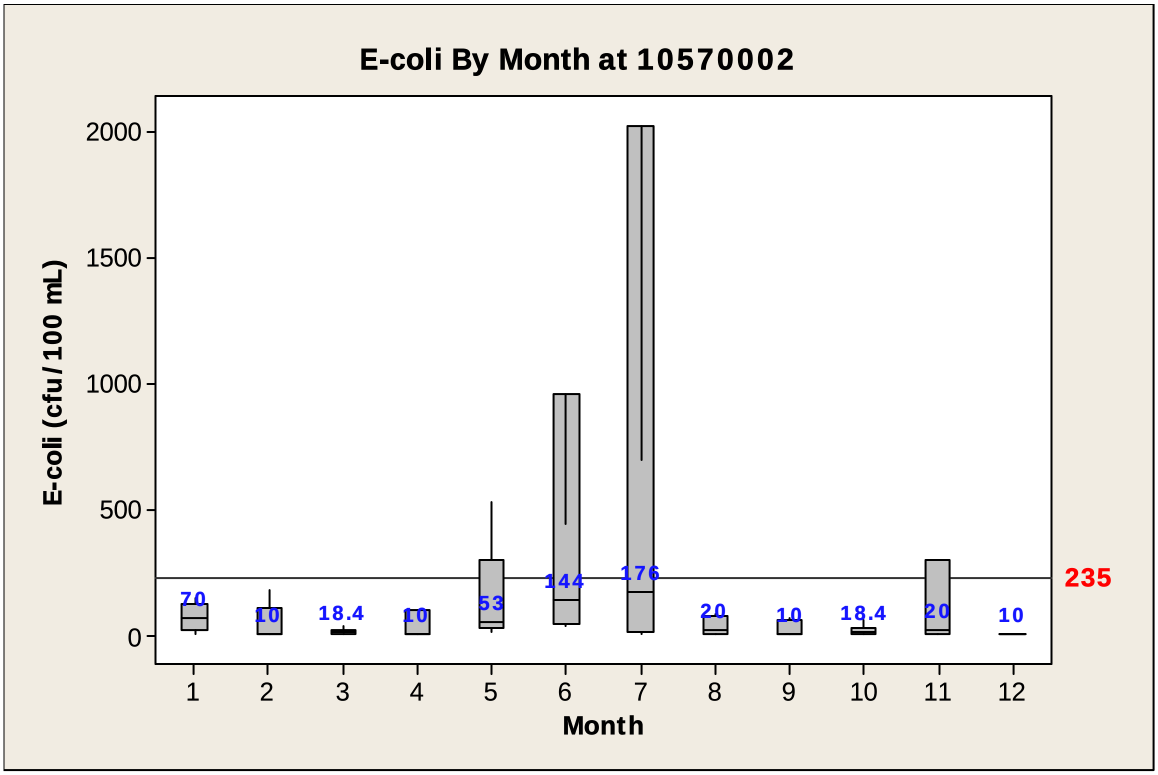


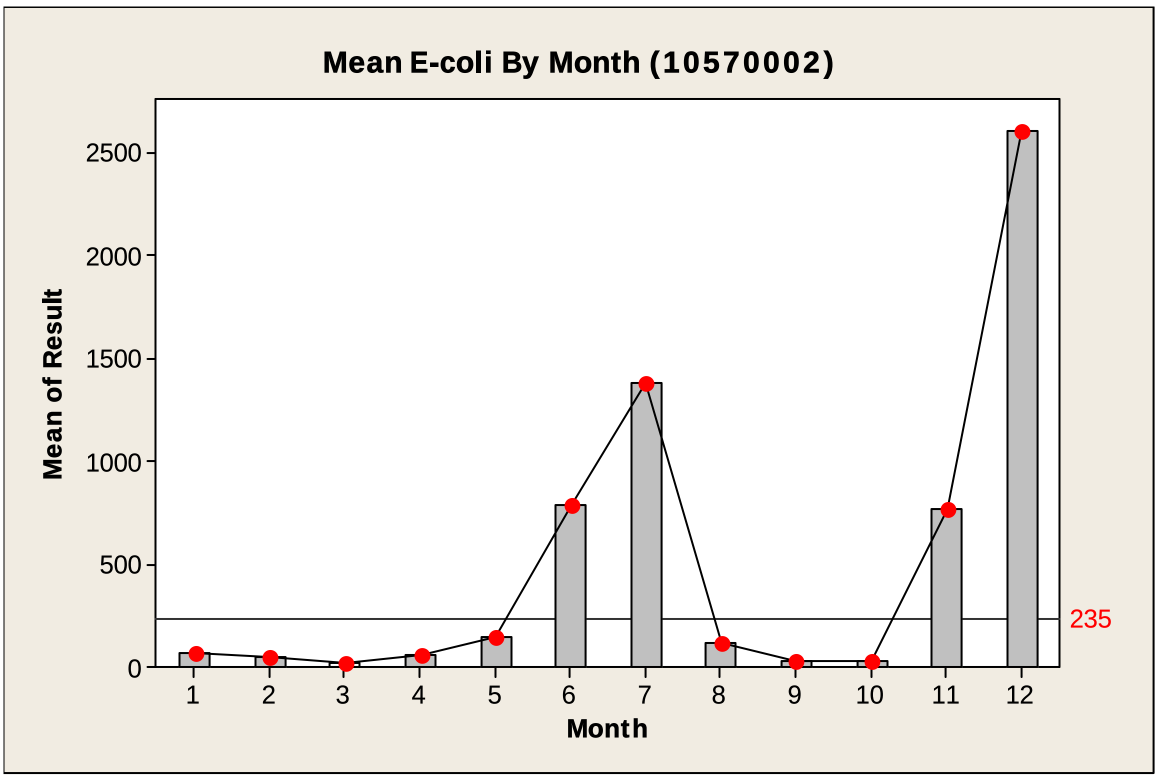


SITE 10570002

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	11	71.6	53.4	10.0	20.0	70.0	128.8	150.0
	2	11	49.4	69.9	9.2	10.0	10.0	110.0	184.0
	3	10	21.12	15.09	9.20	10.00	18.40	25.00	55.20
	4	10	63.0	89.2	9.2	10.0	10.0	100.3	290.0
	5	12	147.9	182.6	18.4	28.2	53.0	297.6	530.0
	6	10	787	1395	40	45	144	956	4140
	7	10	1380	2443	10	18	176	2020	6000
	8	9	112.2	233.5	9.2	10.0	20.0	78.6	730.0
	9	9	31.51	27.36	9.20	10.00	10.00	64.20	70.00
	10	11	32.4	38.6	10.0	10.0	18.4	33.1	140.0
	11	13	766	1710	10	10	20	297	4800
	12	11	2604	5862	9	10	10	10	16560

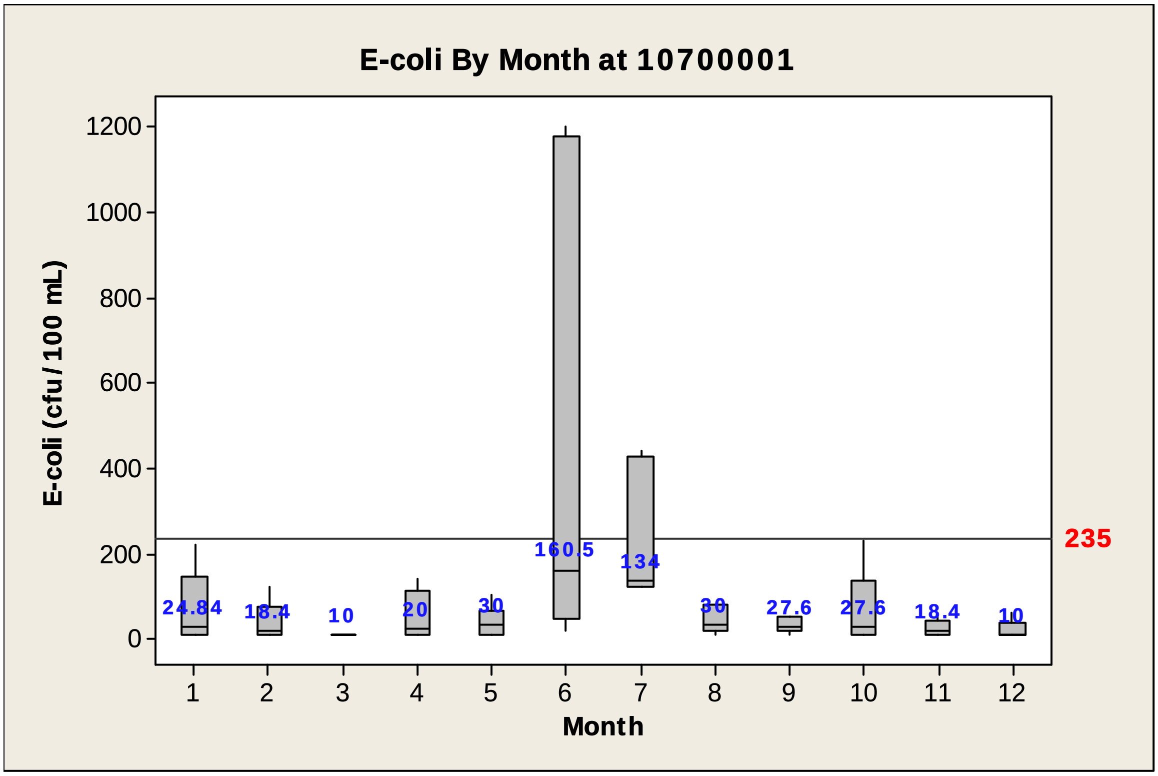

E-coli By Month at 10570002
E-coli (cfu/100 mL)
2000
1500
1000
500
0
70
10
18.4
10
53
144
176
20
10
18.4
20
10
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

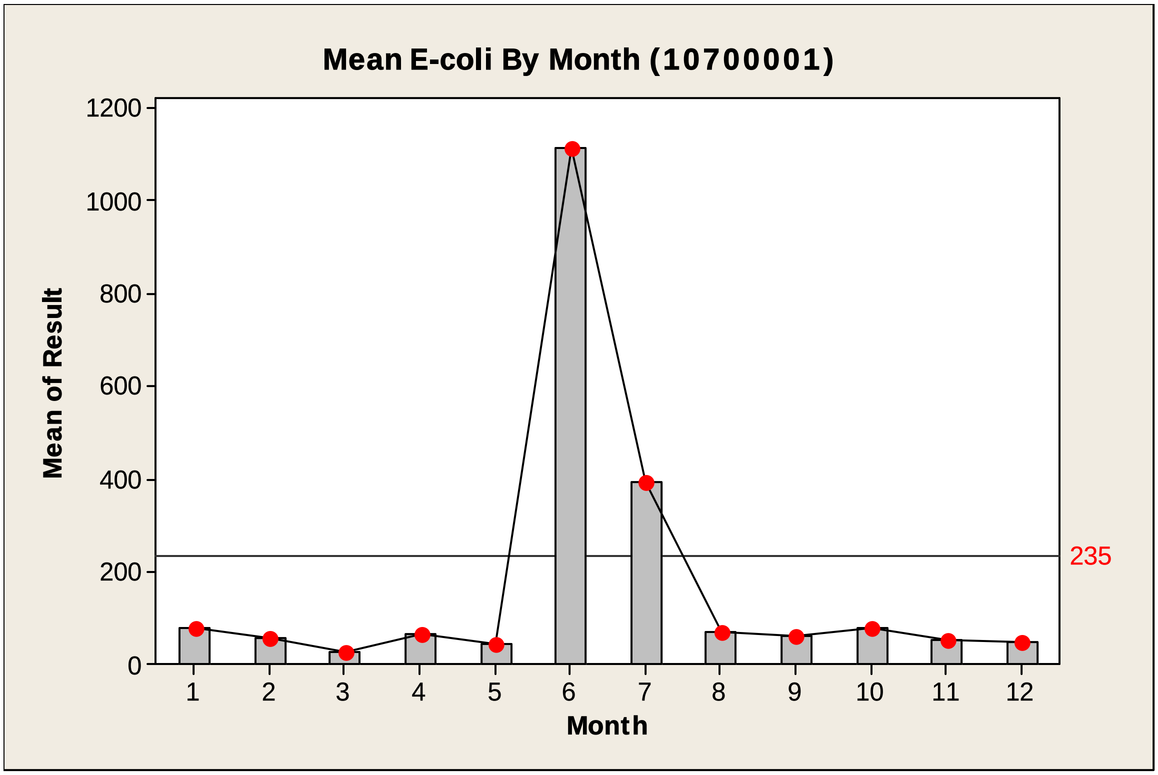

Mean E-coli By Month (10570002)
Mean of Result
2500
2000
1500
1000
500
0
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

SITE 10700001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	13	79.0	106.8	9.2	10.0	24.8	145.0	350.0
	2	13	56.3	89.6	10.0	10.0	18.4	75.5	330.0
	3	12	27.2	38.7	9.2	10.0	10.0	10.0	110.4
	4	12	65.2	87.1	10.0	10.0	20.0	111.6	300.0
	5	12	41.10	34.30	9.20	10.00	30.00	63.30	101.20
	6	12	1114	1958	18	47	161	1176	5980
	7	12	393	457	120	123	134	427	1380
	8	11	70.4	98.3	10.0	18.4	30.0	80.0	322.0
	9	11	61.0	82.0	10.0	18.0	27.6	50.6	230.0
	10	13	78.4	107.5	10.0	10.0	27.6	135.3	331.2
	11	13	50.9	80.8	9.2	10.0	18.4	42.6	240.0
	12	13	49.1	103.1	9.2	10.0	10.0	35.0	380.0

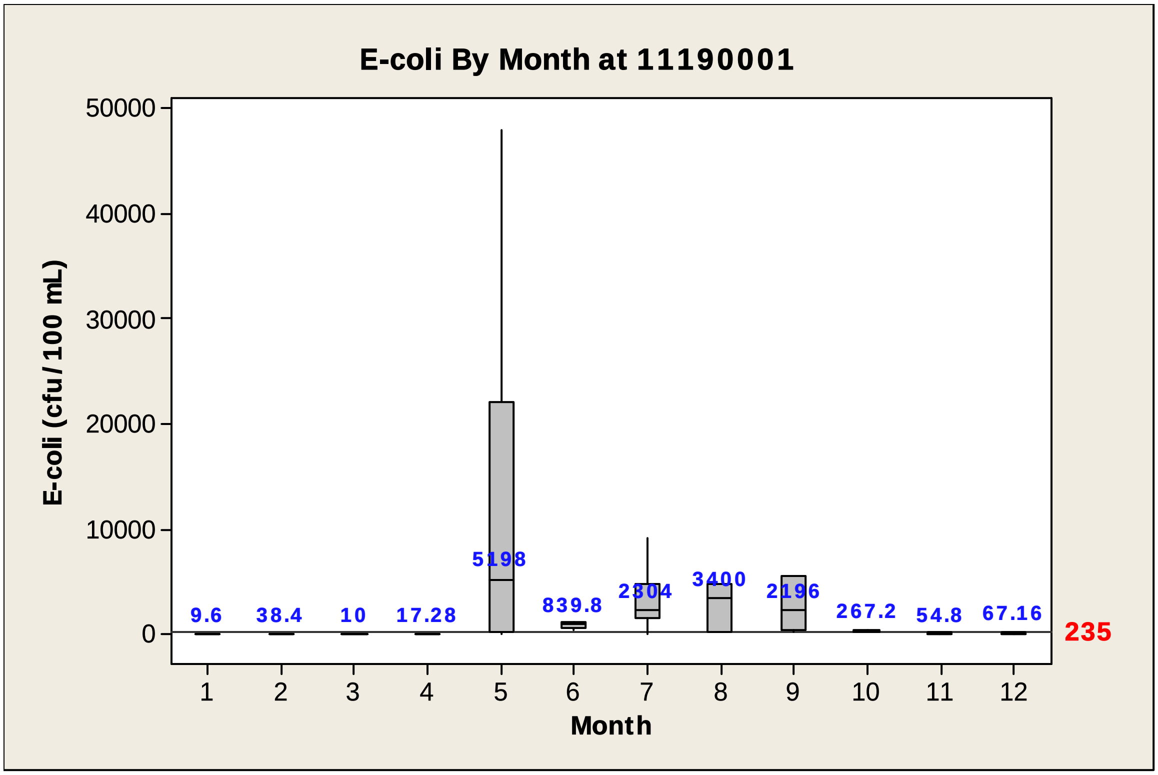


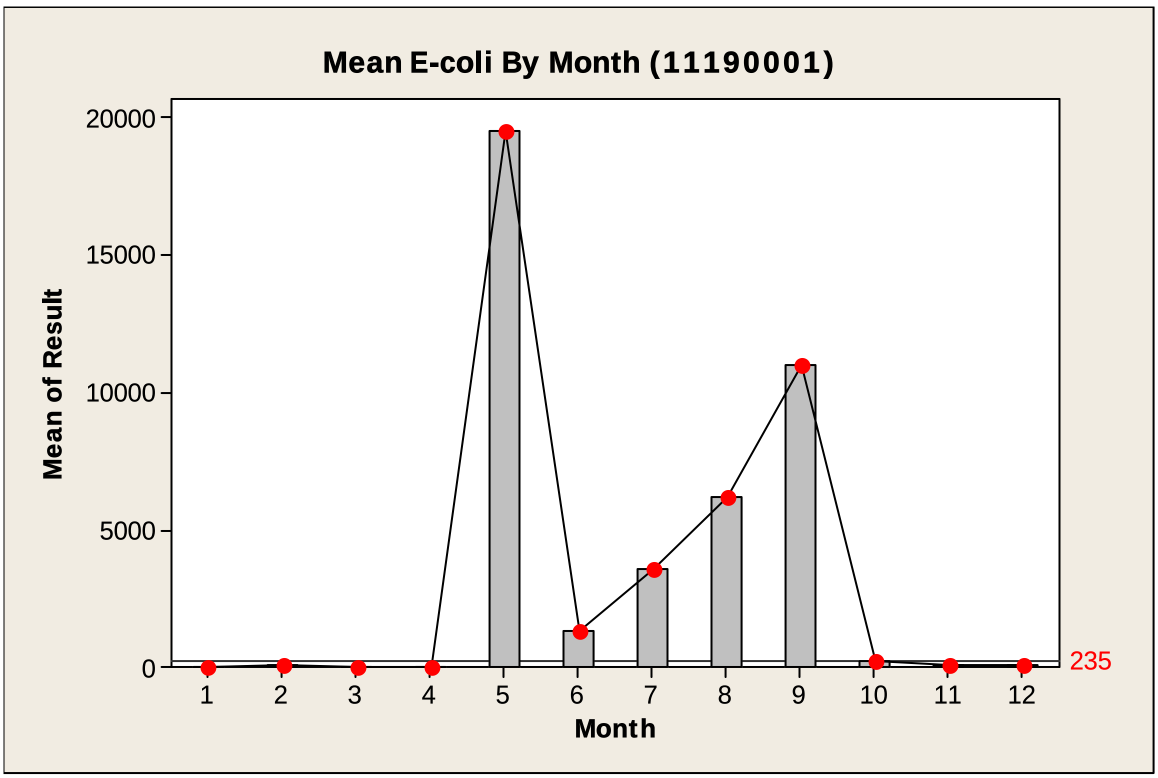


SITE 11190001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	4	9.600	0.462	9.200	9.200	9.600	10.000	10.000
	2	2	38.40	2.26	36.80	*	38.40	*	40.00
	3	4	9.800	0.400	9.200	9.400	10.000	10.000	10.000
	4	6	15.49	4.39	10.00	10.00	17.28	18.80	20.00
	5	20	19501	31131	9	207	5198	22080	110400
	6	20	1314	1746	423	604	840	1081	8004
	7	26	3550	3473	10	1425	2304	4674	11960
	8	14	6164	9875	140	228	3400	4715	36800
	9	12	11009	23509	248	440	2196	5465	80960
	10	8	244.6	93.1	110.4	140.0	267.2	321.5	349.6
	11	8	65.0	50.4	18.4	20.0	54.8	118.4	138.0
	12	8	108.4	152.7	10.0	25.1	67.2	90.8	478.4

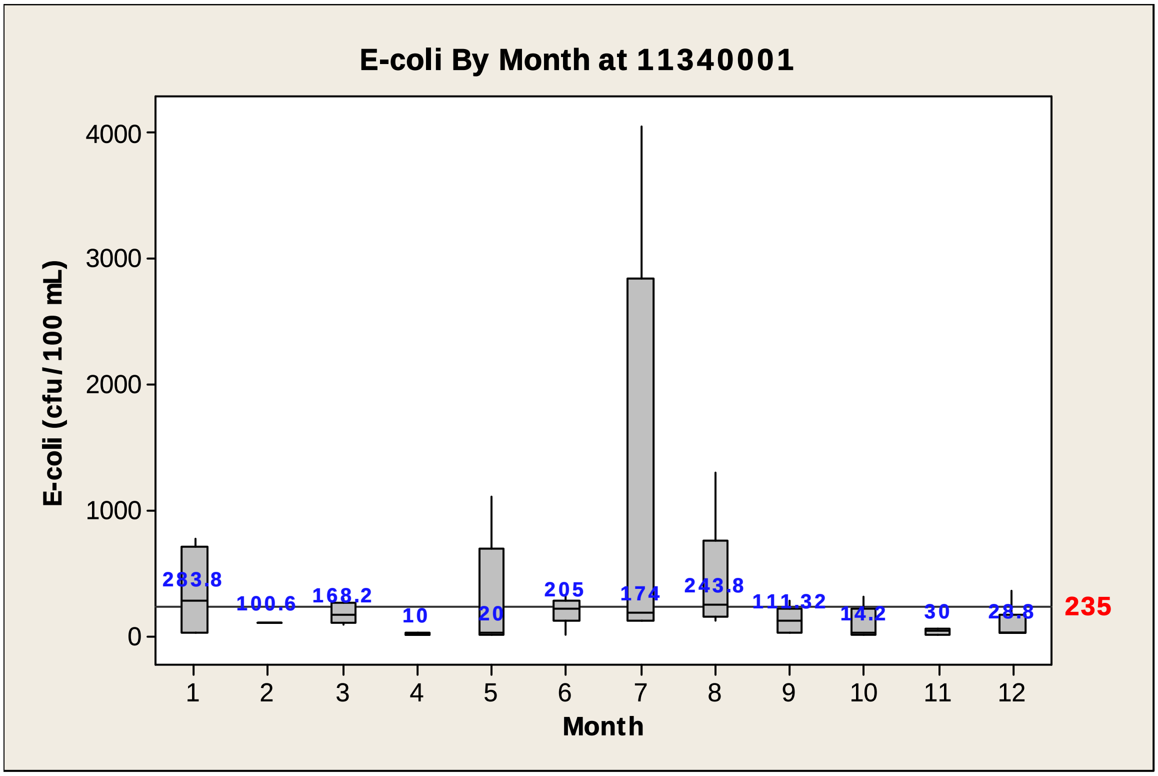

E-coli By Month at 11190001
E-coli (cfu/100 mL)
50000
40000
30000
20000
10000
0
9.6
38.4
10
17.28
5198
839.8
2304
3400
2196
267.2
54.8
67.16
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

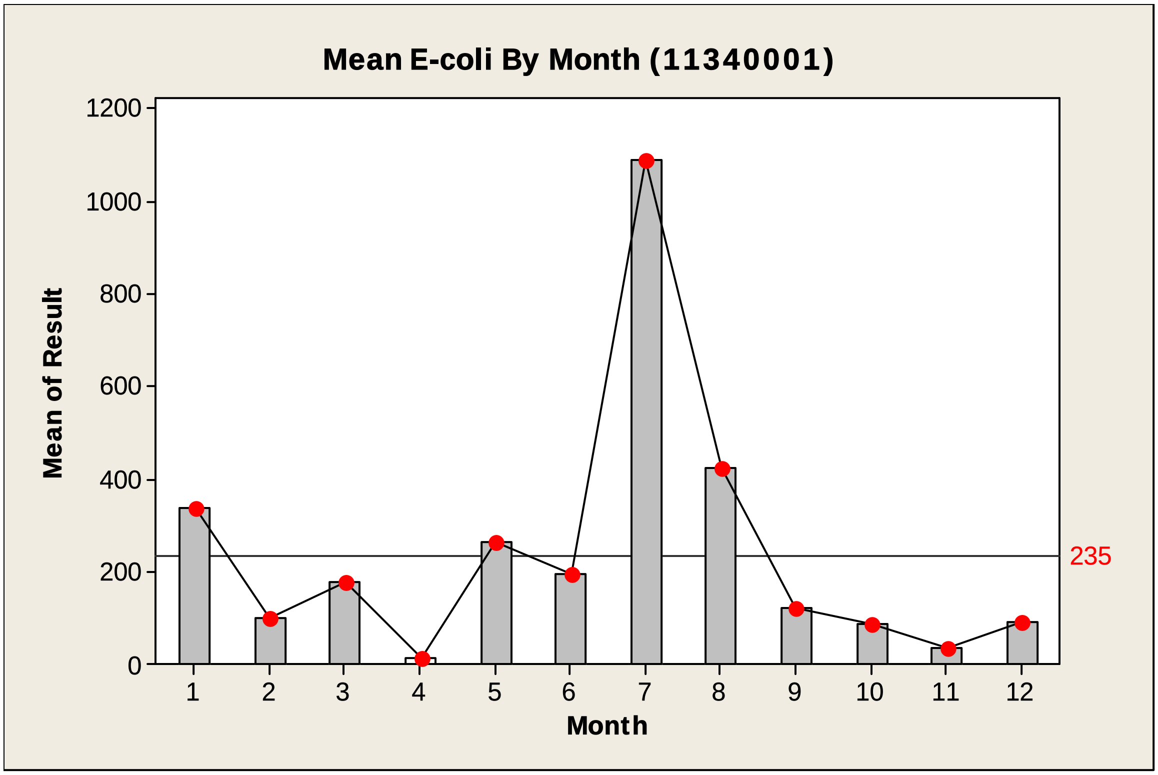

Mean E-coli By Month (11190001)
Mean of Result
20000
15000
10000
5000
0
235
1
2
3
4
5
6
7
8
9
10
11
12
Month

SITE 11340001

Descriptive Statistics: Result

Variable	Month	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1	4	338	374	20	22	284	708	764
	2	2	100.60	0.849	100.00	*	100.60	*	101.20
	3	4	175.9	84.0	82.0	100.6	168.2	258.9	285.2
	4	6	12.93	4.89	9.20	9.80	10.00	18.80	20.00
	5	8	265	461	9	10	20	692	1104
	6	8	195.6	101.6	10.0	123.3	205.0	275.0	331.2
	7	8	1089	1722	110	122	174	2839	4048
	8	8	423	433	110	142	244	753	1288
	9	8	120.3	96.1	18.4	26.3	111.3	205.0	276.0
	10	8	84.7	128.5	9.2	10.0	14.2	211.7	312.8
	11	8	32.39	24.05	10.00	10.00	30.00	55.15	58.88
	12	8	90.4	124.3	18.4	21.8	28.8	160.4	358.8





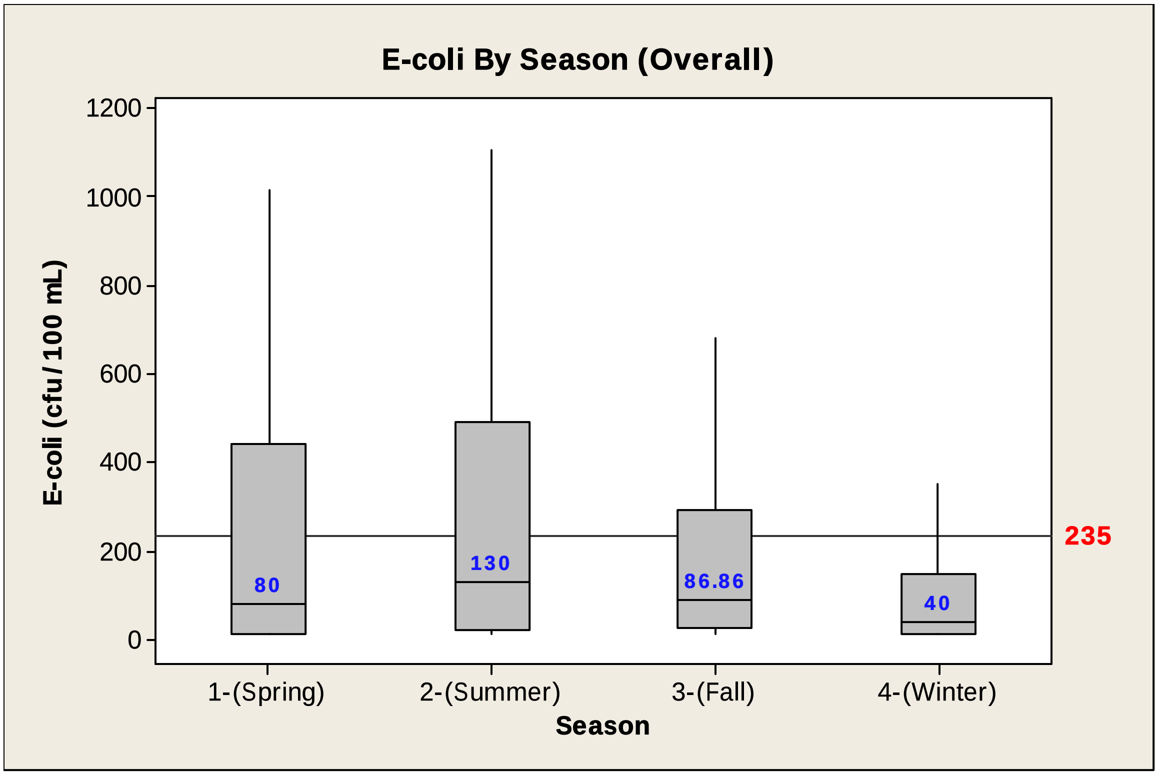
OVERALL STATISTICS BY SEASON

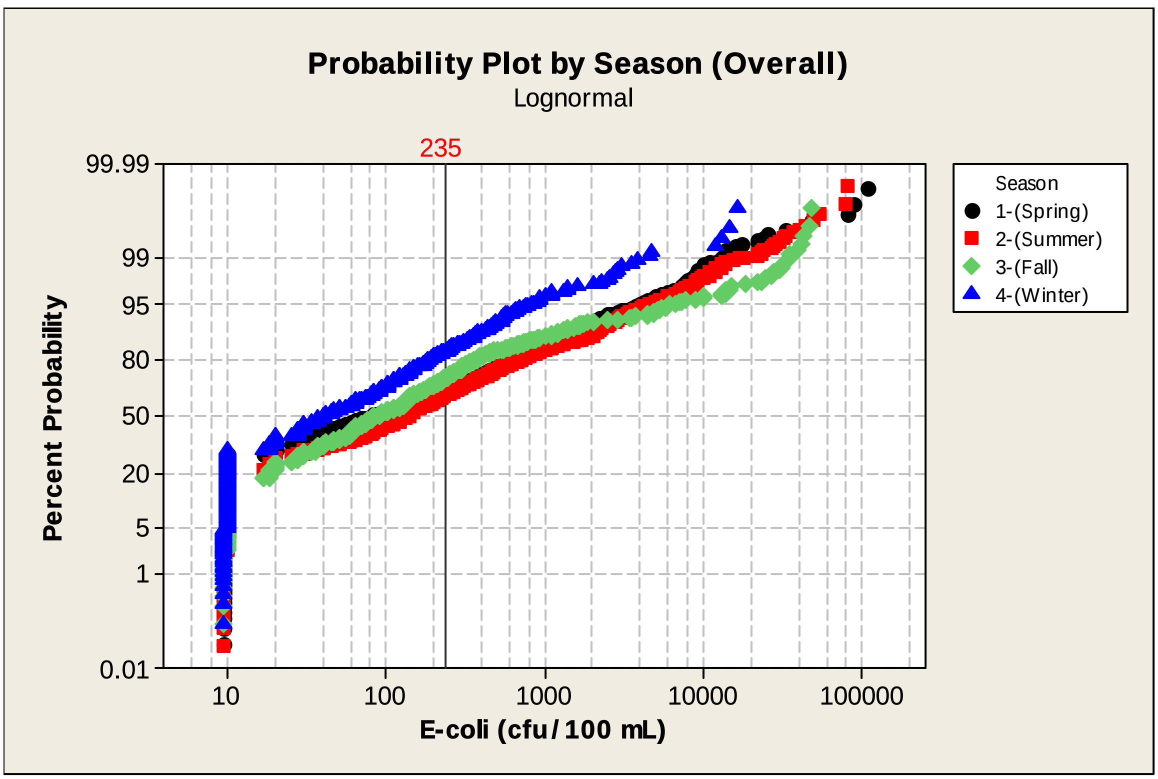
Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	1867	933	4614	9	10	80	442	110400
	2-(Summer)	1943	1098.0	4357.1	9.2	20.0	130.0	490.0	80960.0
	3-(Fall)	676	1433	5636	9	25	87	290	47840
	4-(Winter)	629	271.1	1211.6	9.2	10.0	40.0	147.2	16560.0

Boxplot of Result vs Season

`* NOTE * Percentile reference line is ignored when distribution is not fit.`


E-coli By Season (Overall)
E-coli (cfu/100 mL)
1200
1000
800
600
400
200
0
80
130
86.86
40
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

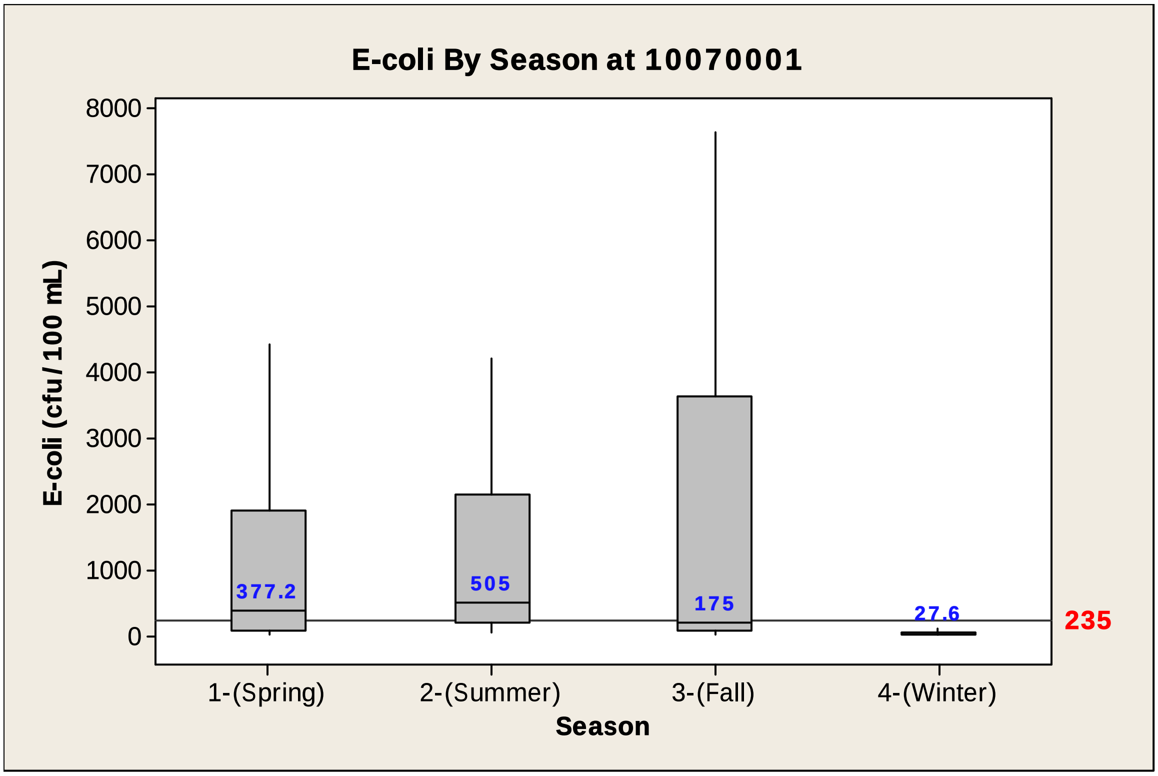

Probability Plot by Season (Overall)
Lognormal
235
Percent Probability
99.99
99
95
80
50
20
5
1
0.01
10
100
1000
10000
100000
E-coli (cfu/100 mL)
Season
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)

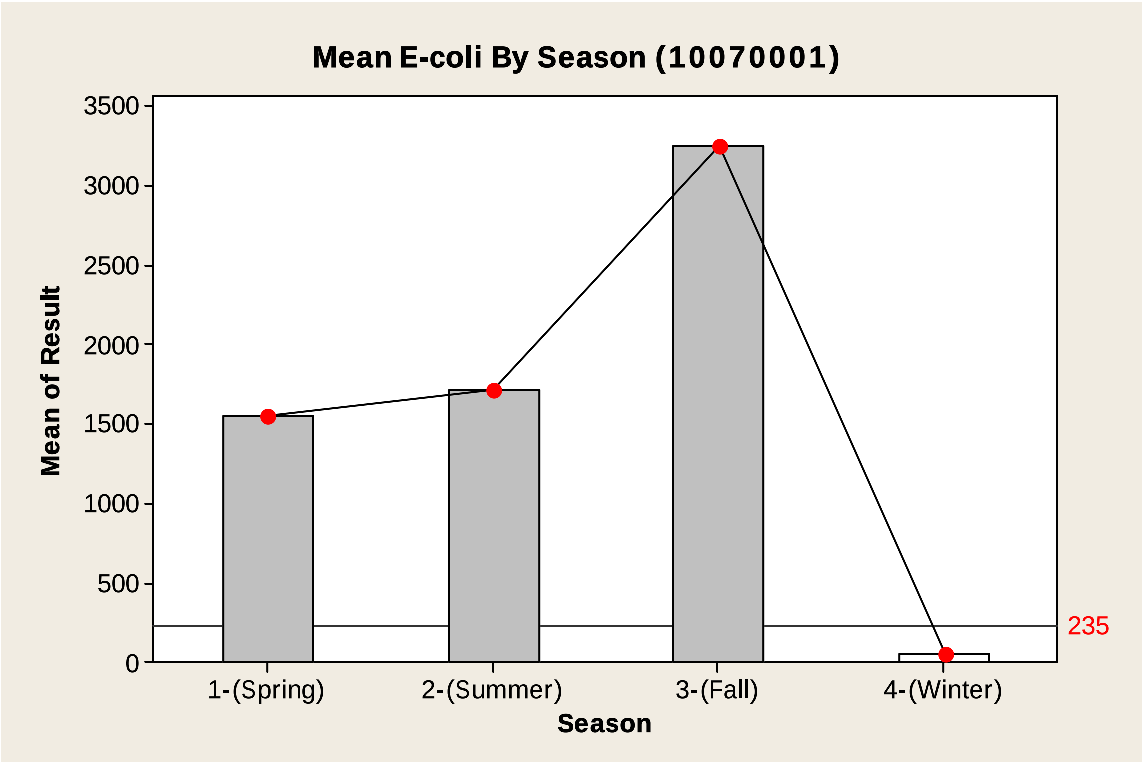
STATISTICS BY SEASON BY SITE

SITE 10070001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	90	1548	3084	9	54	377	1880	17480
	2-(Summer)	50	1708	2490	50	191	505	2125	8500
	3-(Fall)	32	3248	6315	10	56	175	3626	23920
	4-(Winter)	39	54.8	94.3	9.2	10.0	27.6	50.0	540.0

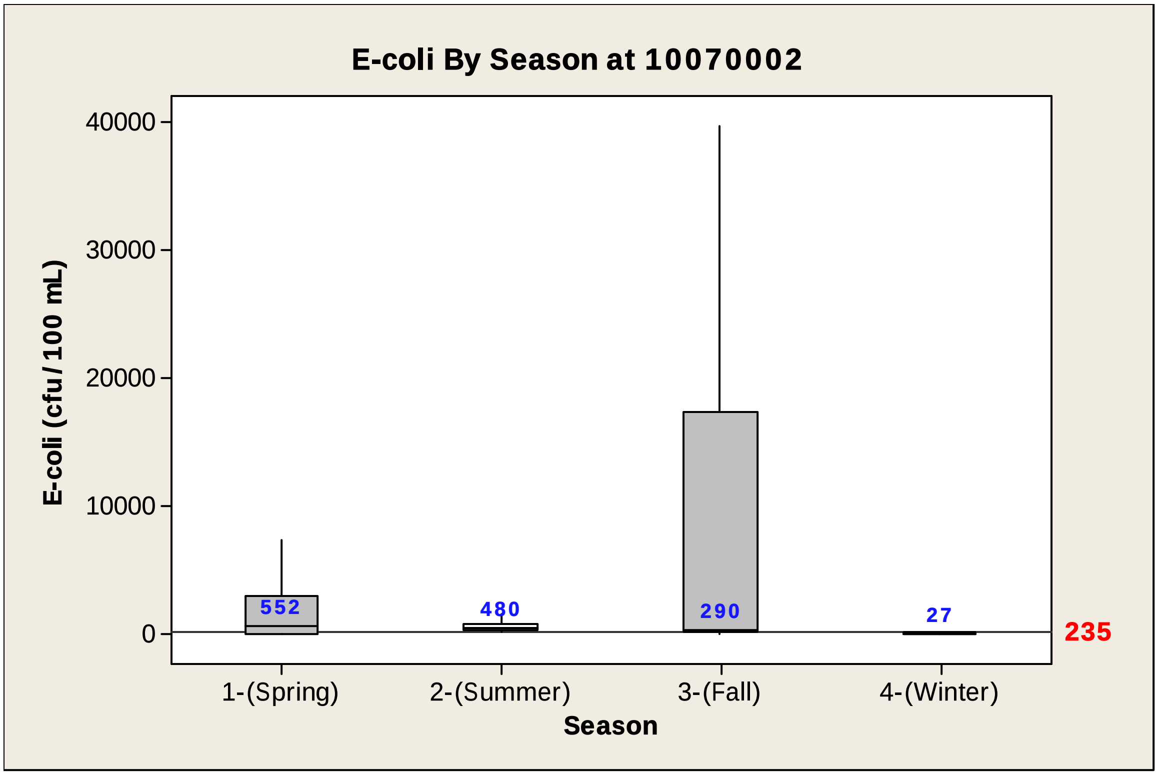


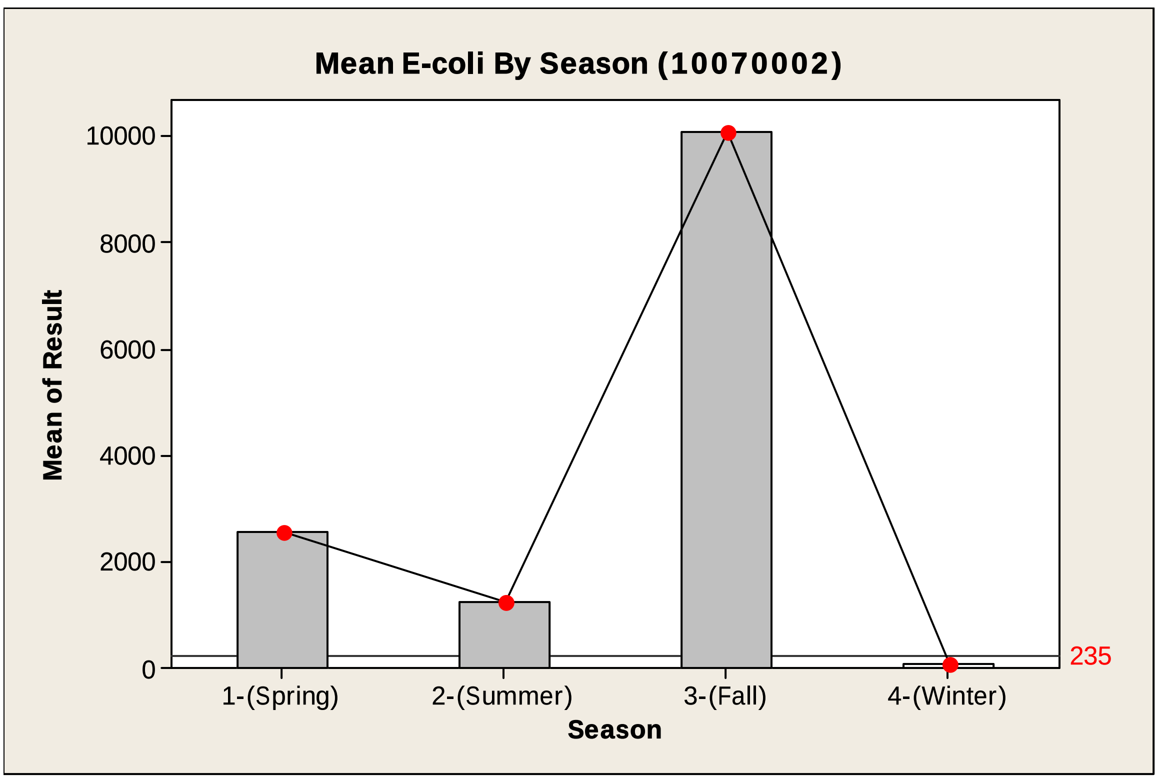


SITE 10070002

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	83	2567	4423	9	51	552	3000	25760
	2-(Summer)	36	1229	2083	120	276	480	762	10120
	3-(Fall)	34	10074	15484	9	140	290	17290	47000
	4-(Winter)	39	88.0	182.4	9.2	10.0	27.0	92.0	1100.0

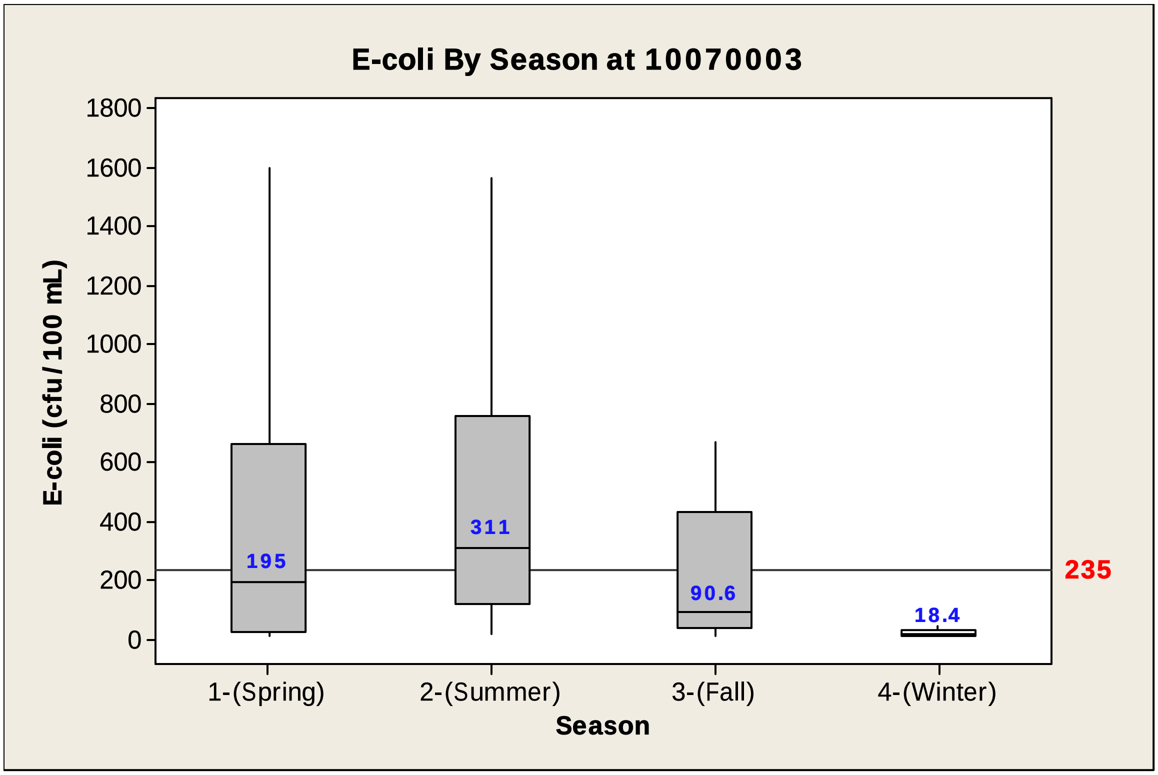

E-coli By Season at 10070002
E-coli (cfu/ 100 mL)
40000
30000
20000
10000
0
552
480
290
27
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

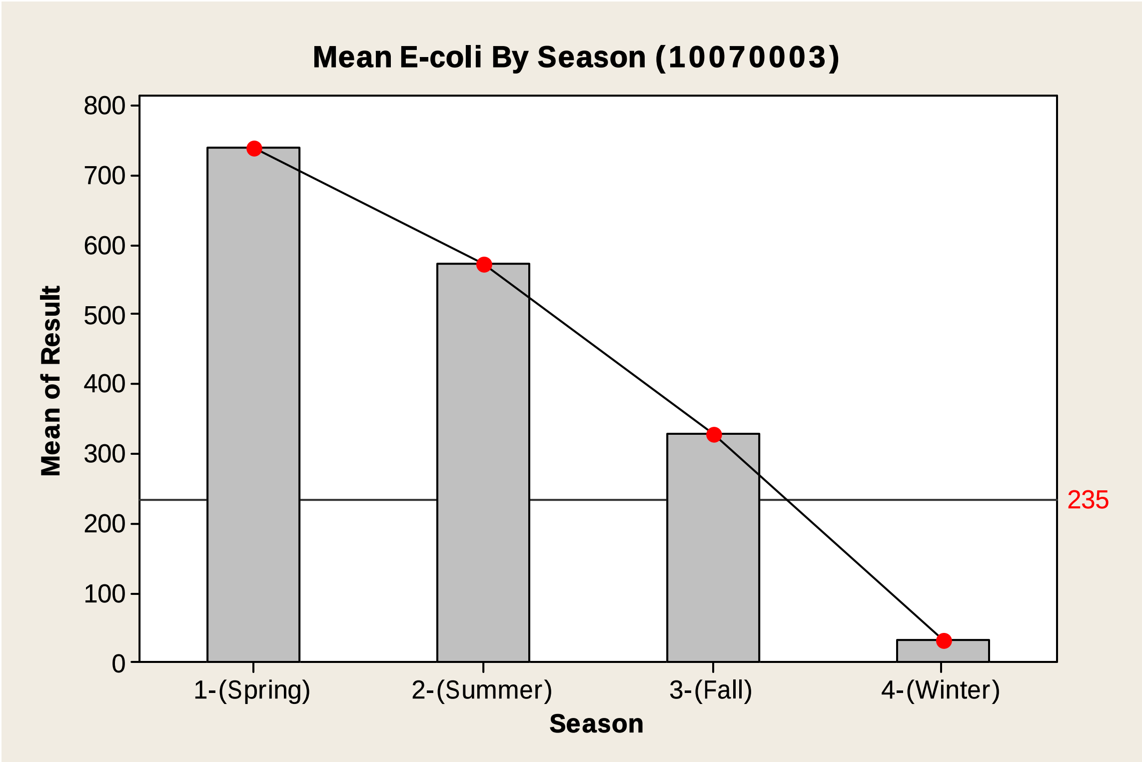

Mean E-coli By Season (10070002)
Mean of Result
10000
8000
6000
4000
2000
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10070003

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	84	739	1448	9	22	195	659	8000
	2-(Summer)	58	573.4	702.0	18.4	119.9	311.0	754.4	3400.0
	3-(Fall)	40	328.4	466.8	9.2	36.8	90.6	427.5	1656.0
	4-(Winter)	39	32.70	59.43	9.20	10.00	18.40	30.00	360.00

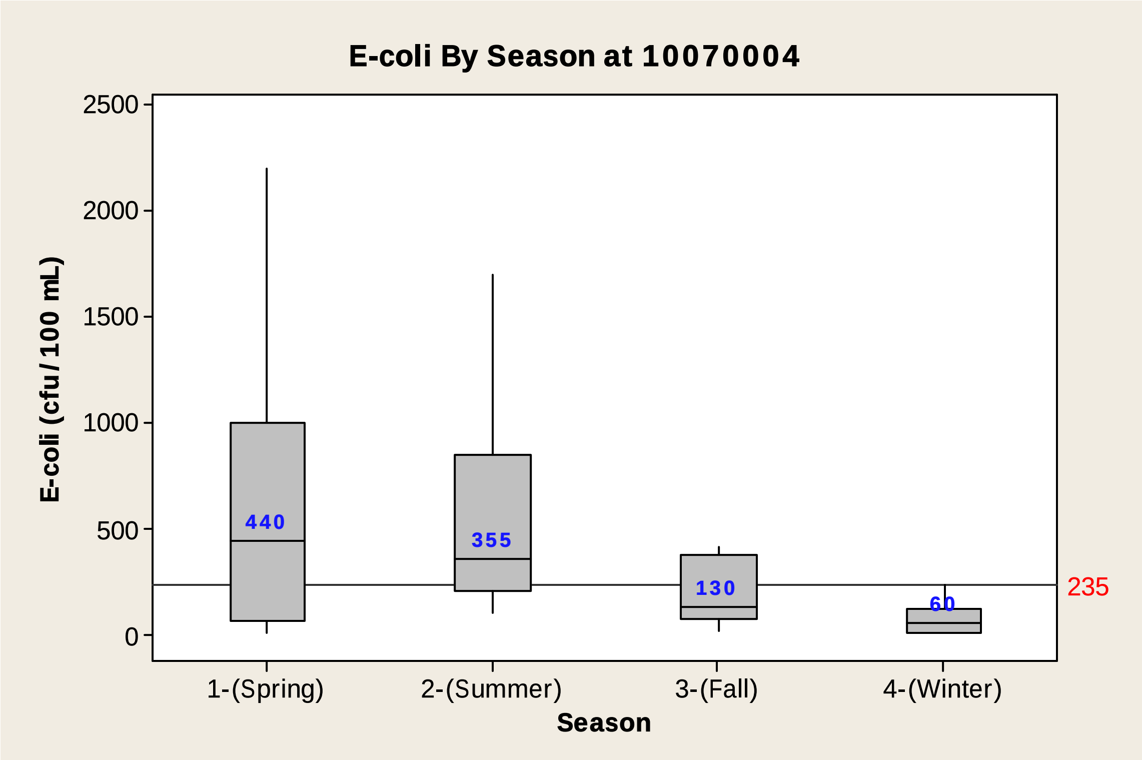


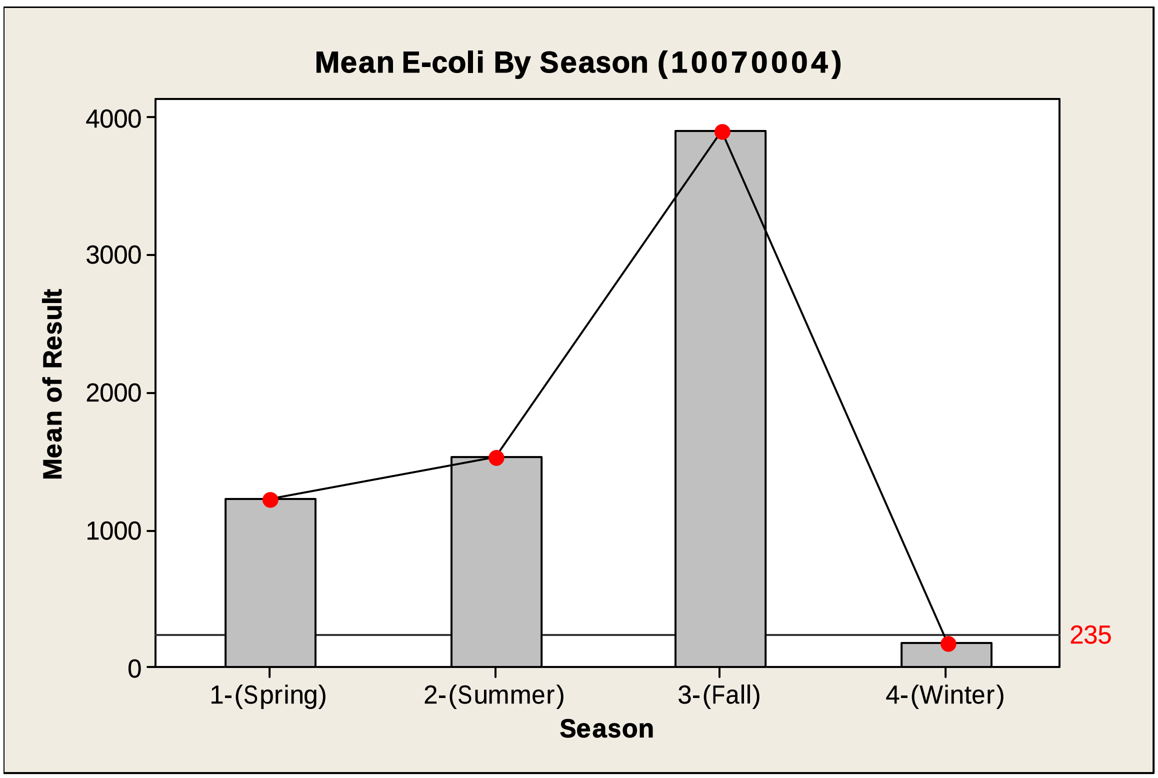


SITE 10070004

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	91	1220	2213	9	70	440	1000	11040
	2-(Summer)	74	1534	3604	100	208	355	855	23000
	3-(Fall)	43	3901	10254	18	73	130	380	47840
	4-(Winter)	39	175.9	487.6	9.2	10.0	60.0	120.0	3000.0

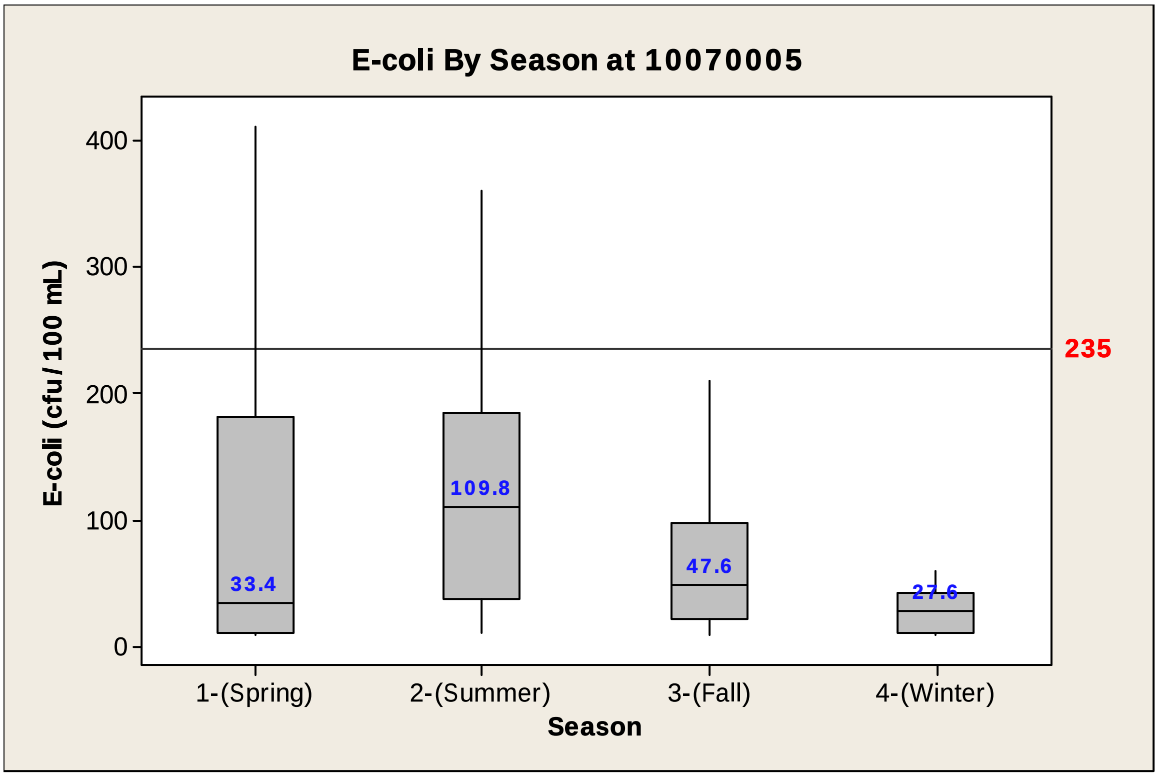

E-coli By Season at 10070004
E-coli (cfu/ 100 mL)
2500
2000
1500
1000
500
0
440
355
130
60
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

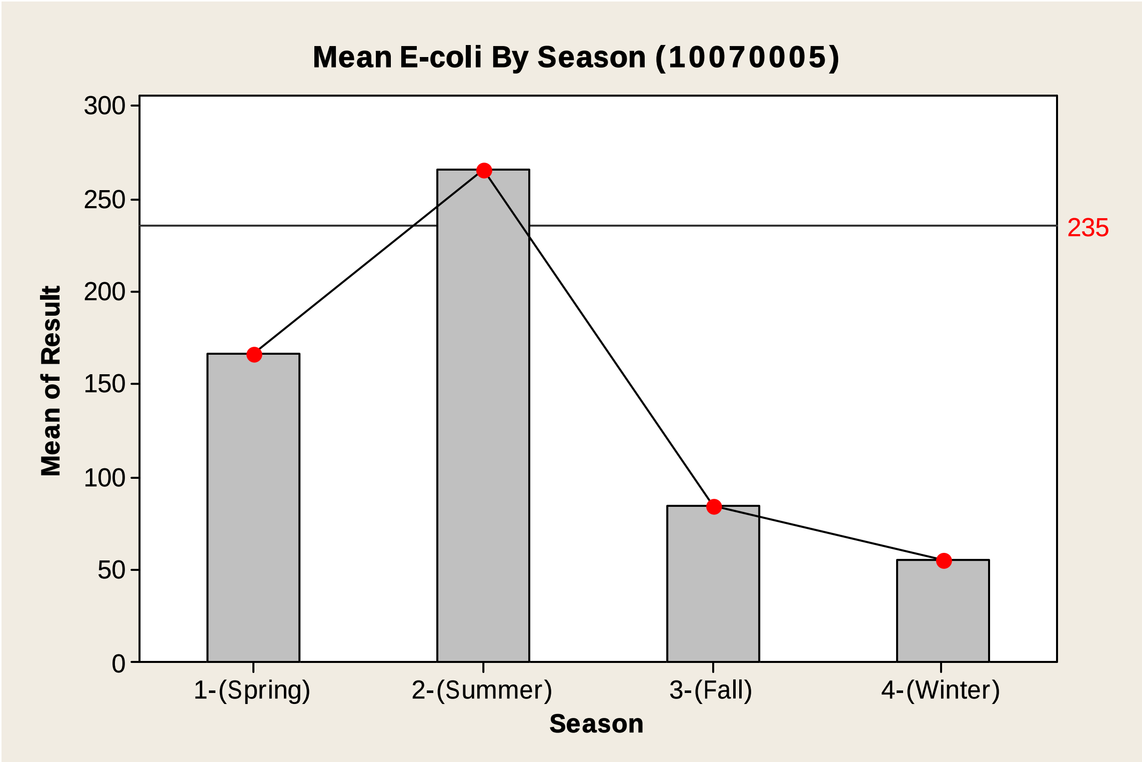

Mean E-coli By Season (10070004)
Mean of Result
4000
3000
2000
1000
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10070005

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	42	166.3	352.3	9.2	10.0	33.4	181.0	1700.0
	2-(Summer)	28	265	556	10	37	110	184	2300
	3-(Fall)	24	84.5	100.4	9.2	21.2	47.6	97.8	414.0
	4-(Winter)	33	55.3	116.4	9.2	10.0	27.6	41.4	640.0

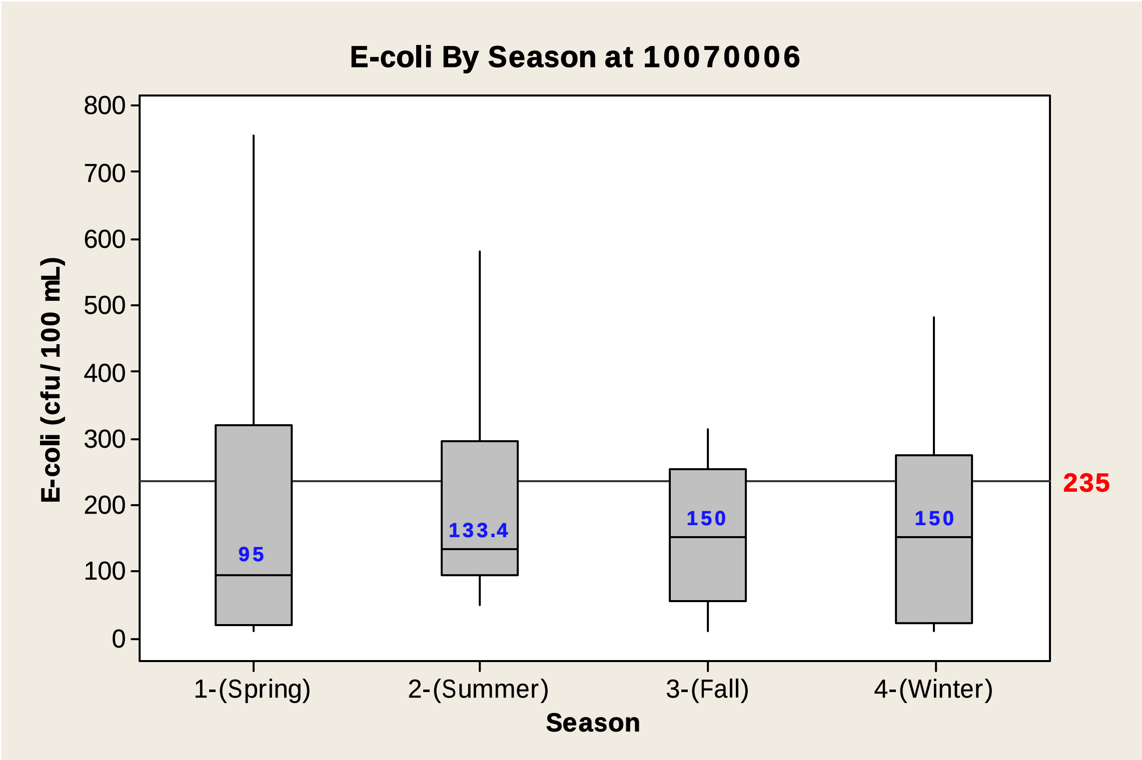


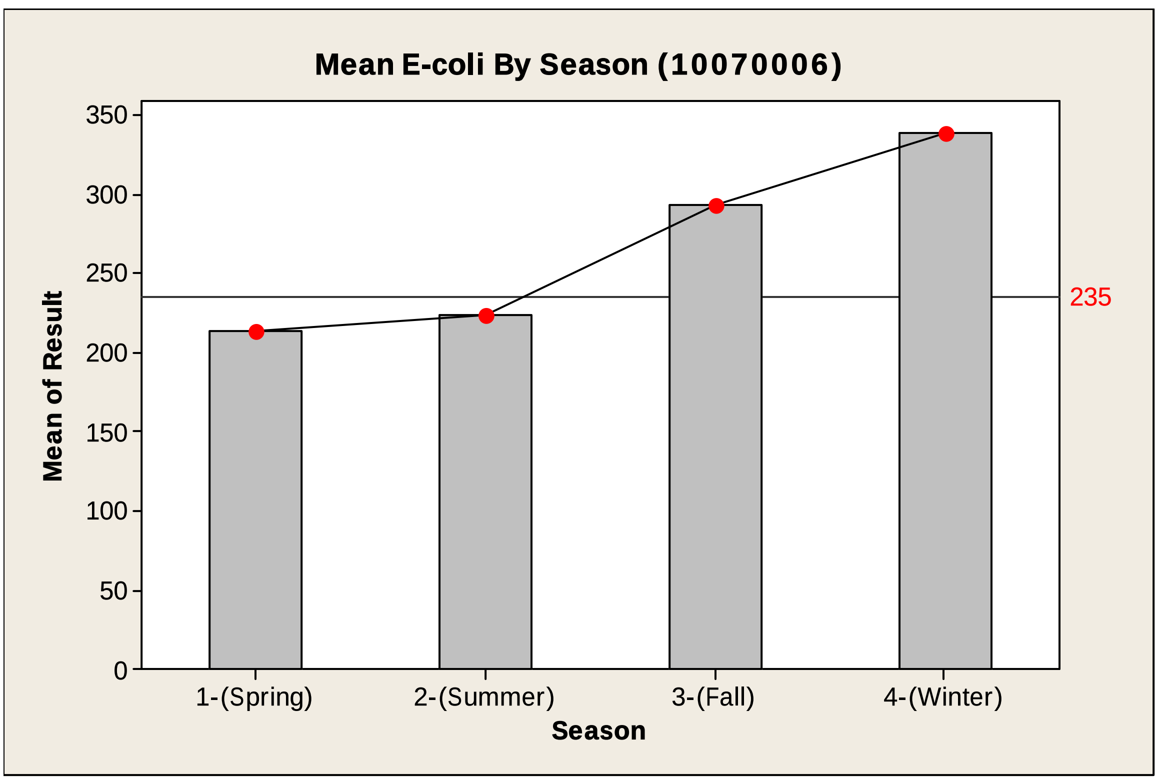


SITE 10070006

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	42	212.8	244.6	9.2	19.6	95.0	319.6	754.4
	2-(Summer)	28	223.3	193.2	50.0	94.0	133.4	295.0	708.4
	3-(Fall)	24	292.4	457.3	10.0	55.0	150.0	253.2	1748.0
	4-(Winter)	33	338	714	10	23	150	273	3496

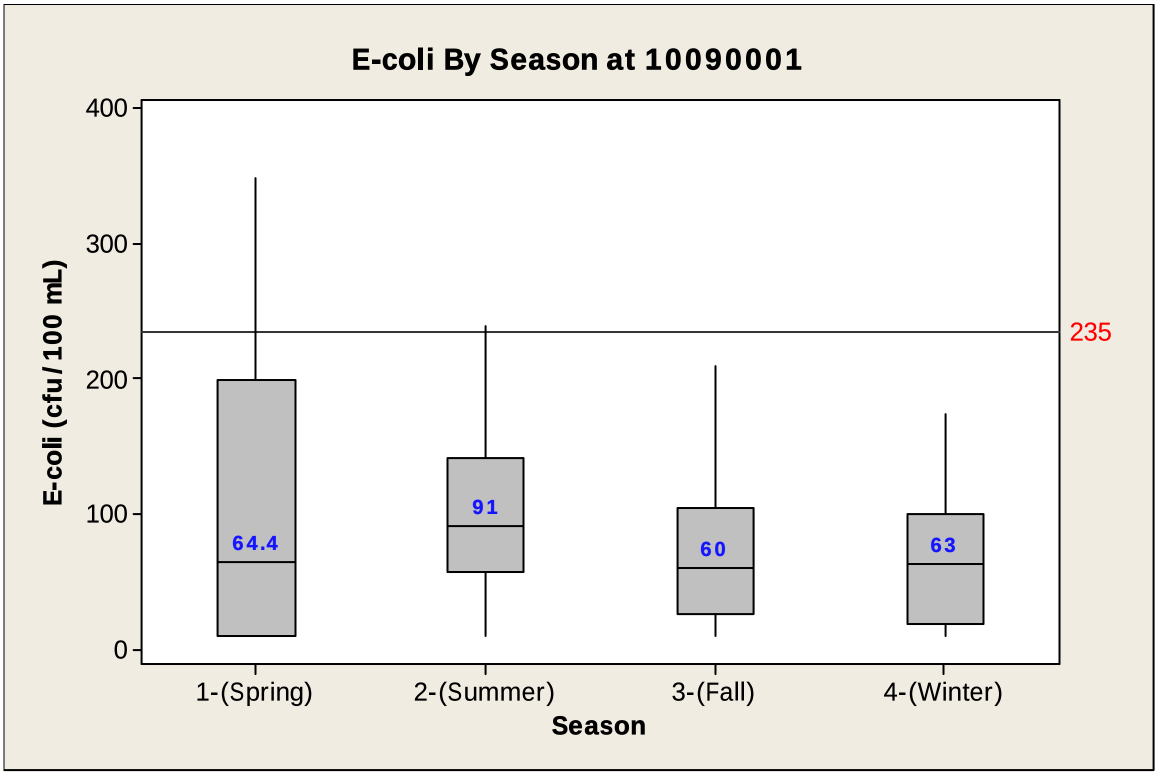

E-coli By Season at 10070006
E-coli (cfu/ 100 mL)
800
700
600
500
400
300
200
100
0
95
133.4
150
150
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

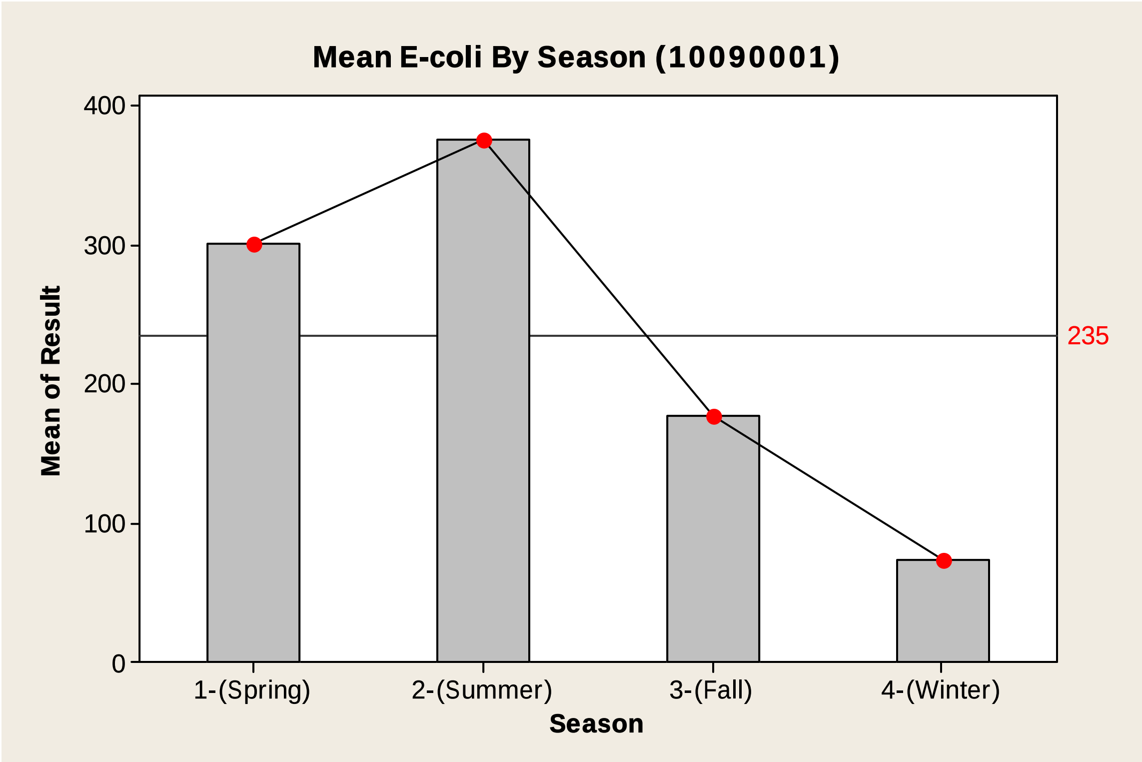

Mean E-coli By Season (10070006)
Mean of Result
350
300
250
200
150
100
50
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10090001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	48	301	690	9	10	64	200	3036
	2-(Summer)	34	376	845	9	57	91	142	3600
	3-(Fall)	26	177.4	381.2	9.2	25.7	60.0	104.9	1656.0
	4-(Winter)	39	73.2	72.1	9.2	18.4	63.0	100.0	360.0

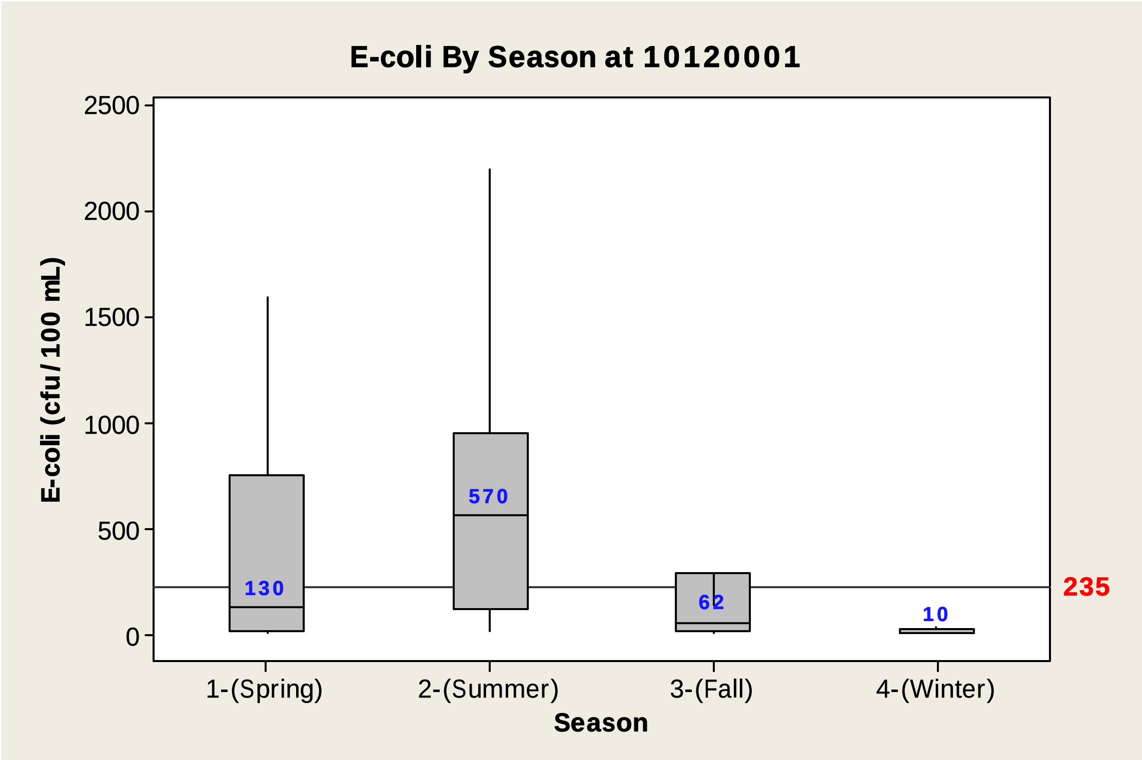


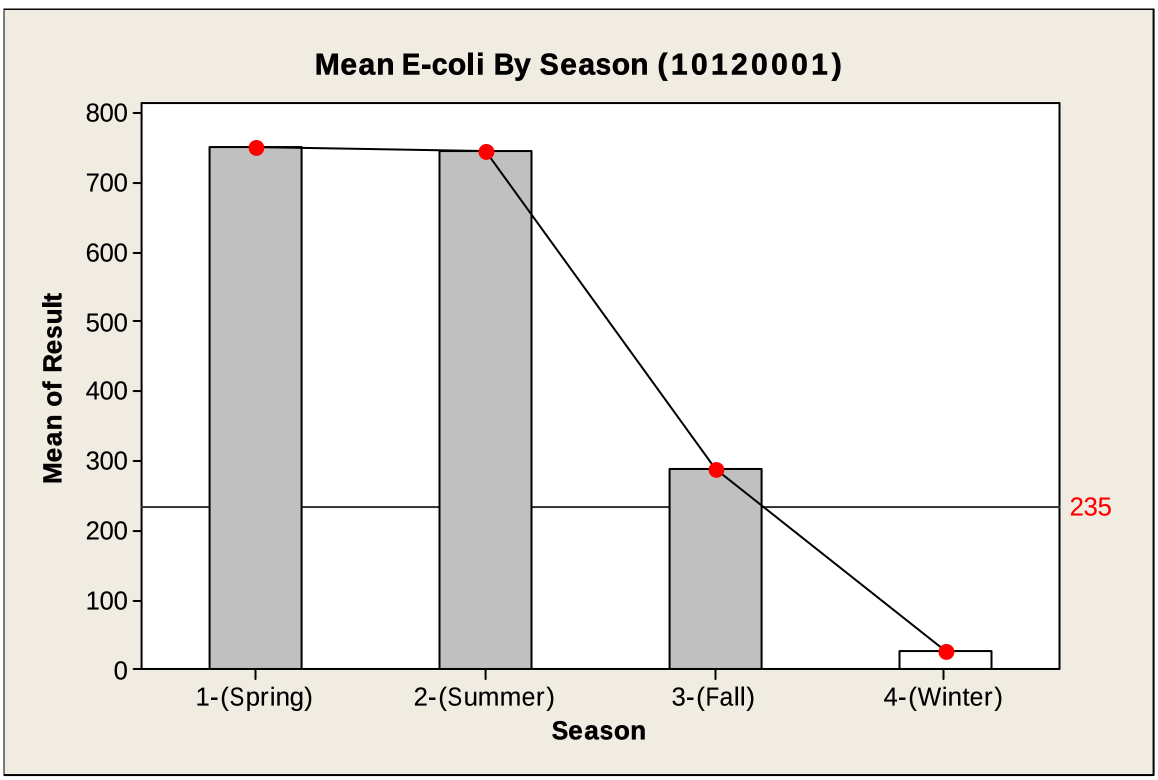


SITE 10120001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	90	751	1592	9	16	130	753	9200
	2-(Summer)	56	747	811	20	120	570	958	3220
	3-(Fall)	34	287.2	440.2	9.2	16.3	62.0	292.9	1380.0
	4-(Winter)	39	27.02	47.70	9.20	10.00	10.00	27.60	300.00

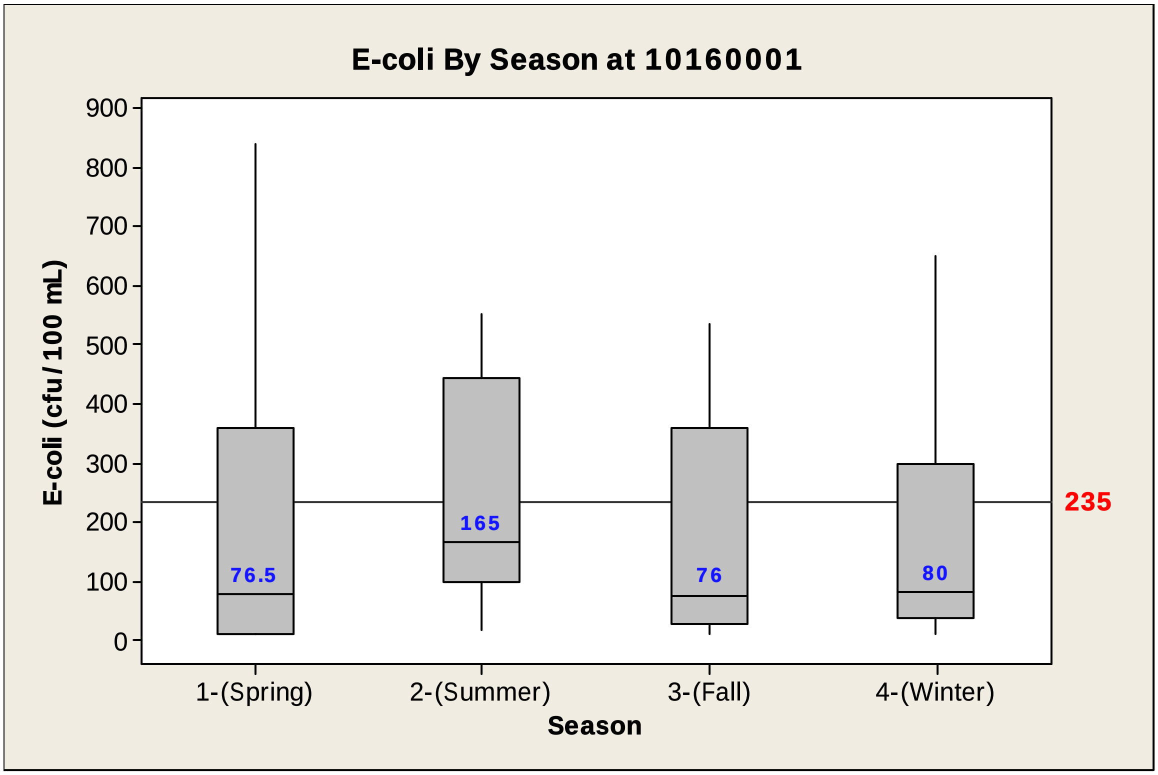

E-coli By Season at 10120001
2500
2000
1500
1000
500
0
E-coli (cfu/100 mL)
130
570
62
10
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

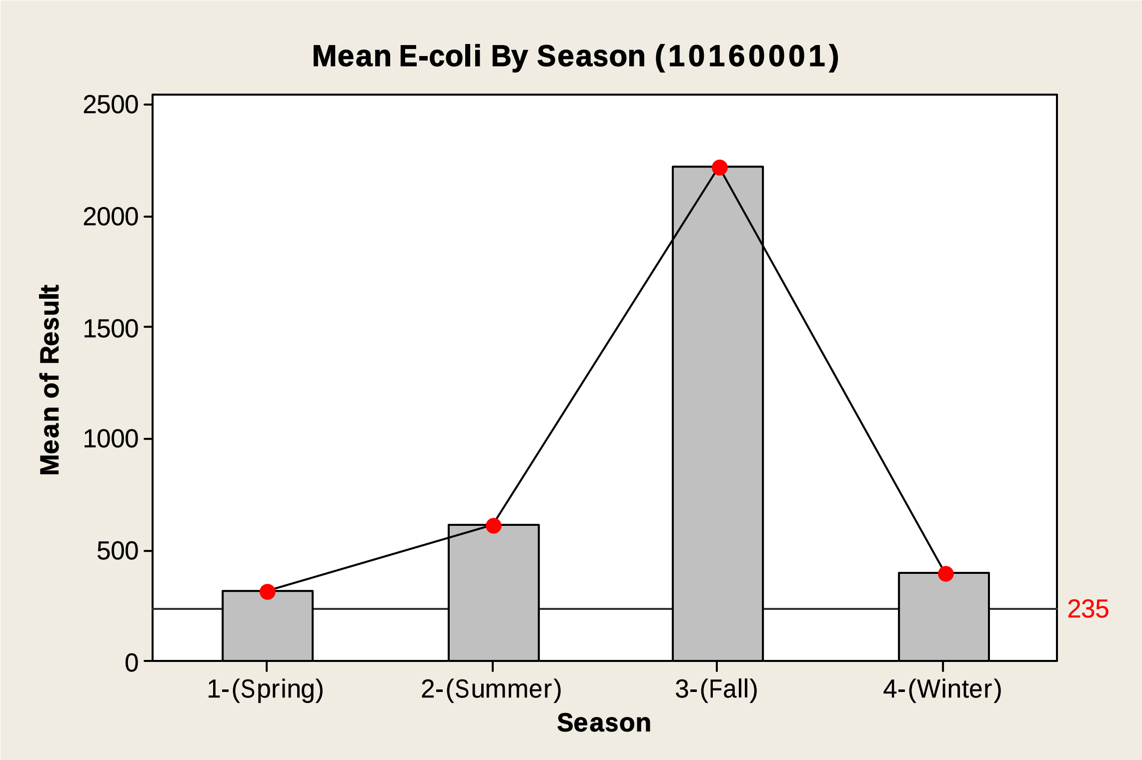

Mean E-coli By Season (10120001)
800
700
600
500
400
300
200
100
0
Mean of Result
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10160001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	48	311.6	667.0	9.2	10.0	76.5	357.4	3588.0
	2-(Summer)	34	608	1304	18	98	165	443	5000
	3-(Fall)	24	2222	5481	9	25	76	359	23000
	4-(Winter)	36	391	871	9	38	80	297	3800

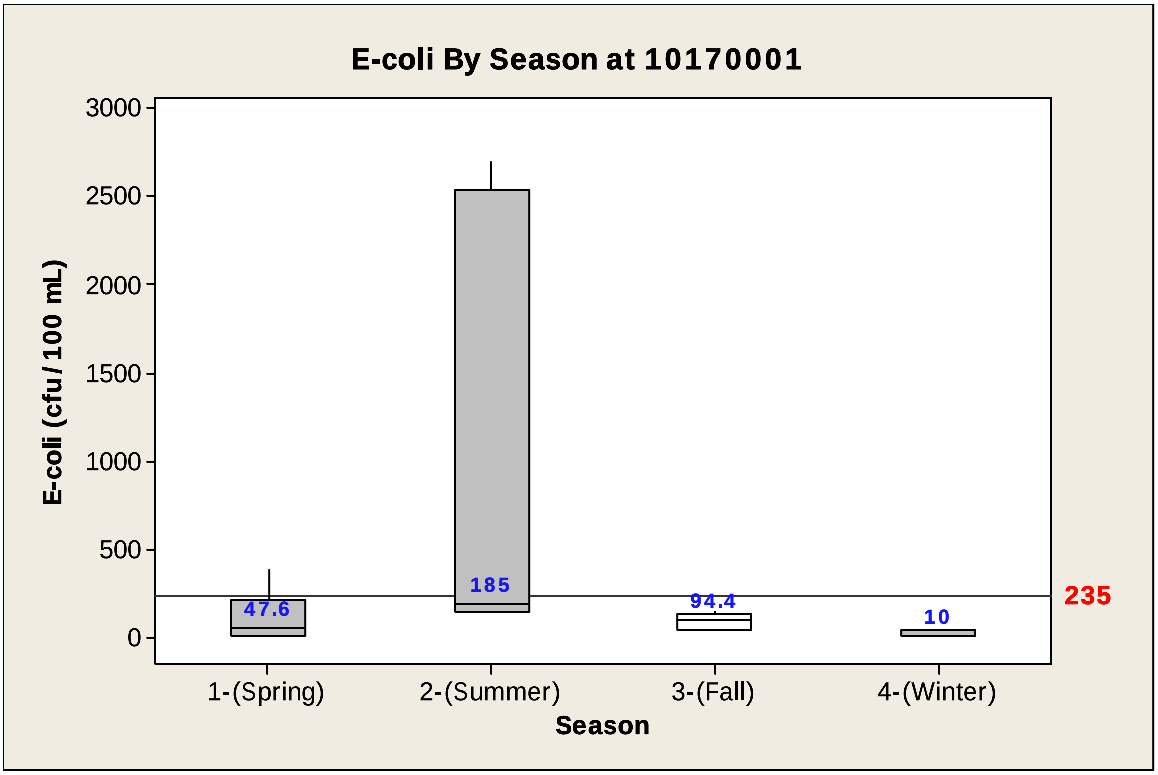


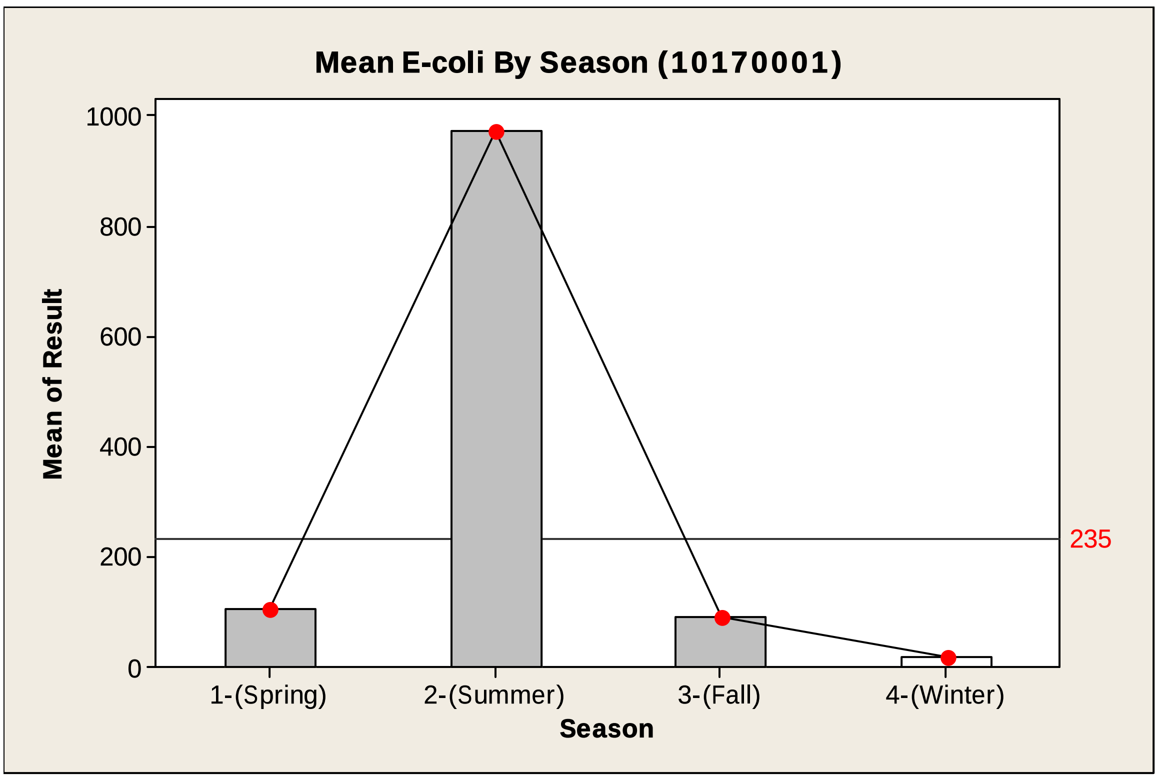


SITE 10170001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	8	103.9	140.3	9.2	10.0	47.6	215.1	380.0
	2-(Summer)	6	972	1257	138	138	185	2538	2700
	3-(Fall)	4	91.4	50.8	36.8	42.6	94.4	137.2	140.0
	4-(Winter)	6	19.55	15.57	9.20	9.80	10.00	36.09	45.00

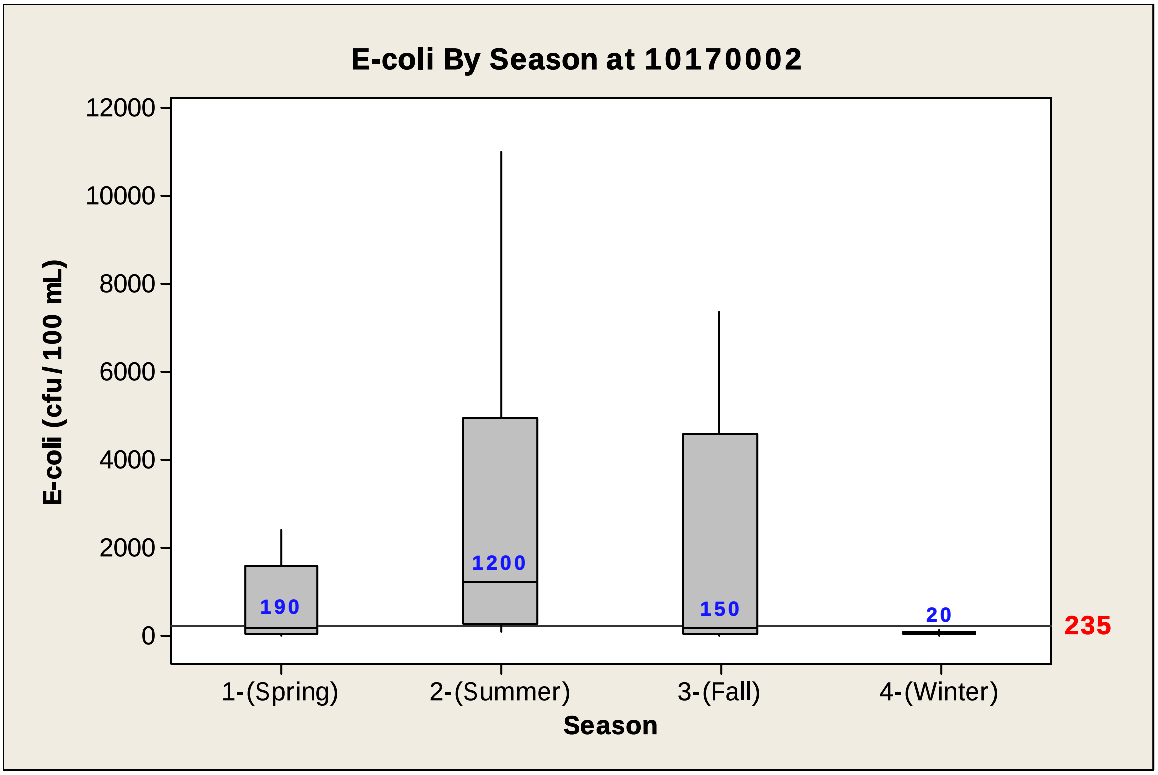

E-coli By Season at 10170001
E-coli (cfu/ 100 mL)
3000
2500
2000
1500
1000
500
0
47.6
185
94.4
10
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

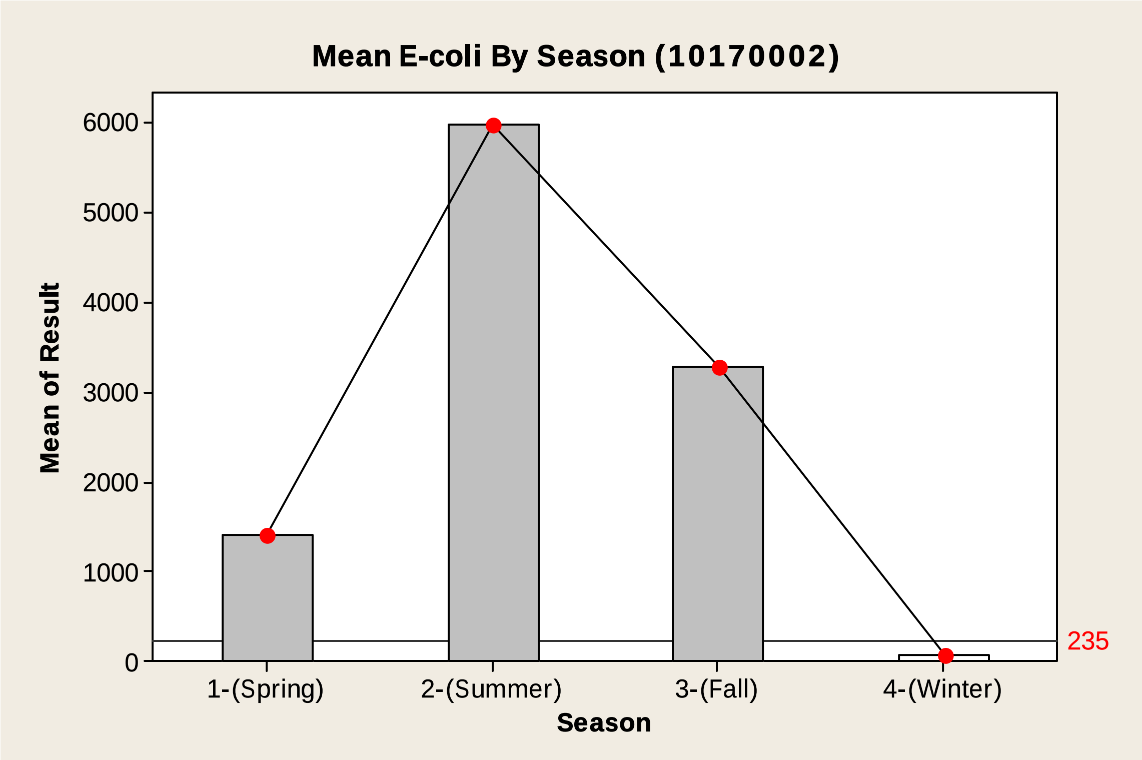

Mean E-coli By Season (10170001)
Mean of Result
1000
800
600
400
200
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10170002

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	64	1401	2723	9	19	190	1575	13800
	2-(Summer)	48	5969	13989	73	273	1200	4945	80040
	3-(Fall)	30	3281	7669	9	39	150	4571	32200
	4-(Winter)	33	66.3	114.3	9.2	10.0	20.0	82.9	533.6

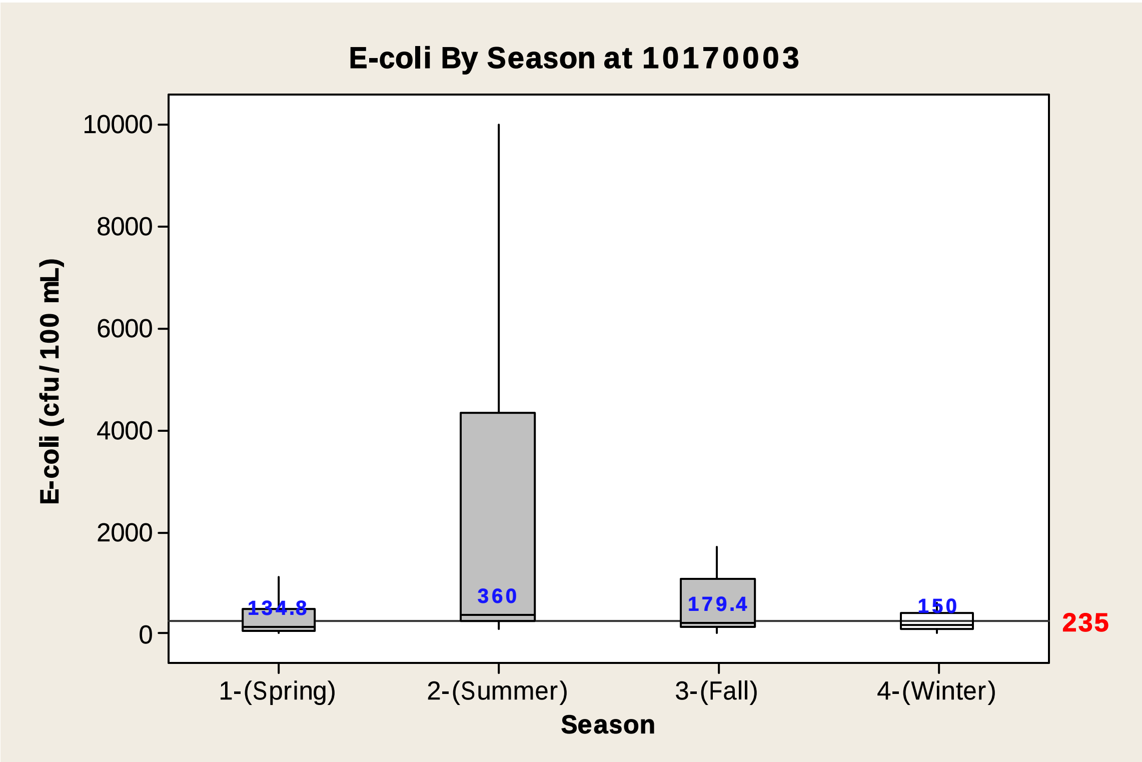


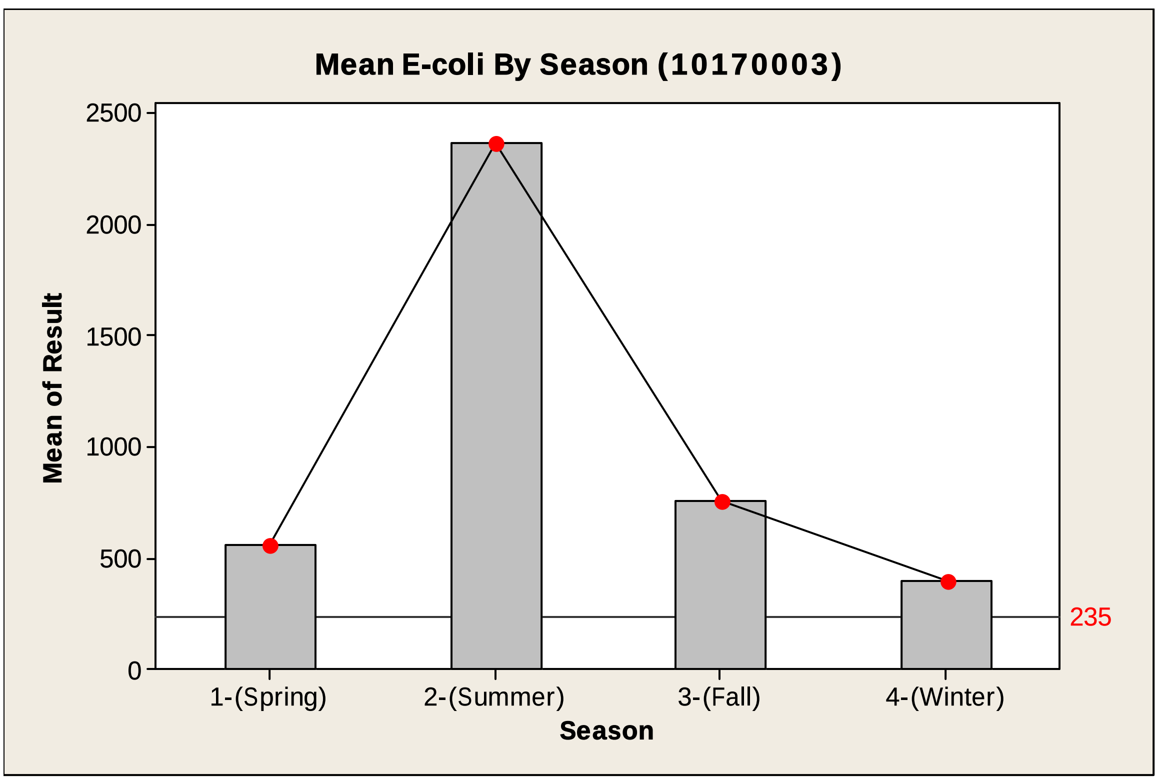


SITE 10170003

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	42	559	1354	9	39	135	490	7084
	2-(Summer)	28	2369	3541	90	226	360	4350	11040
	3-(Fall)	24	757	1178	20	118	179	1058	5300
	4-(Winter)	33	399	635	9	96	150	400	2576

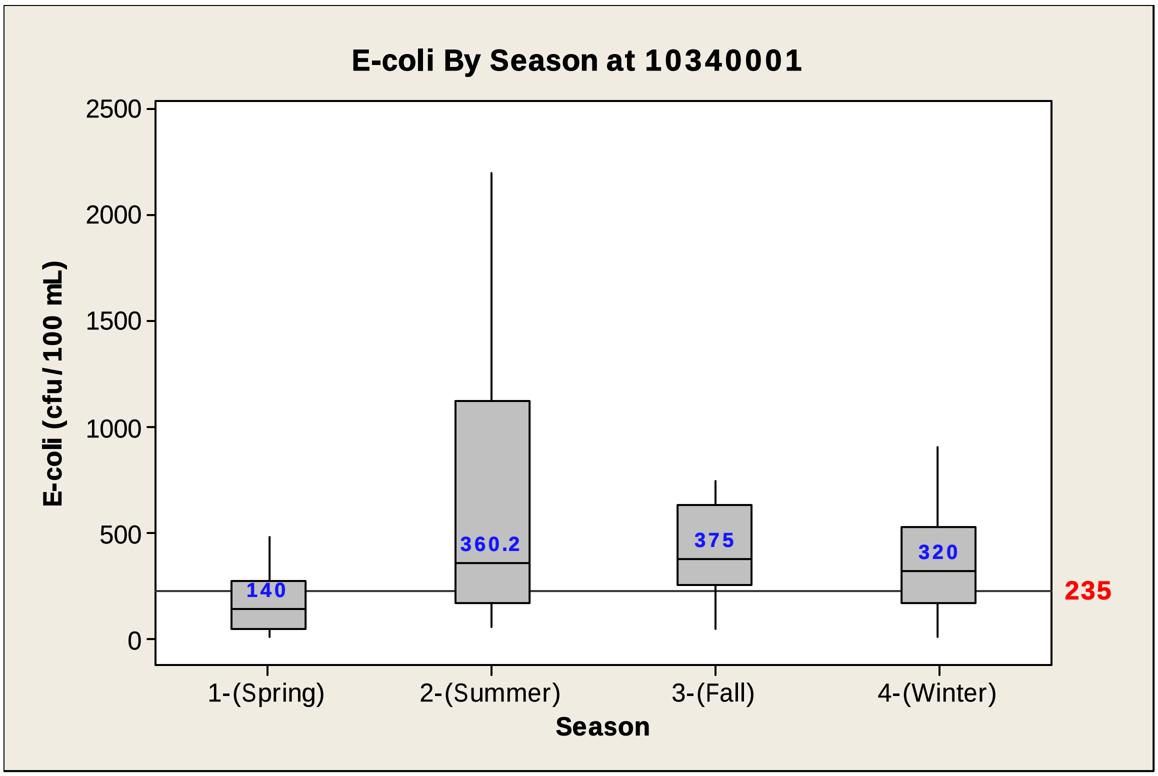

E-coli By Season at 10170003
E-coli (cfu/ 100 mL)
10000
8000
6000
4000
2000
0
134.8
360
179.4
150
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

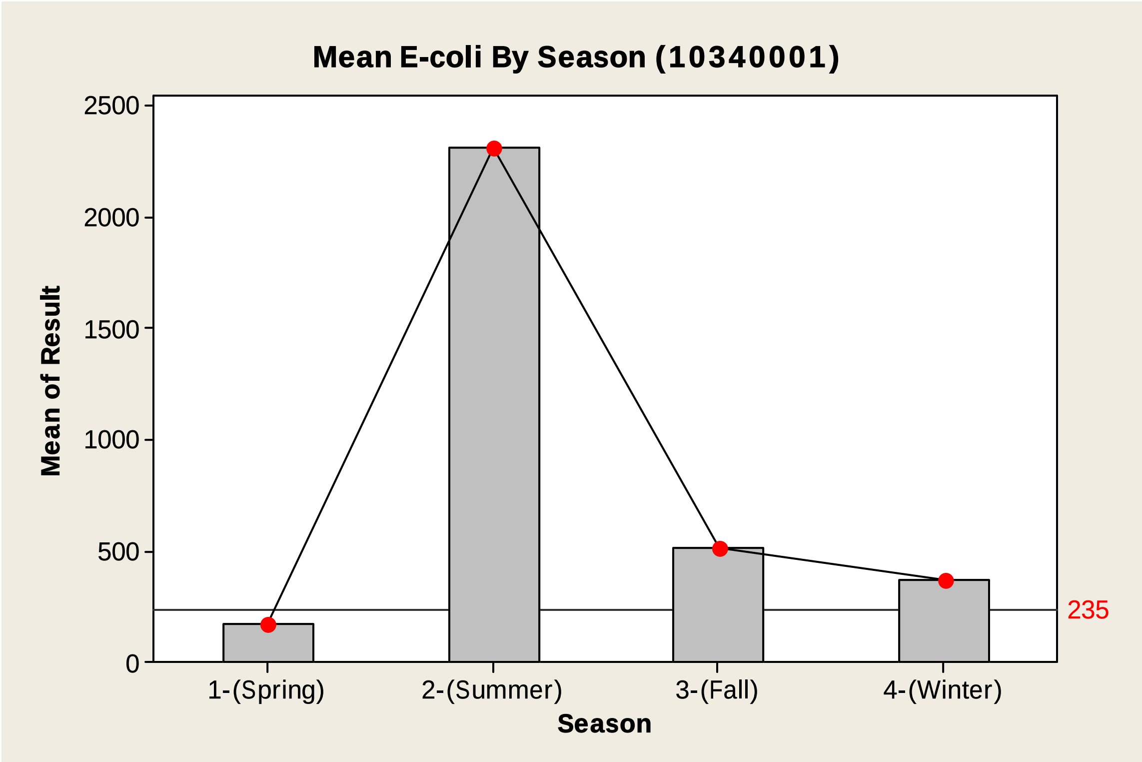

Mean E-coli By Season (10170003)
Mean of Result
2500
2000
1500
1000
500
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10340001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	60	171.8	147.4	9.2	45.3	140.0	277.5	480.0
	2-(Summer)	46	2309	7519	60	174	360	1127	40480
	3-(Fall)	32	516.7	442.6	50.0	254.2	375.0	631.8	2024.0
	4-(Winter)	39	373.3	294.6	10.0	170.0	320.0	533.6	1380.0

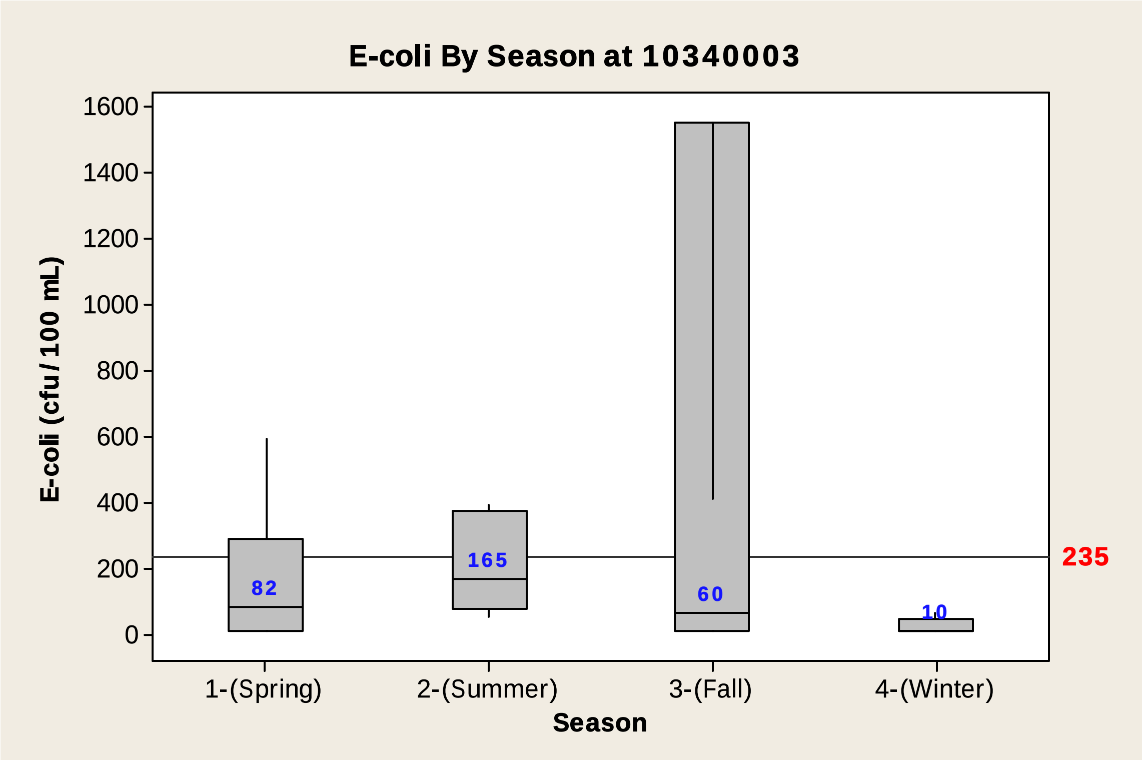


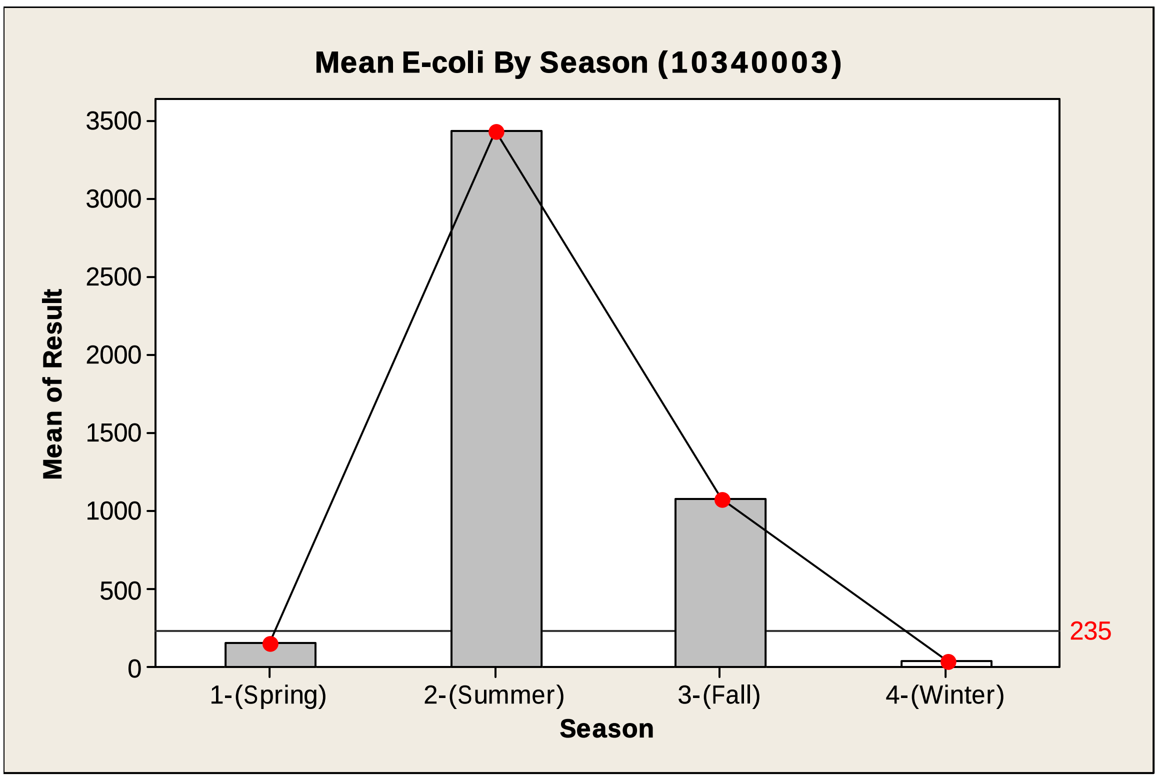


SITE 10340003

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	16	148.1	178.9	10.0	10.0	82.0	285.0	588.8
	2-(Summer)	16	3434	8594	51	77	165	373	27600
	3-(Fall)	10	1080	2114	9	10	60	1550	5200
	4-(Winter)	12	34.0	52.0	9.2	10.0	10.0	42.5	190.0

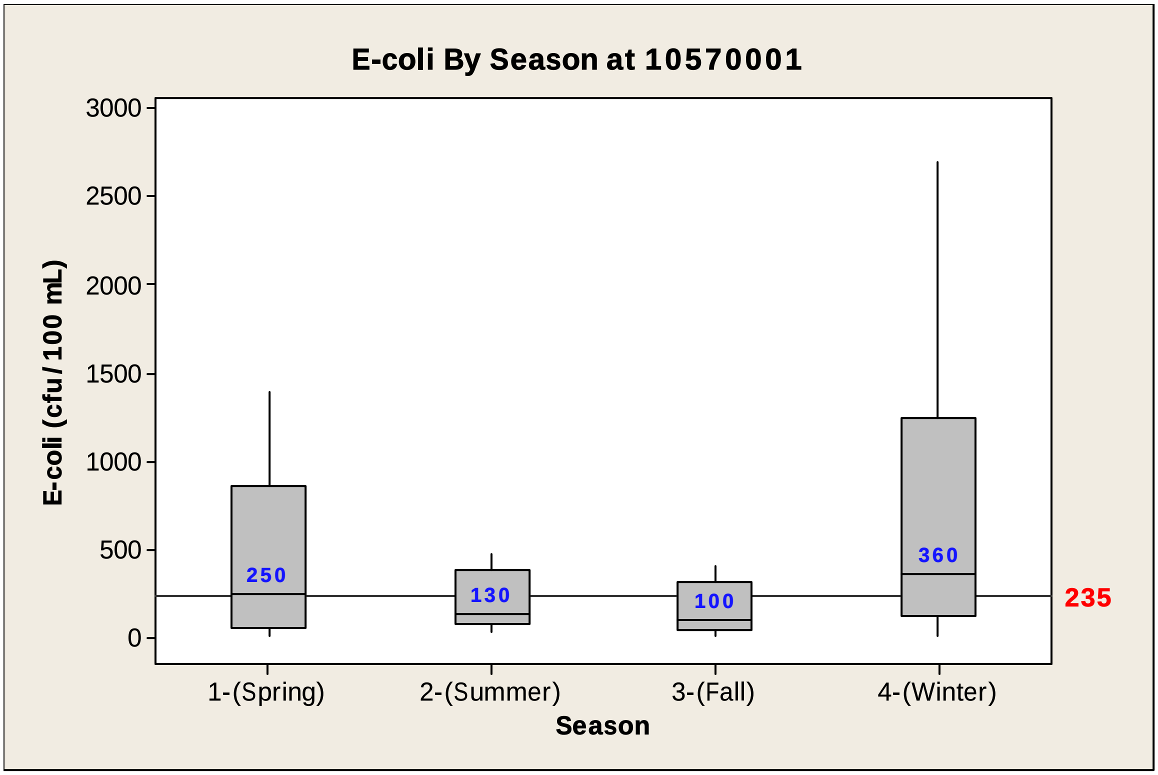

E-coli By Season at 10340003
E-coli (cfu/ 100 mL)
1600
1400
1200
1000
800
600
400
200
0
82
165
60
10
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

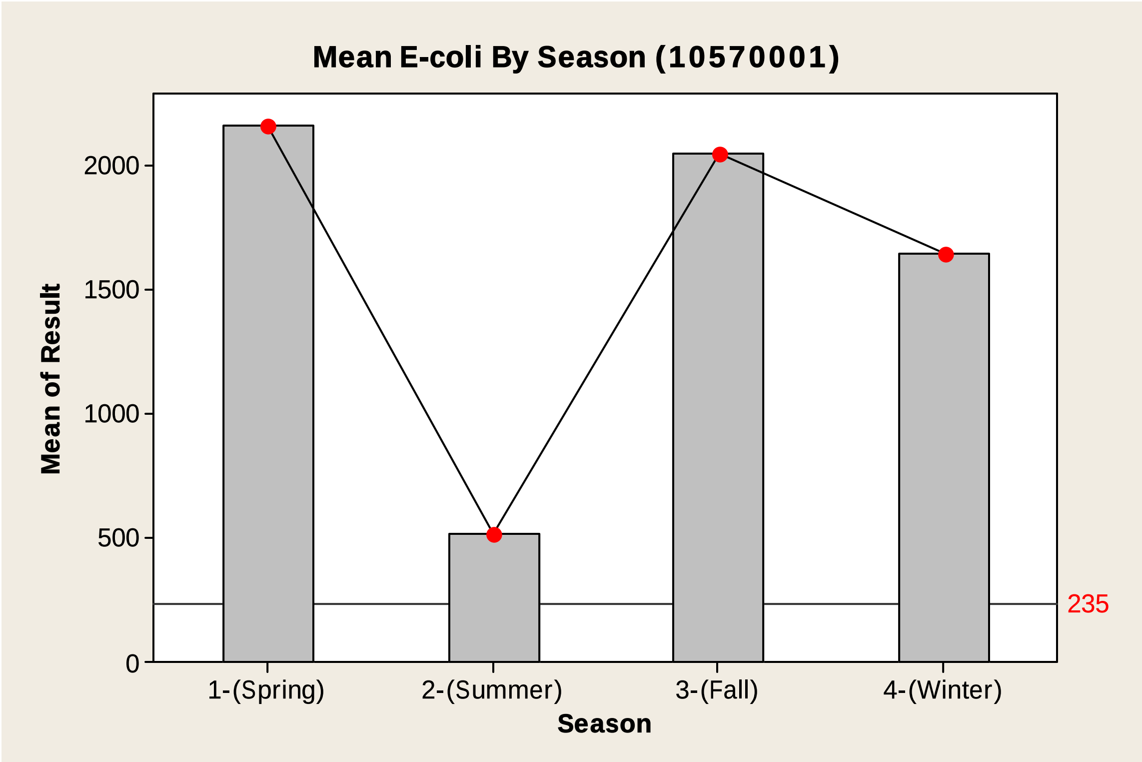

Mean E-coli By Season (10340003)
Mean of Result
3500
3000
2500
2000
1500
1000
500
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10570001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	61	2157	10524	10	55	250	862	82000
	2-(Summer)	59	515	1021	27	80	130	380	6164
	3-(Fall)	37	2049	6688	10	36	100	311	31280
	4-(Winter)	33	1641	3367	10	124	360	1242	14720

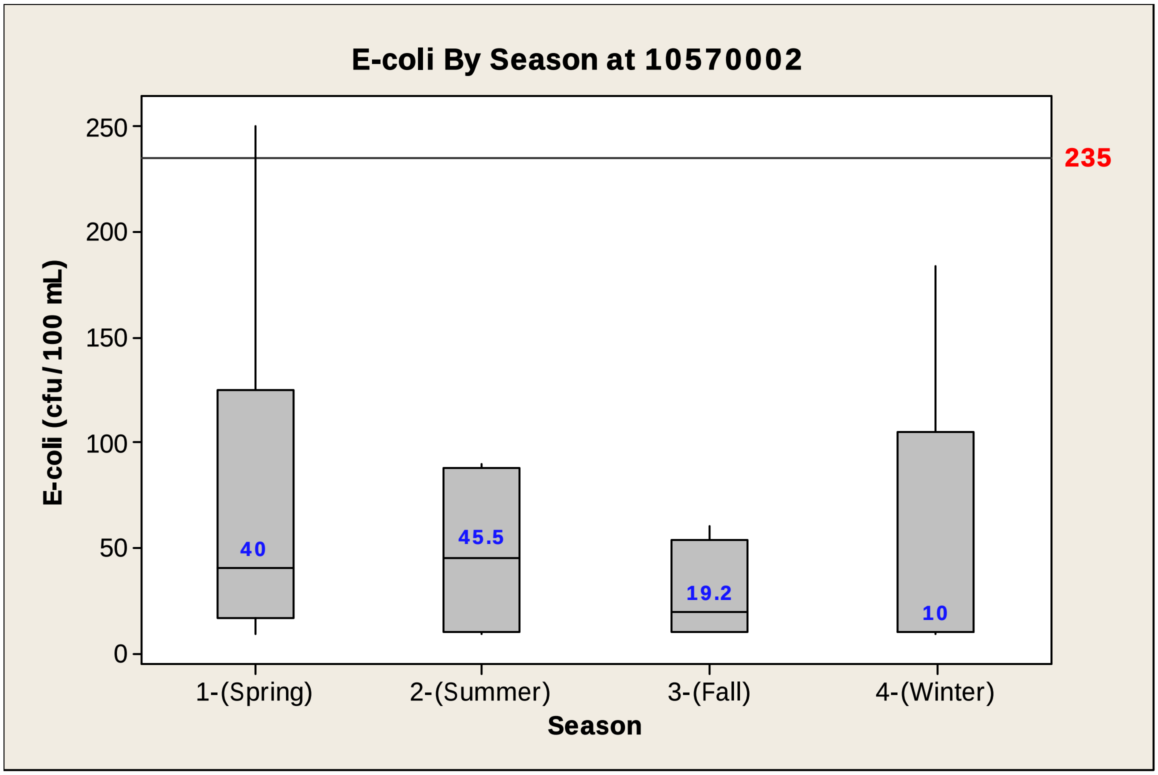


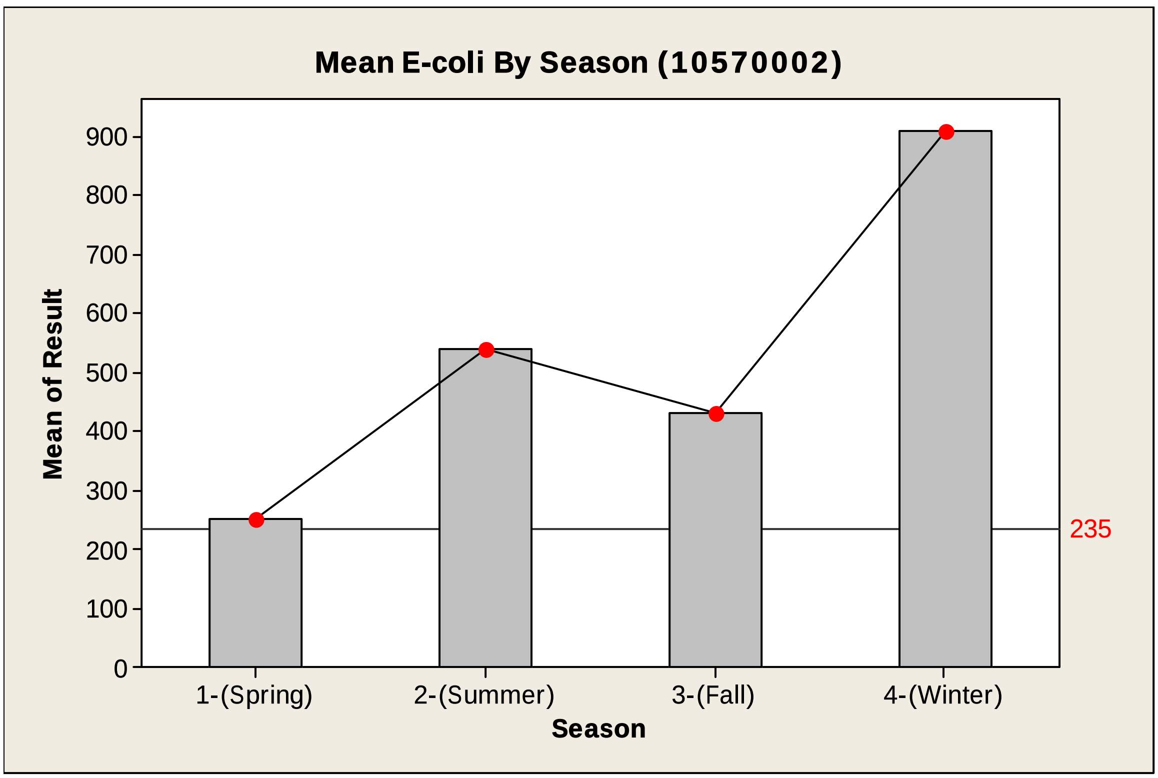


SITE 10570002

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	42	250	730	9	16	40	125	4140
	2-(Summer)	28	539	1554	9	10	46	88	6000
	3-(Fall)	24	430	1291	10	10	19	54	4800
	4-(Winter)	33	908	3496	9	10	10	105	16560

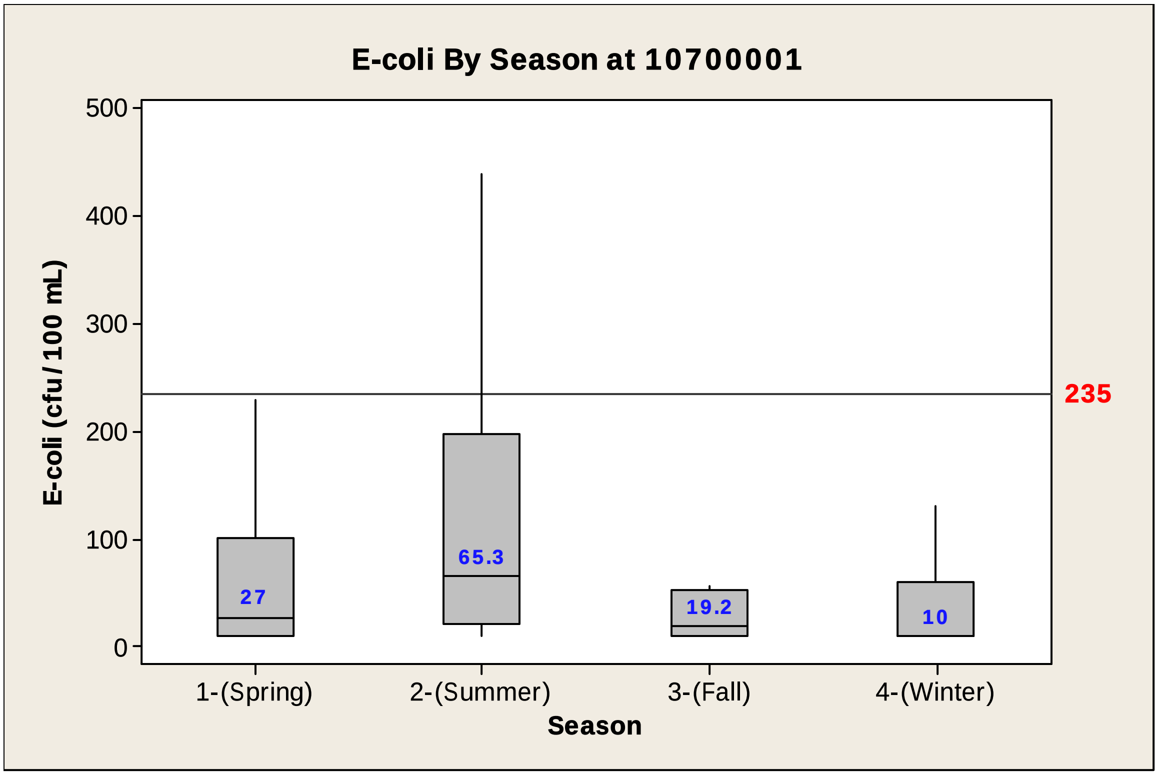

E-coli By Season at 10570002
E-coli (cfu/100 mL)
250
200
150
100
50
0
235
40
45.5
19.2
10
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

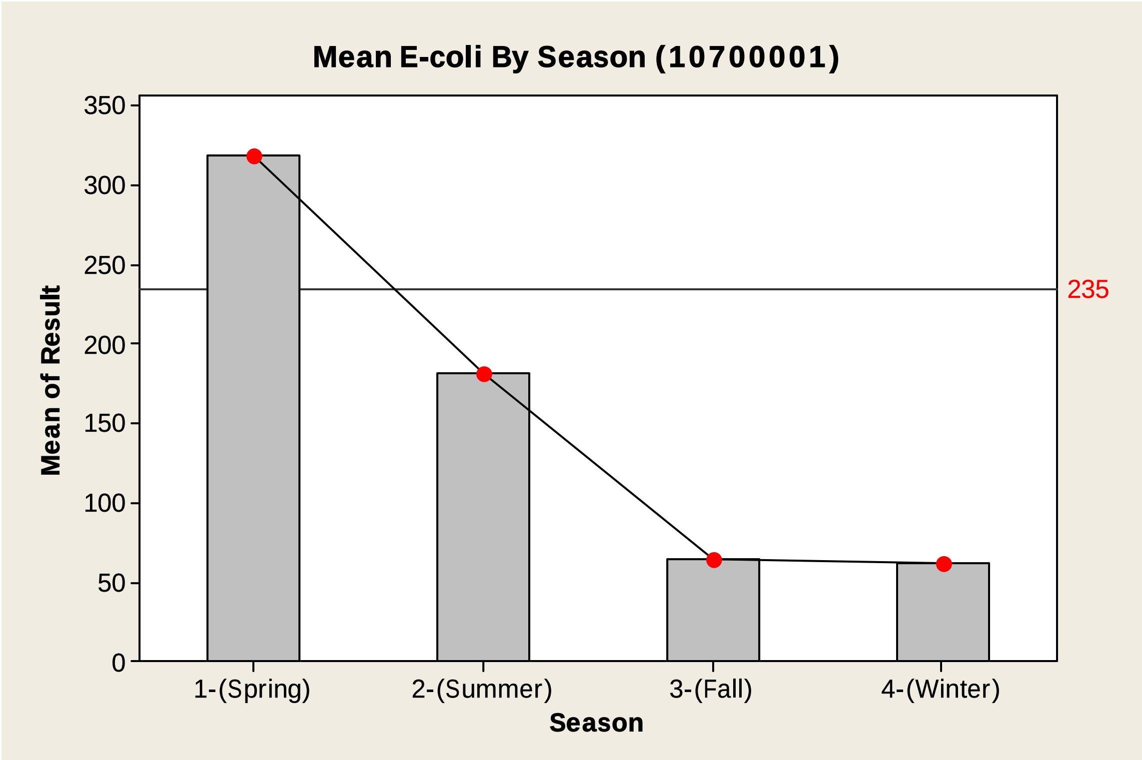

Mean E-coli By Season (10570002)
Mean of Result
900
800
700
600
500
400
300
200
100
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 10700001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	48	318	1068	9	10	27	100	5980
	2-(Summer)	34	181.1	316.0	10.0	20.0	65.3	197.5	1380.0
	3-(Fall)	26	64.7	94.2	9.2	10.0	19.2	51.8	331.2
	4-(Winter)	39	61.5	98.3	9.2	10.0	10.0	60.0	380.0

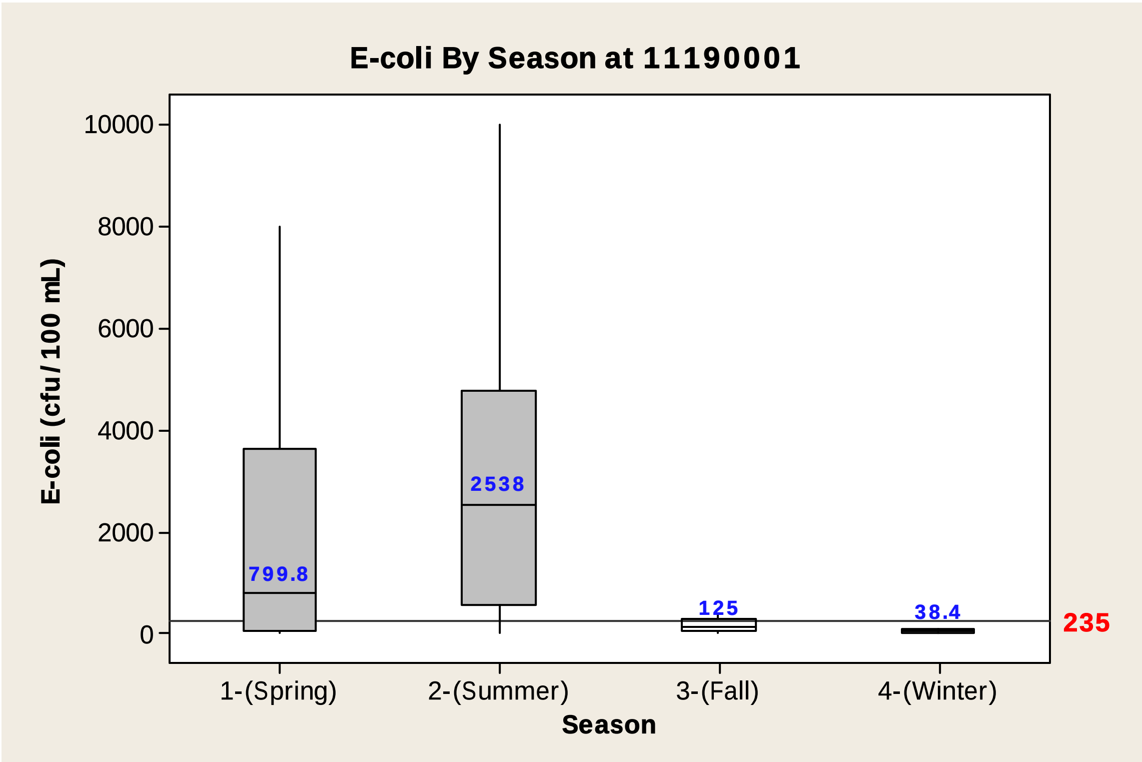


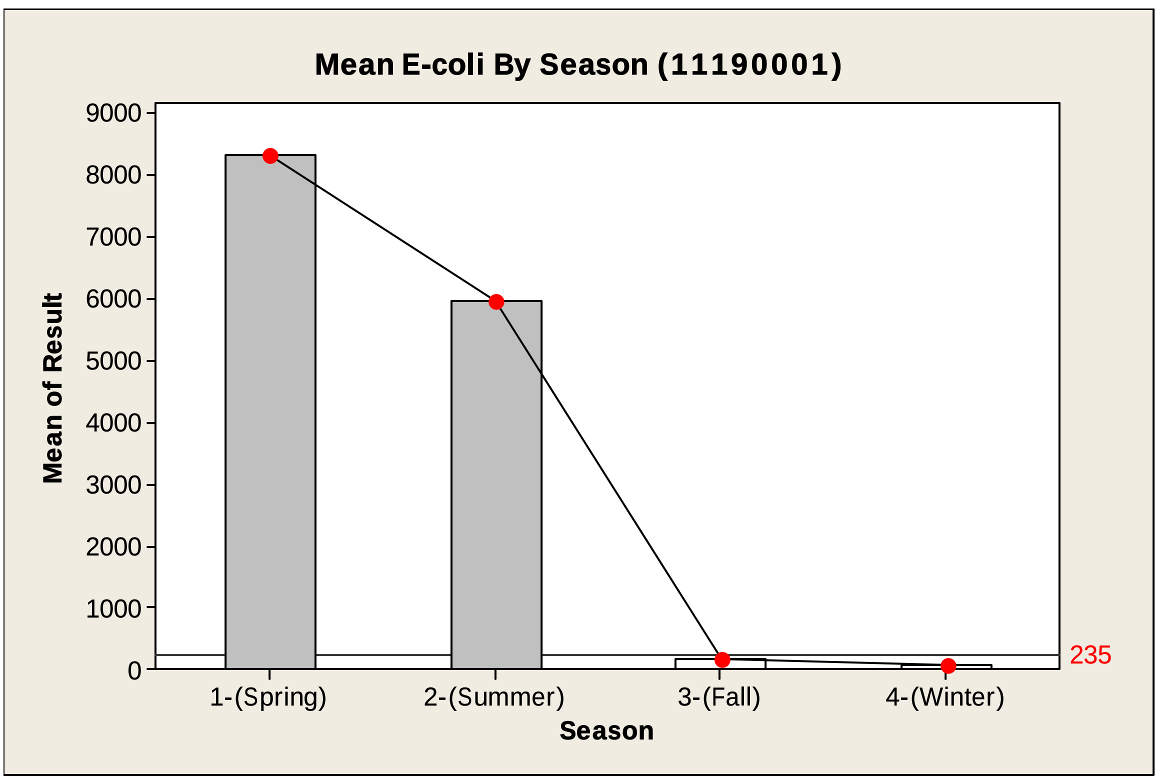


SITE 11190001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	50	8328	21497	9	33	800	3622	110400
	2-(Summer)	52	5975	12607	10	564	2538	4761	80960
	3-(Fall)	16	154.8	117.6	18.4	41.2	125.0	280.8	349.6
	4-(Winter)	14	70.2	121.4	9.2	10.0	38.4	85.3	478.4

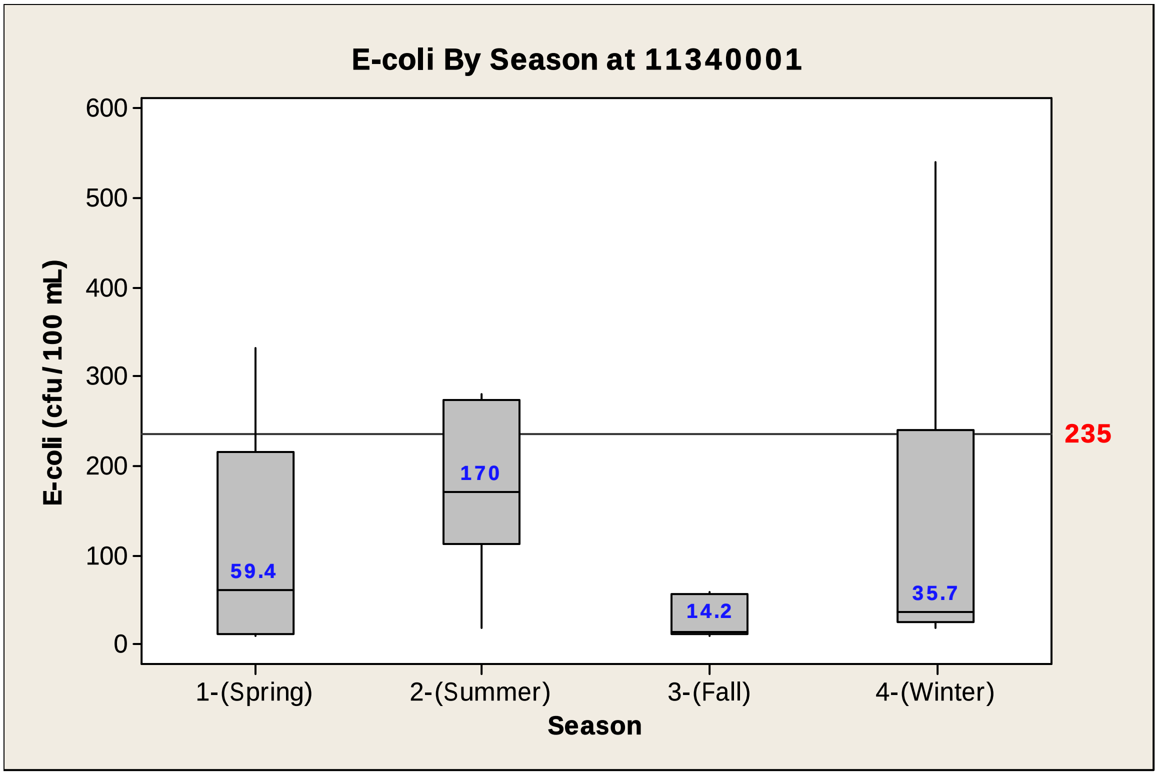

E-coli By Season at 11190001
E-coli (cfu/100 mL)
10000
8000
6000
4000
2000
0
799.8
2538
125
38.4
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

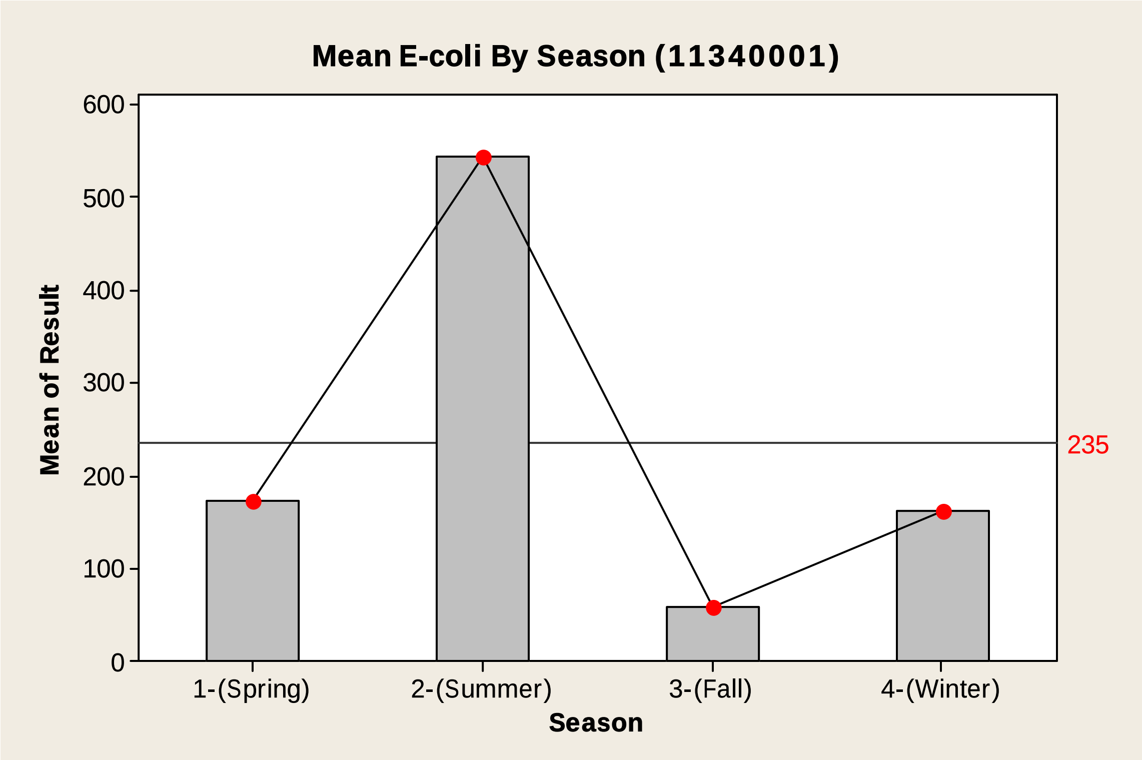

Mean E-coli By Season (11190001)
Mean of Result
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
235
1-(Spring)
2-(Summer)
3-(Fall)
4-(Winter)
Season

SITE 11340001

Descriptive Statistics: Result

Variable	Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	1-(Spring)	26	171.8	268.8	9.2	10.0	59.4	215.0	1104.0
	2-(Summer)	24	544	1065	18	113	170	274	4048
	3-(Fall)	16	58.5	93.3	9.2	10.0	14.2	55.2	312.8
	4-(Winter)	14	162.5	232.0	18.4	25.3	35.7	239.7	763.6

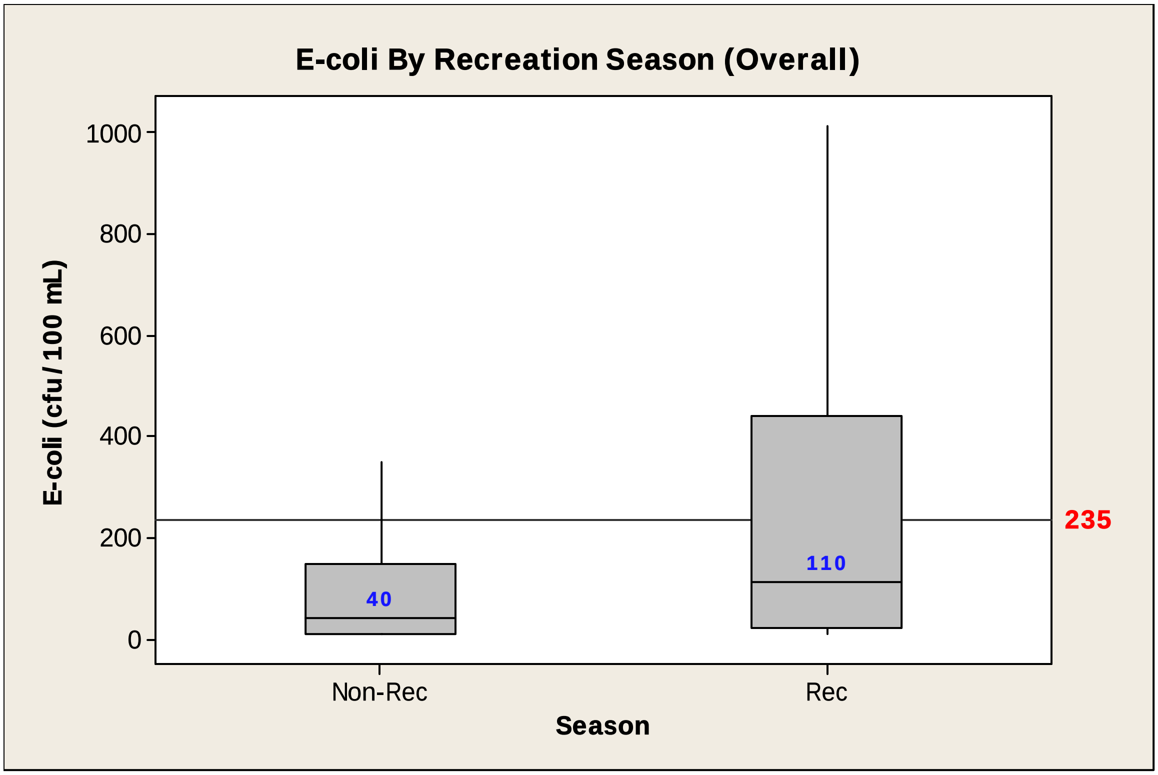


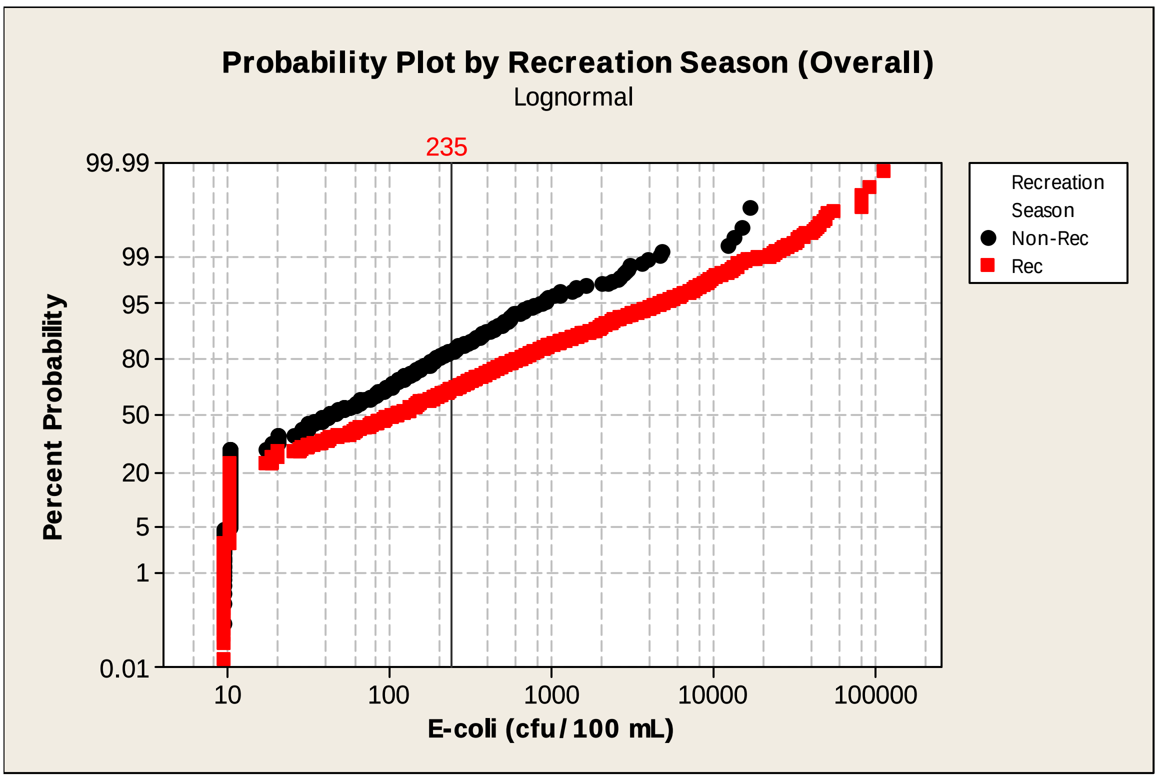


STATISTICS BY RECREATION SEASON

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	629	271.1	1211.6	9.2	10.0	40.0	147.2	16560.0
	Rec	4486	1080	4678	9.2	18.4	110	440	110400


E-coli By Recreation Season (Overall)
E-coli (cfu/100 mL)
1000
800
600
400
200
0
40
110
235
Non-Rec
Rec
Season

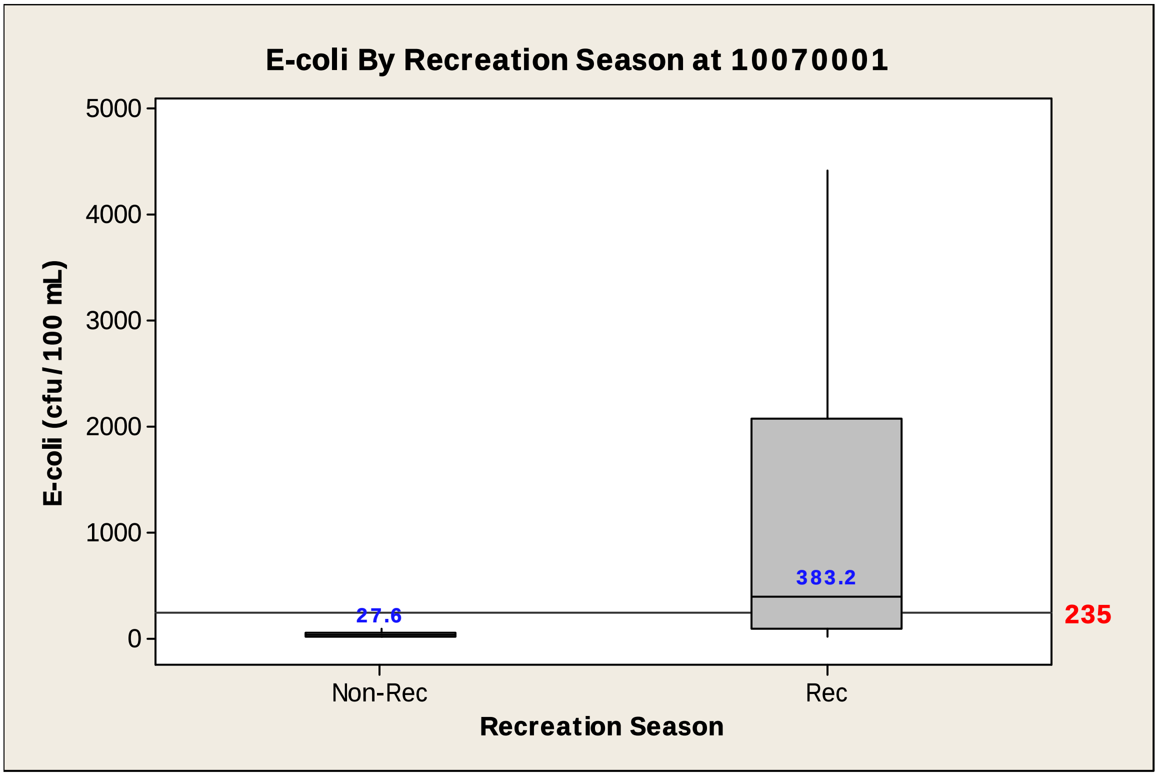

Probability Plot by Recreation Season (Overall)
Lognormal
235
Percent Probability
99.99
99
95
80
50
20
5
1
0.01
10
100
1000
10000
100000
E-coli (cfu/100 mL)
Recreation Season
Non-Rec
Rec

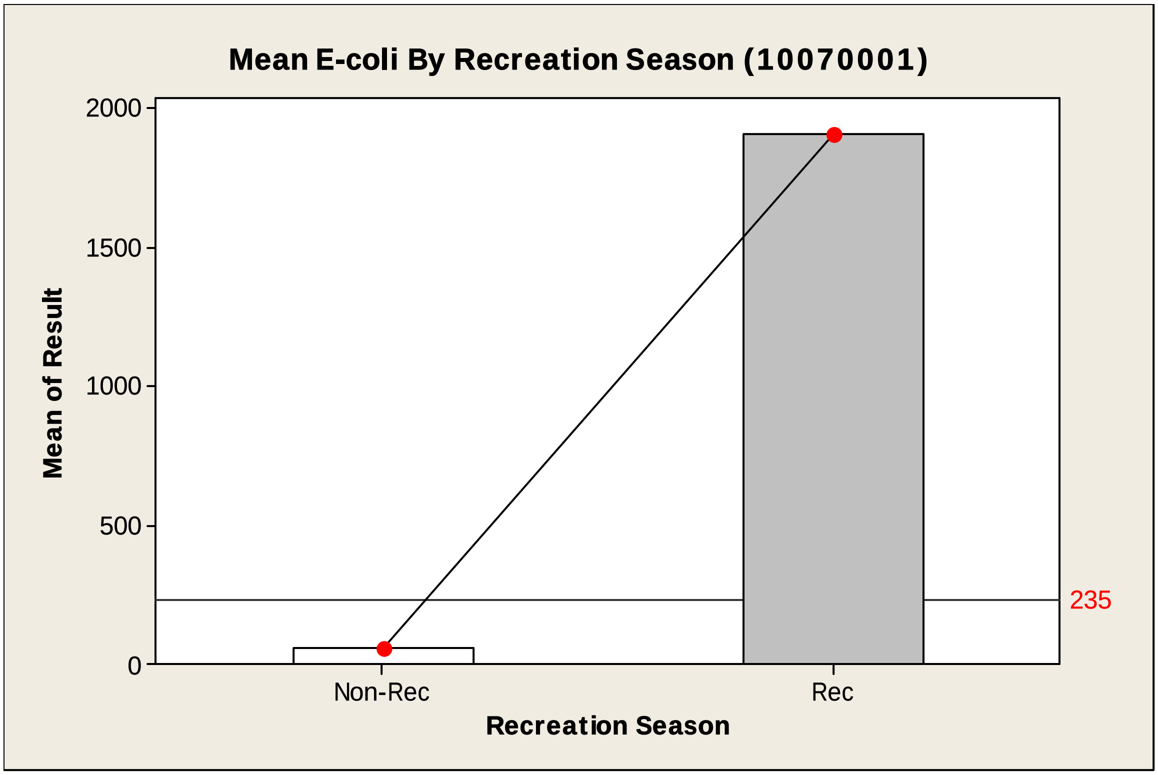
STATISTICS BY RECREATION SEASON BY SITE

SITE 10070001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	54.8	94.3	9.2	10.0	27.6	50.0	540.0
	Rec	172	1911	3791	9	91	383	2075	23920

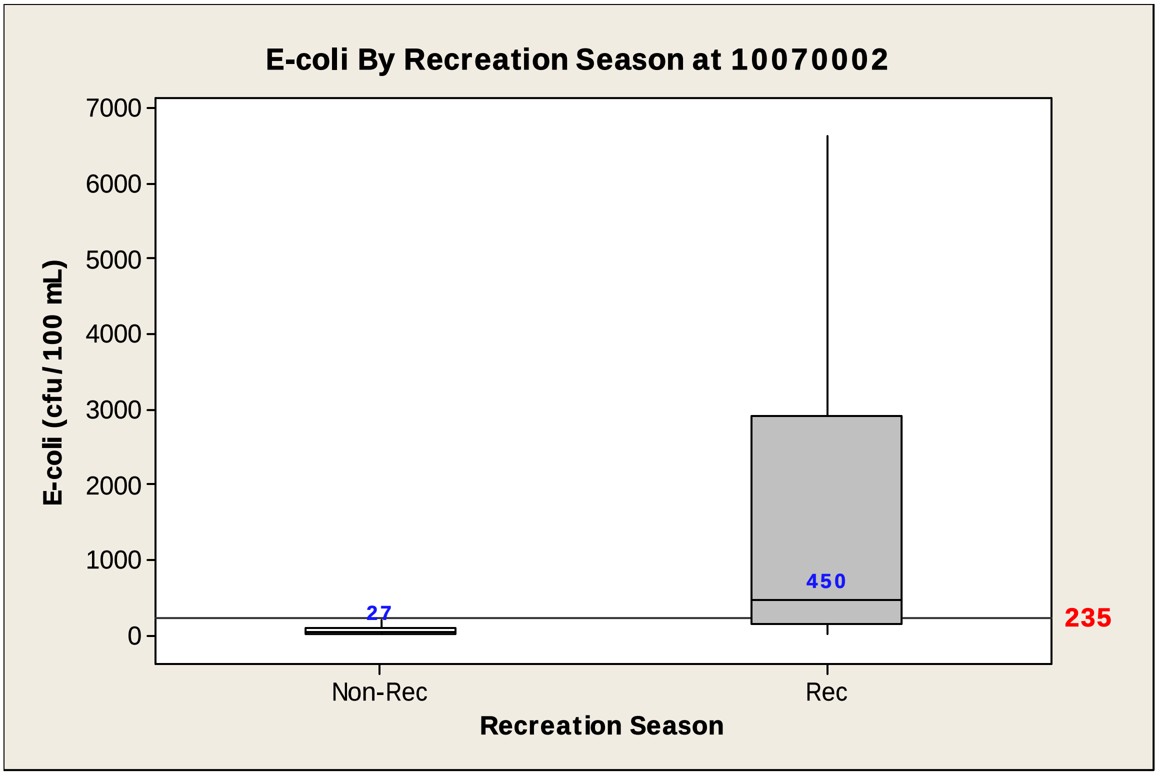


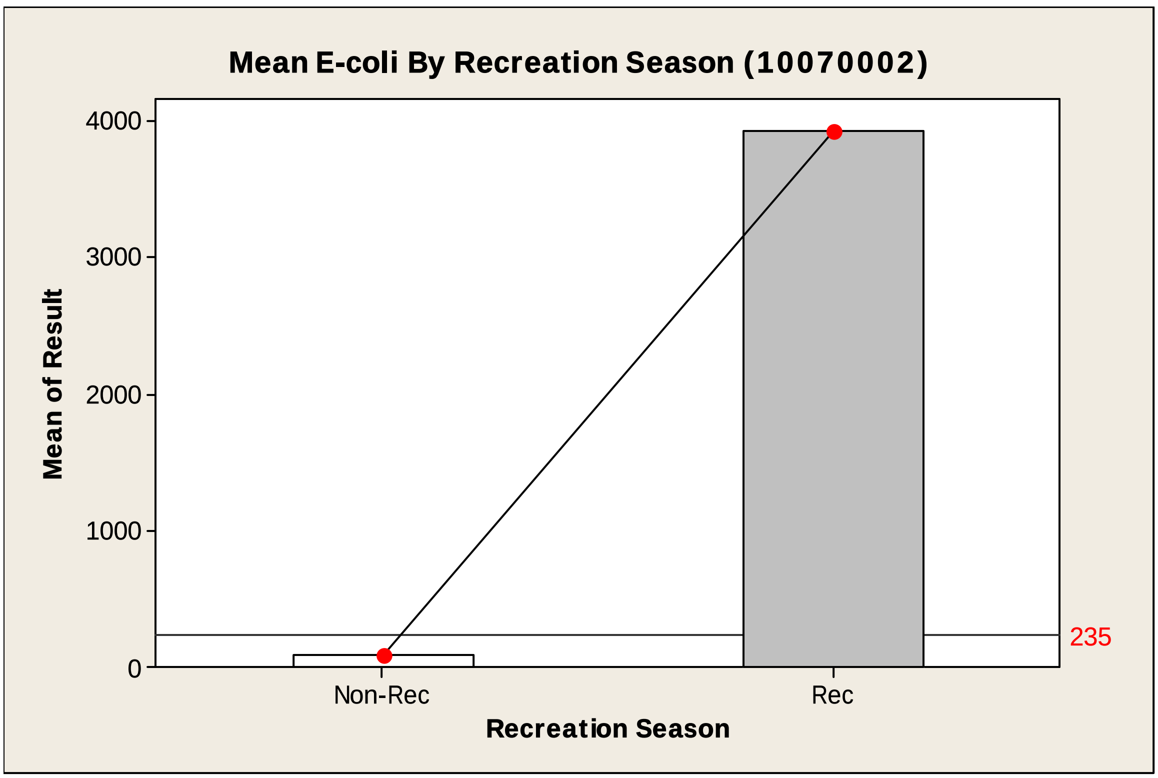


SITE 10070002

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	88.0	182.4	9.2	10.0	27.0	92.0	1100.0
	Rec	153	3920	8648	9	134	450	2898	47000

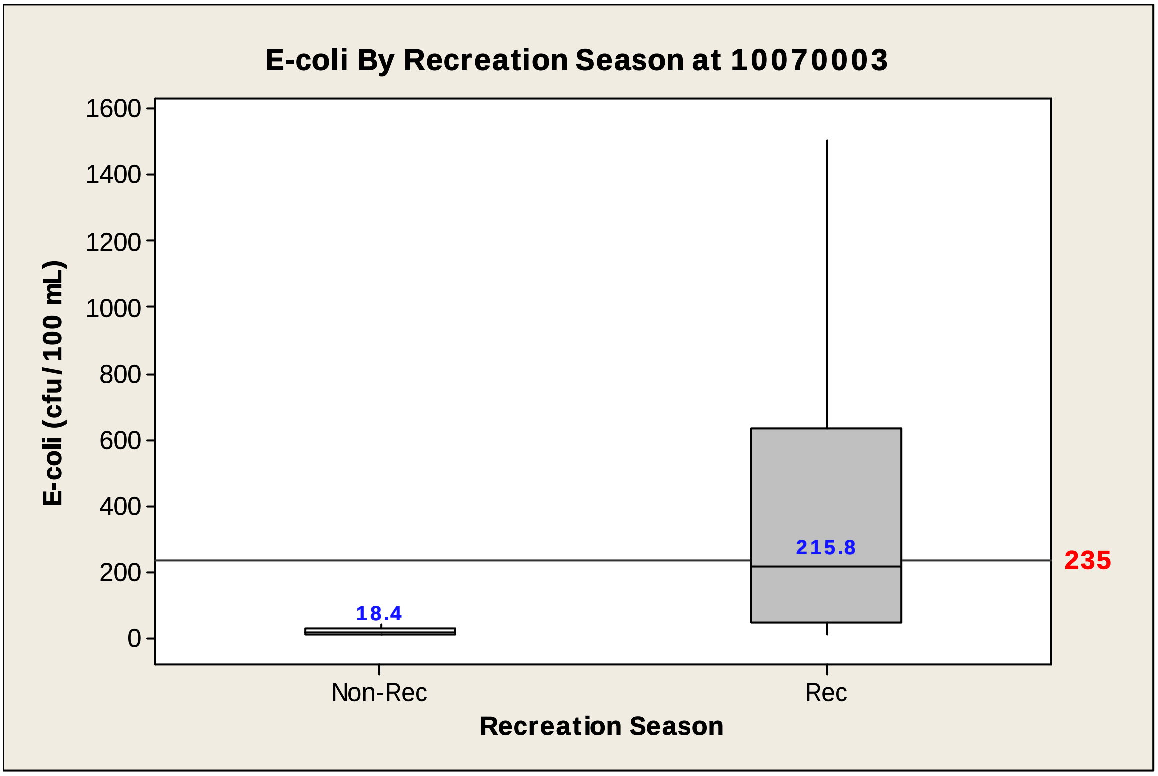

E-coli By Recreation Season at 10070002
E-coli (cfu/100 mL)
7000
6000
5000
4000
3000
2000
1000
0
27
450
235
Non-Rec
Rec
Recreation Season

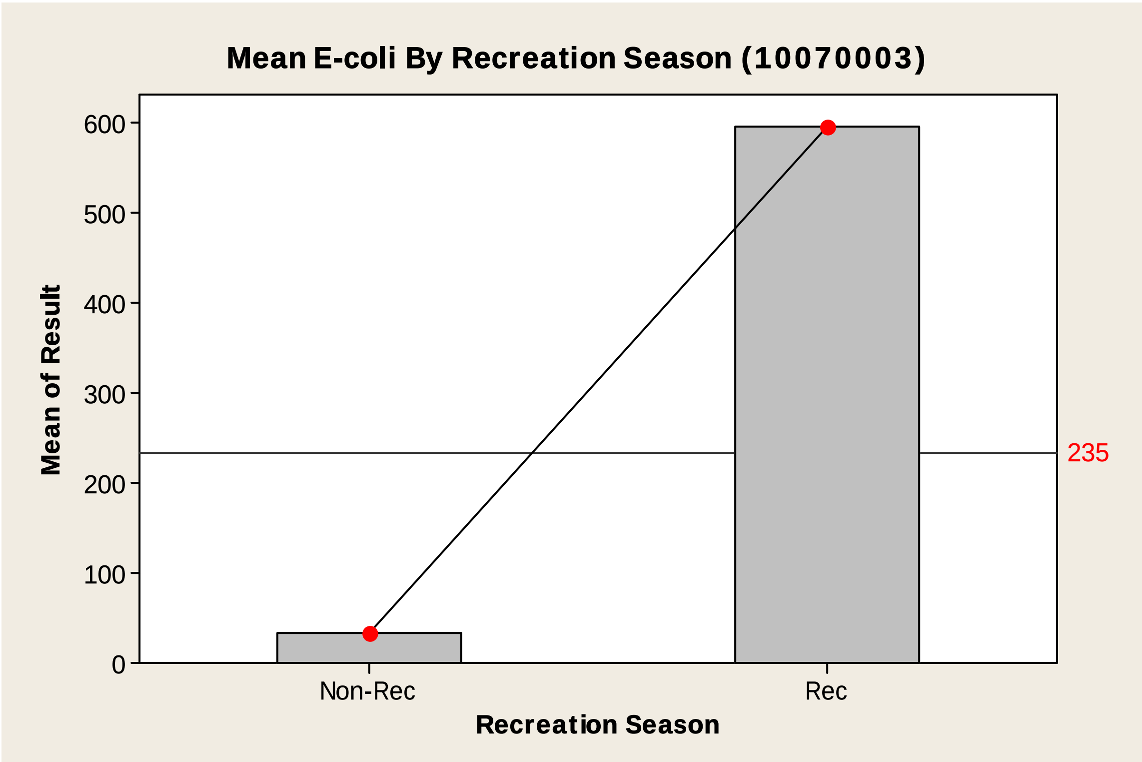

Mean E-coli By Recreation Season (10070002)
Mean of Result
4000
3000
2000
1000
0
235
Non-Rec
Rec
Recreation Season

SITE 10070003

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	32.70	59.43	9.20	10.00	18.40	30.00	360.00
	Rec	182	595.9	1090.2	9.2	45.0	215.8	630.0	8000.0

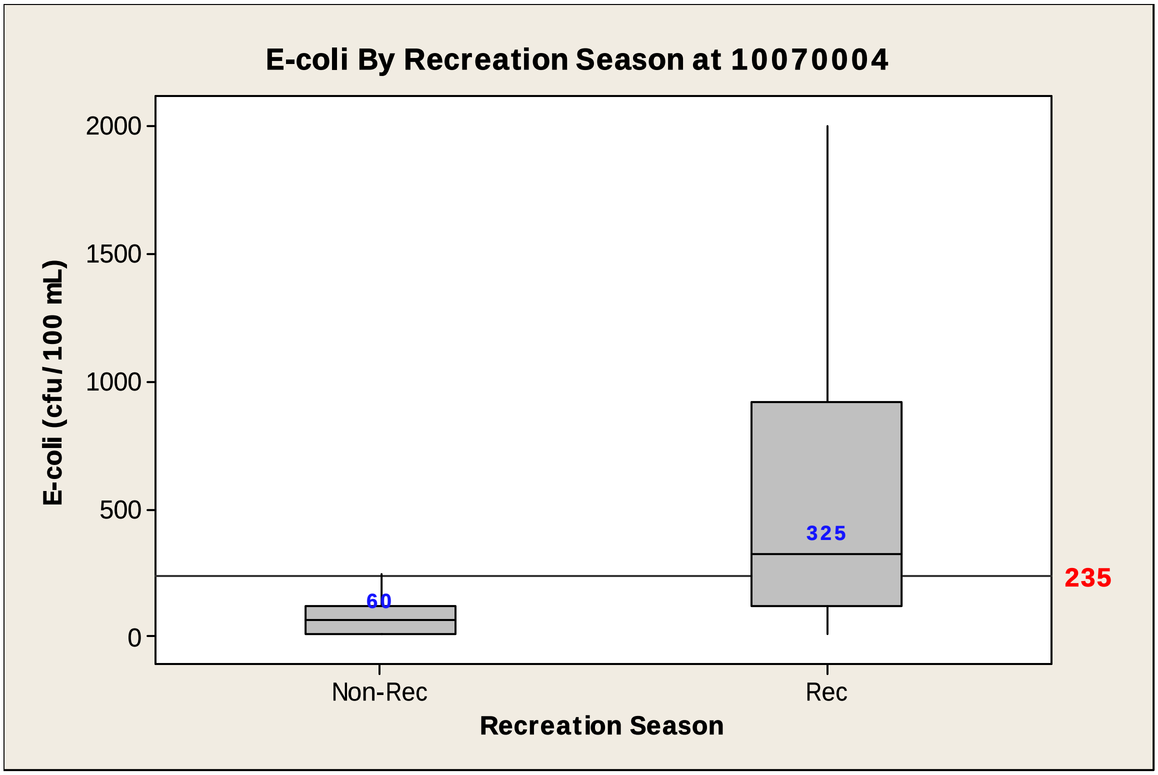


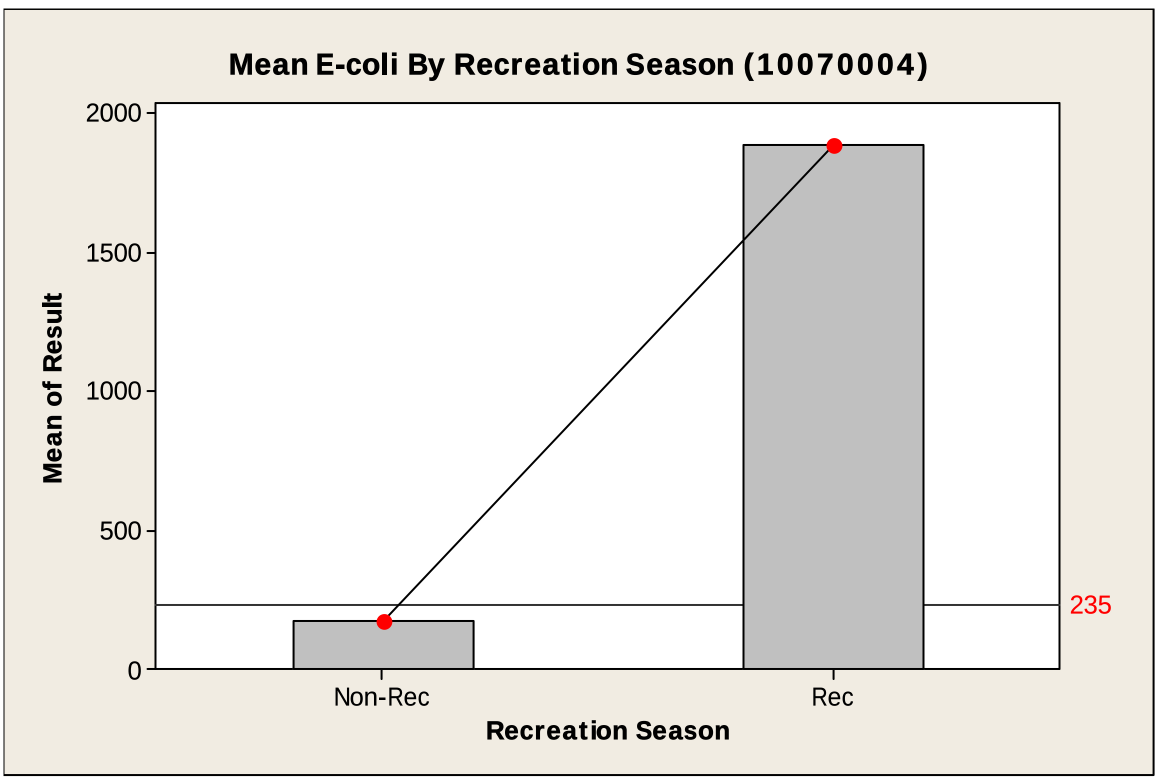


SITE 10070004

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	175.9	487.6	9.2	10.0	60.0	120.0	3000.0
	Rec	208	1886	5397	9	120	325	915	47840

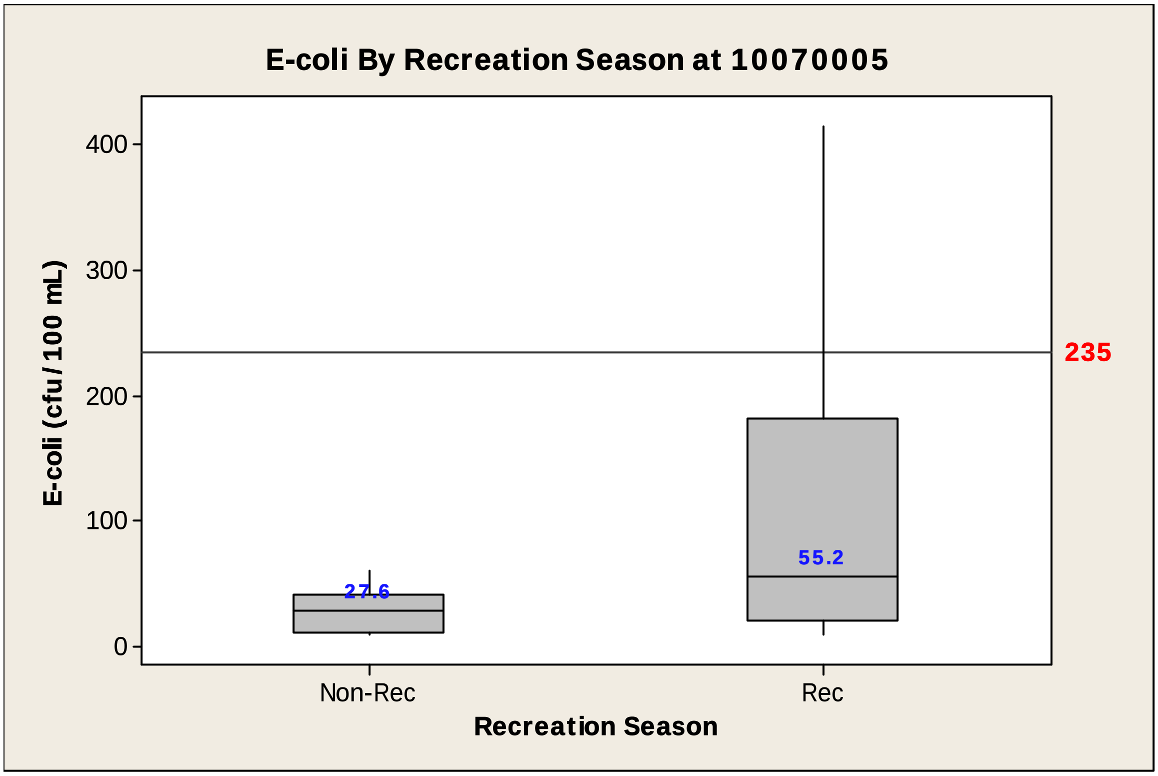

E-coli By Recreation Season at 10070004
E-coli (cfu/100 mL)
2000
1500
1000
500
0
325
60
235
Non-Rec
Rec
Recreation Season

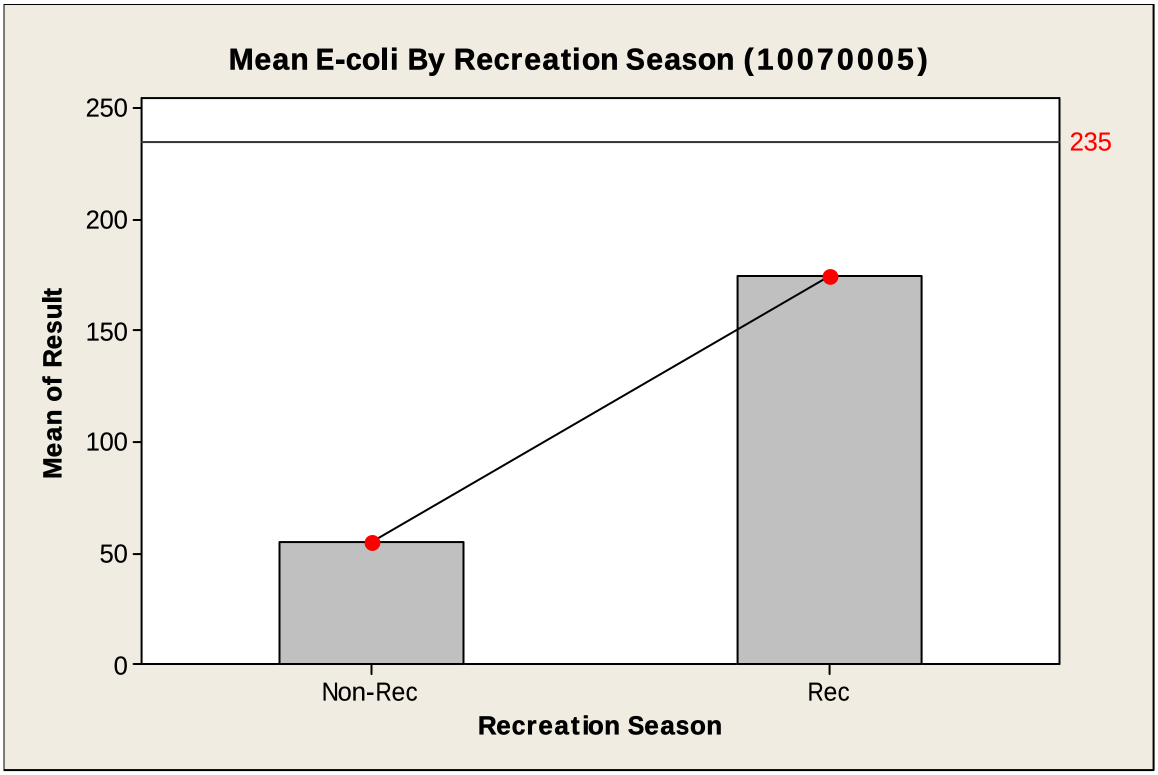

Mean E-coli By Recreation Season (10070004)
Mean of Result
2000
1500
1000
500
0
235
Non-Rec
Rec
Recreation Season

SITE 10070005

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	33	55.3	116.4	9.2	10.0	27.6	41.4	640.0
	Rec	94	174.9	389.1	9.2	20.0	55.2	181.0	2300.0

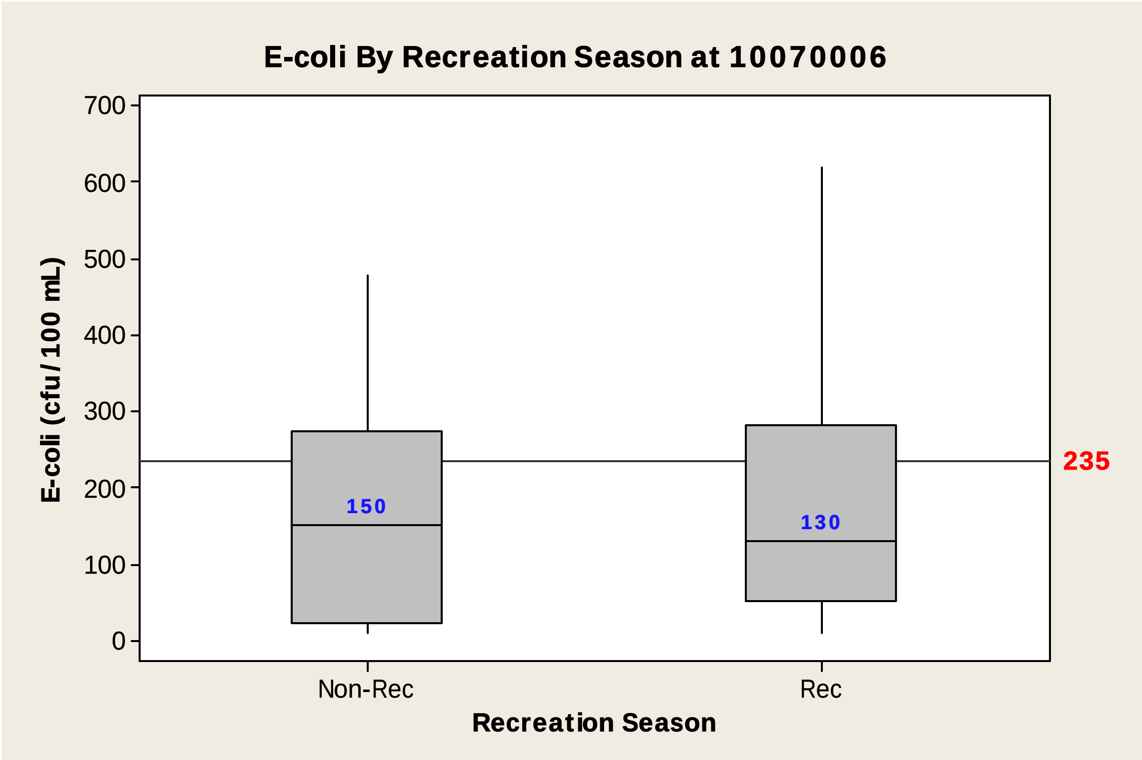


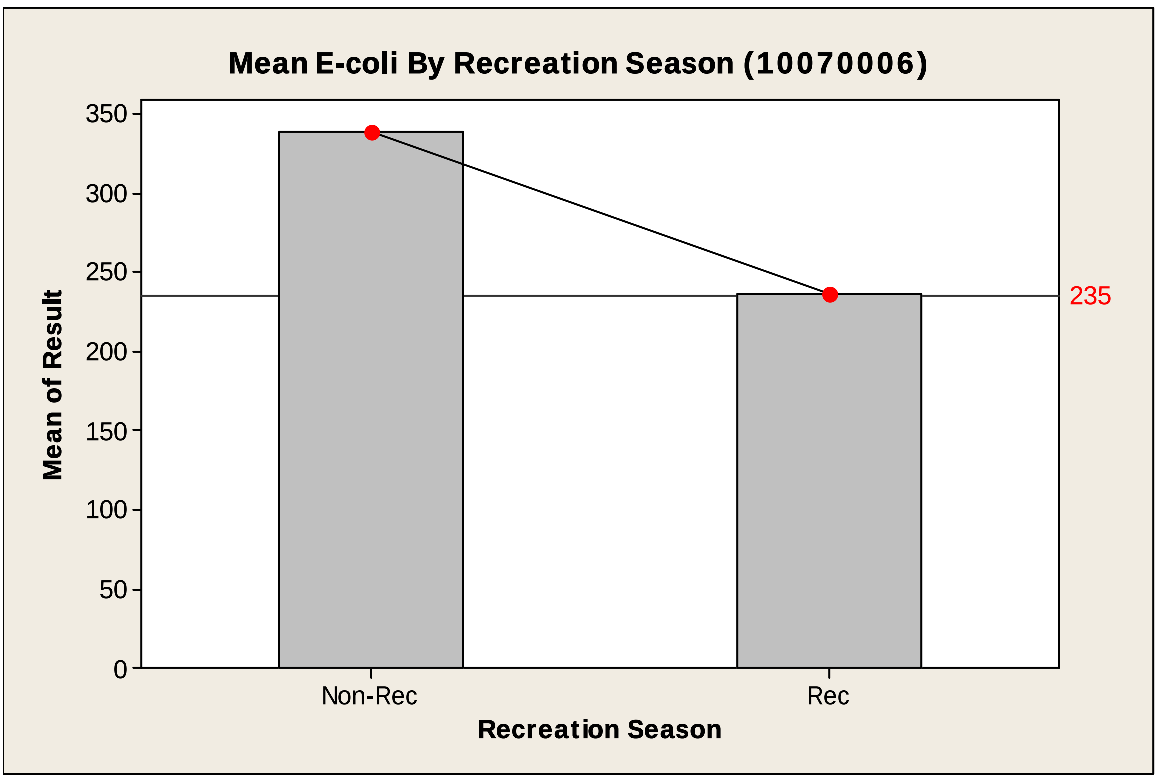


SITE 10070006

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	33	338	714	10	23	150	273	3496
	Rec	94	236.3	300.1	9.2	50.0	130.0	282.5	1748.0

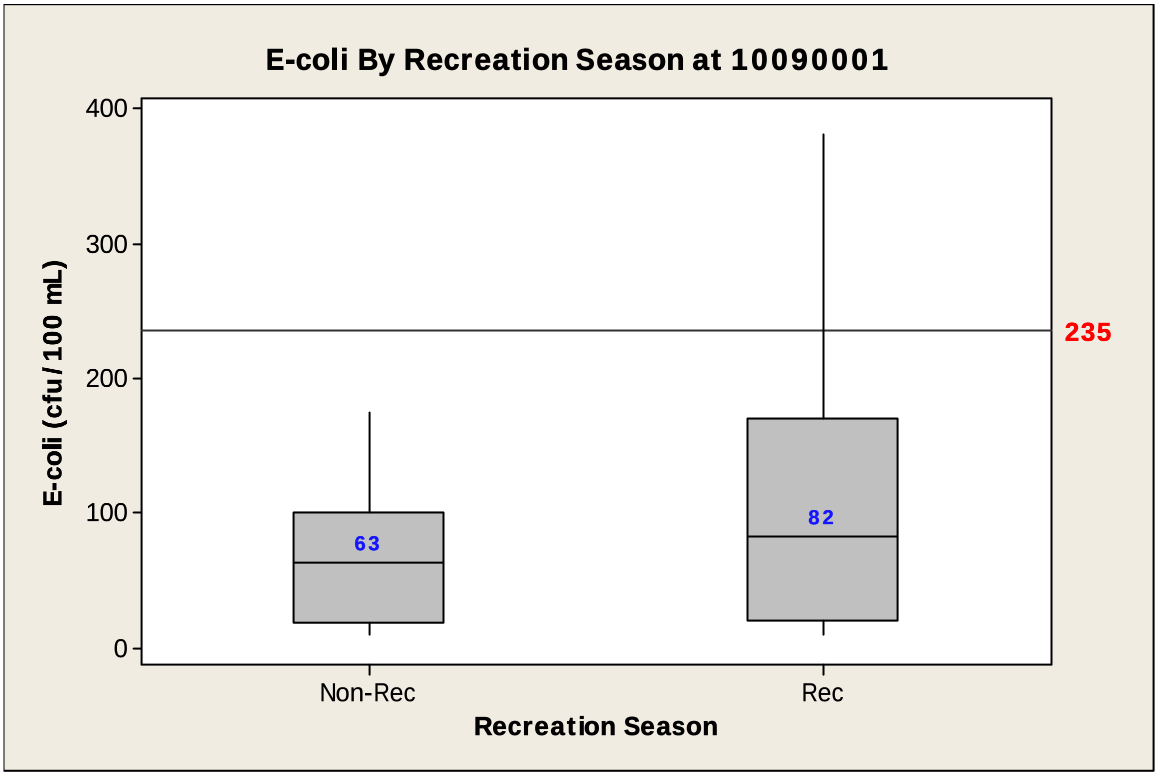

E-coli By Recreation Season at 10070006
E-coli (cfu/100 mL)
700
600
500
400
300
200
100
0
150
130
235
Non-Rec
Rec
Recreation Season

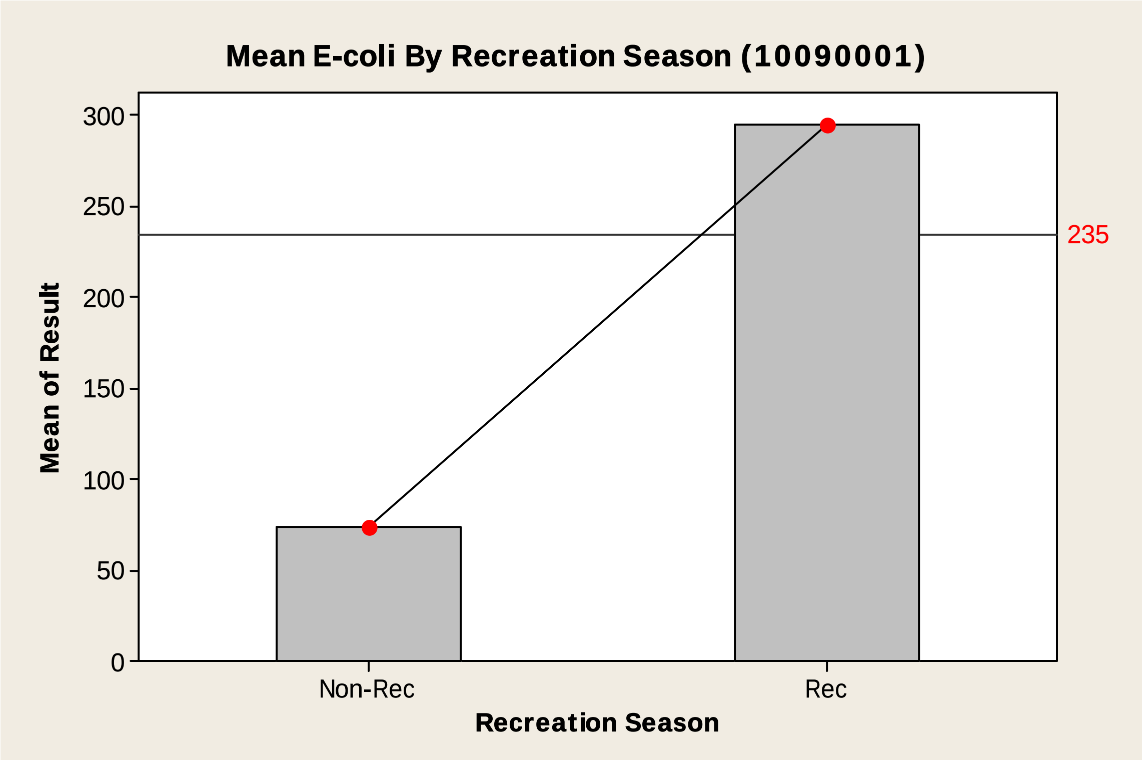

Mean E-coli By Recreation Season (10070006)
Mean of Result
350
300
250
200
150
100
50
0
235
Non-Rec
Rec
Recreation Season

SITE 10090001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	73.2	72.1	9.2	18.4	63.0	100.0	360.0
	Rec	108	294.8	684.4	9.2	20.0	82.0	170.0	3600.0

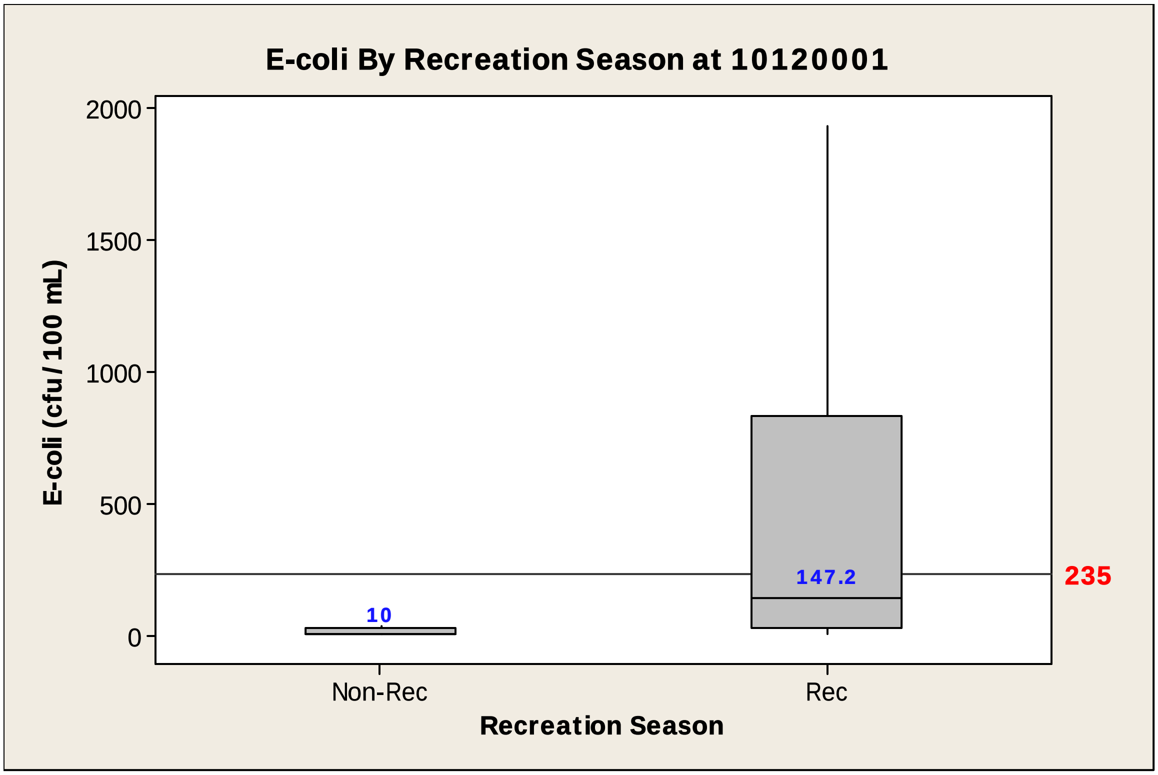


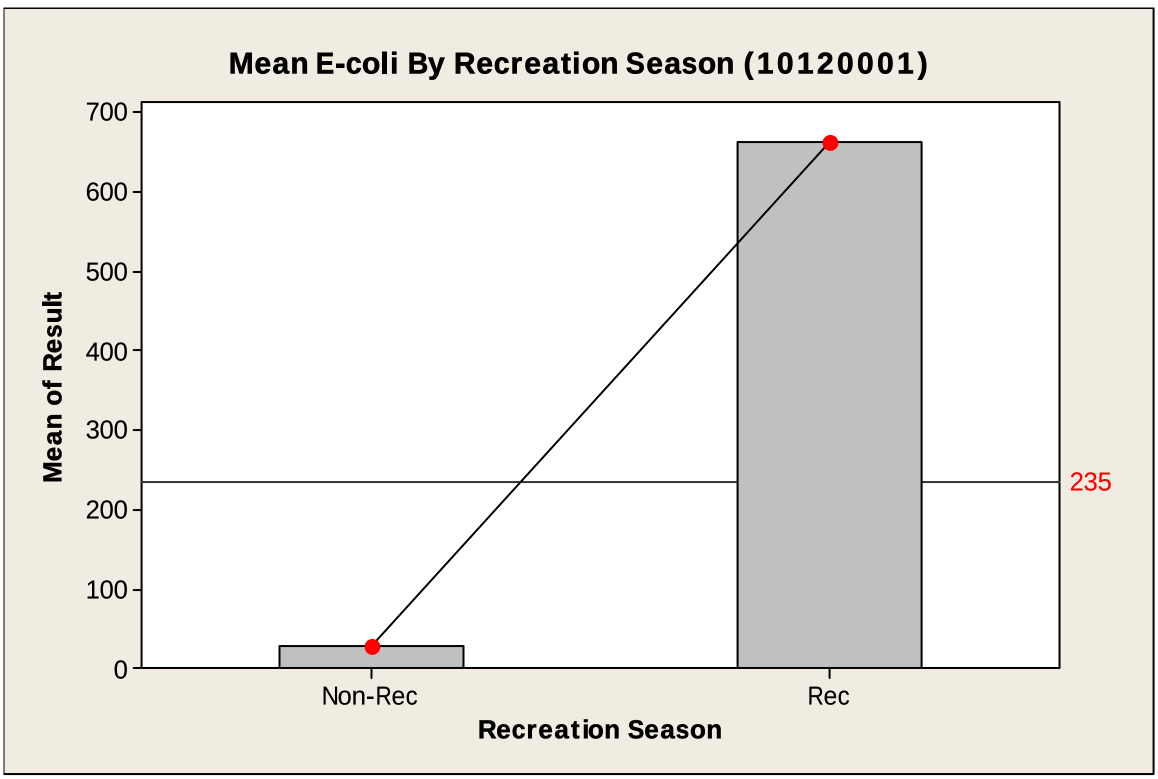


SITE 10120001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	27.02	47.70	9.20	10.00	10.00	27.60	300.00
	Rec	180	662.2	1237.5	9.2	28.2	147.2	837.2	9200.0

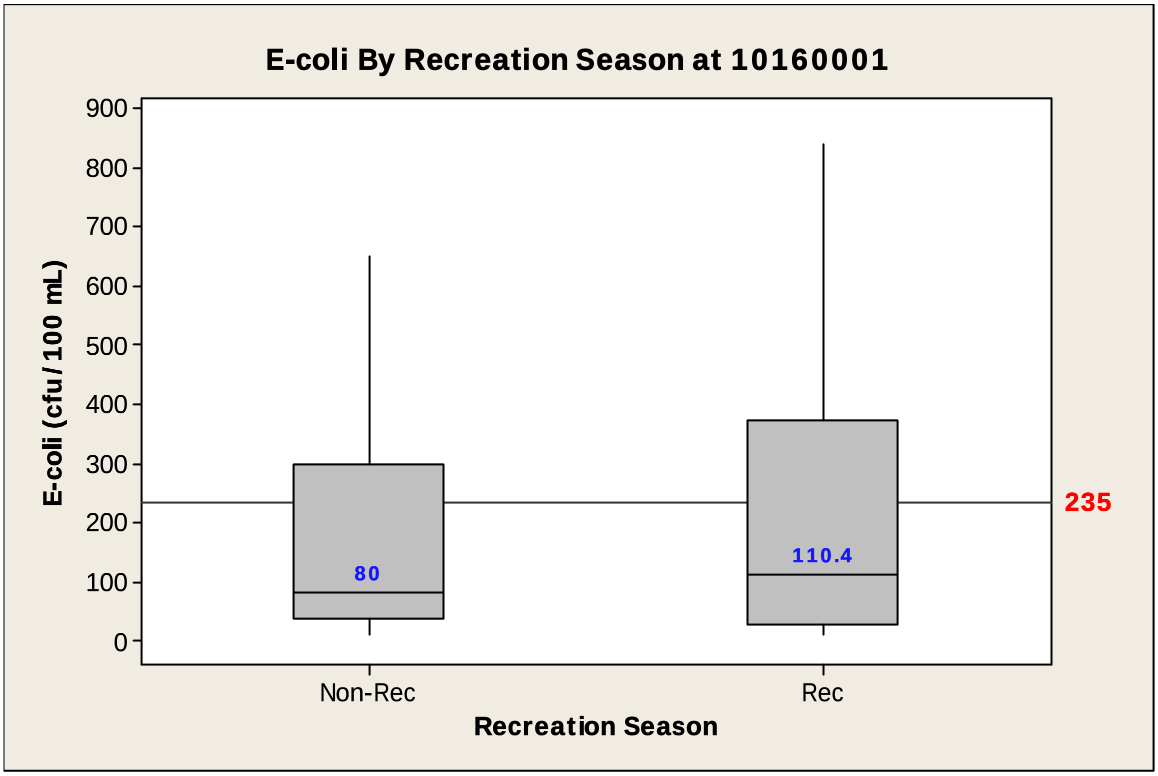

E-coli By Recreation Season at 10120001
2000
1500
1000
500
0
E-coli (cfu/100 mL)
147.2
10
235
Non-Rec
Rec
Recreation Season

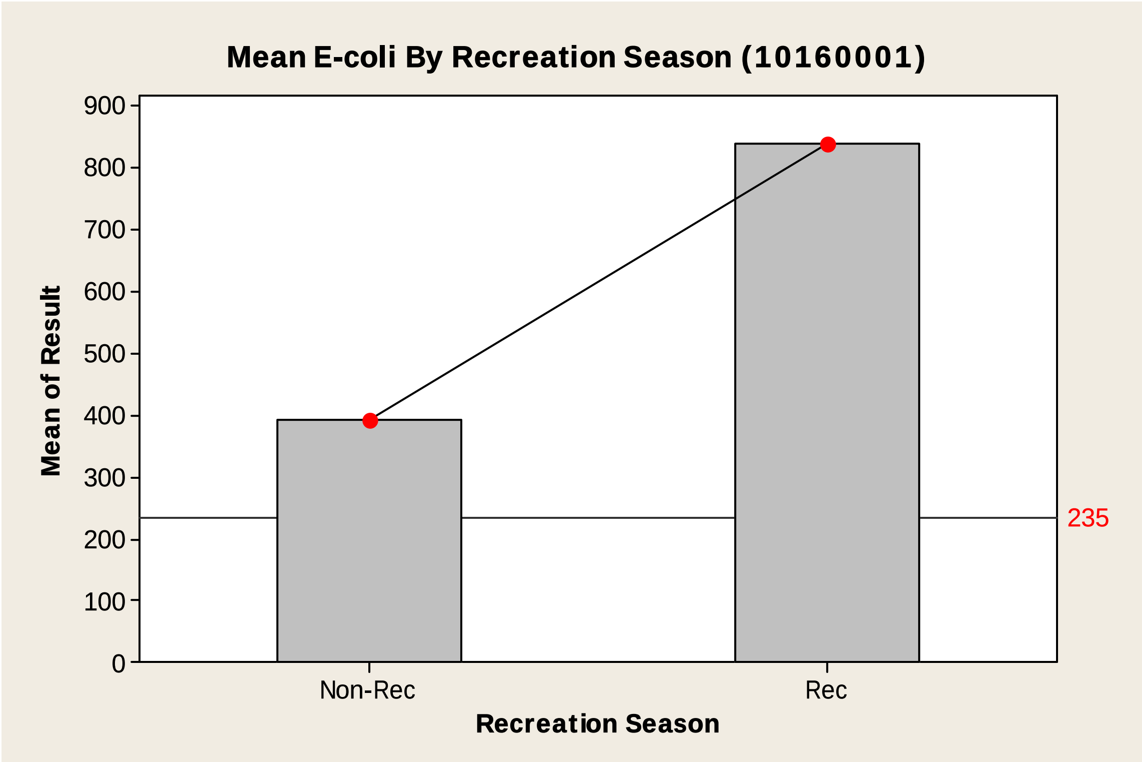

Mean E-coli By Recreation Season (10120001)
700
600
500
400
300
200
100
0
Mean of Result
235
Non-Rec
Rec
Recreation Season

SITE 10160001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	36	391	871	9	38	80	297	3800
	Rec	106	839	2810	9	27	110	371	23000

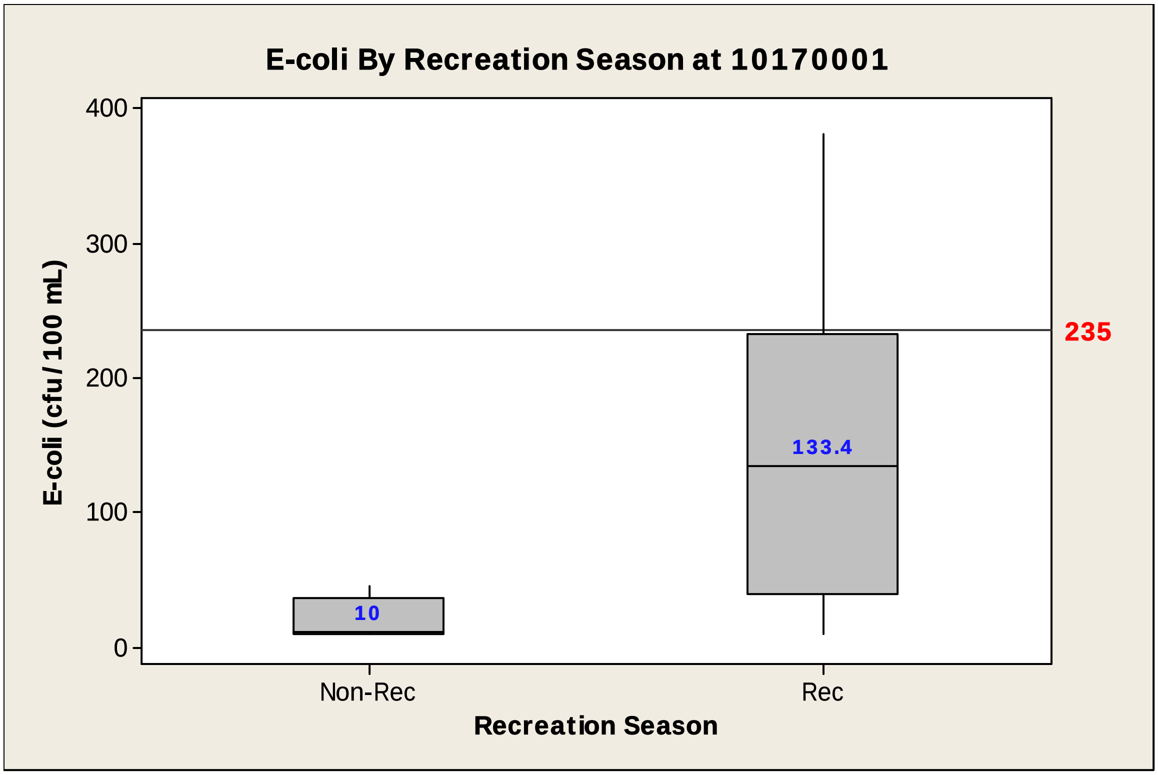


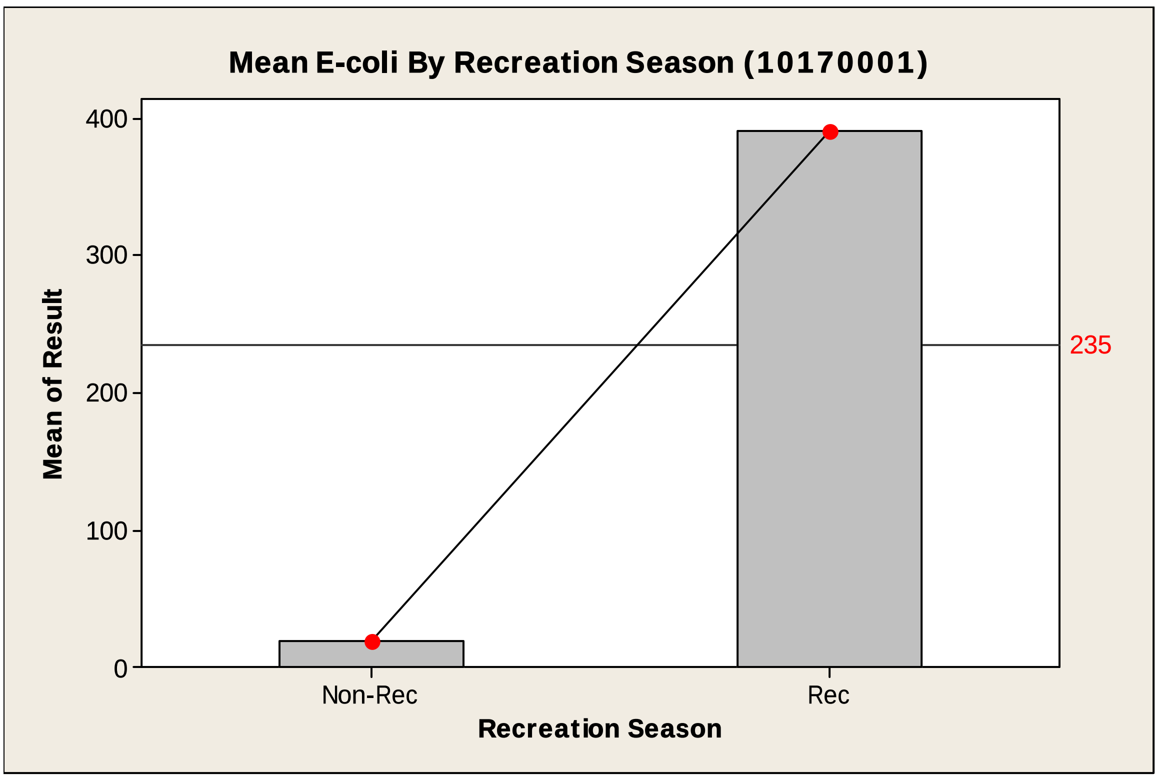


SITE 10170001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	6	19.55	15.57	9.20	9.80	10.00	36.09	45.00
	Rec	18	390	808	9	39	133	232	2700

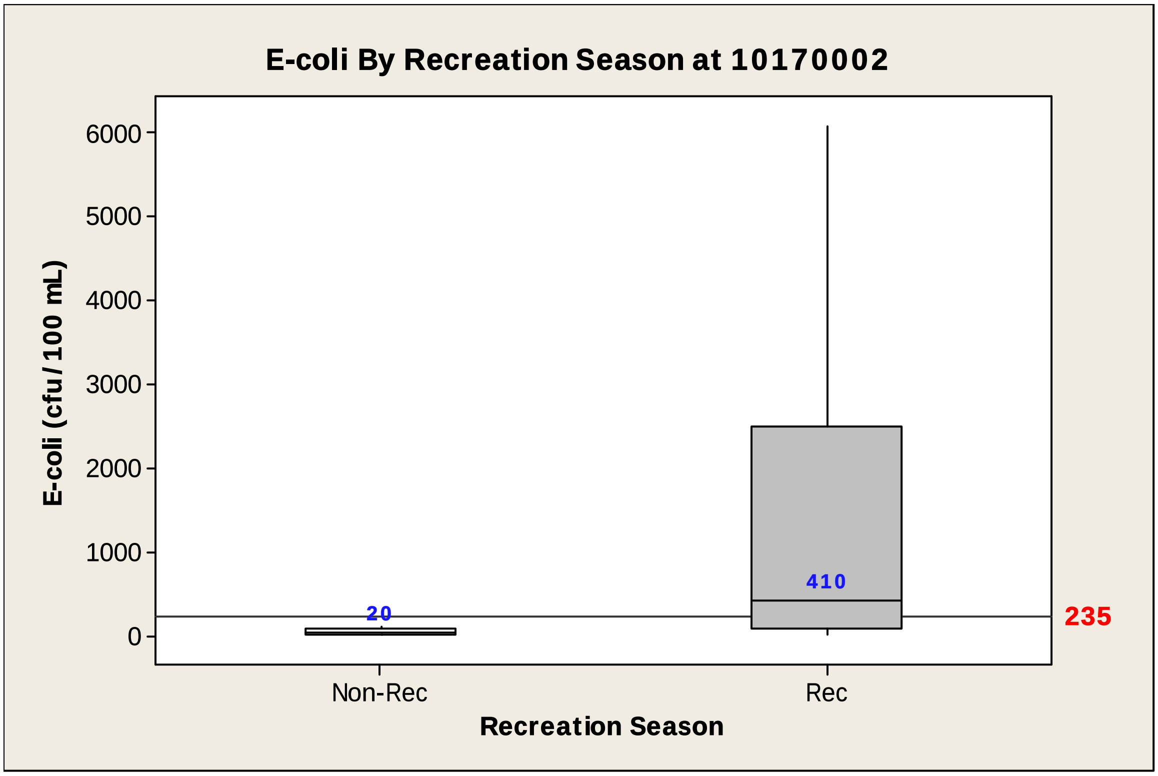

E-coli By Recreation Season at 10170001
400
300
200
100
0
E-coli (cfu/100 mL)
235
133.4
10
Non-Rec
Rec
Recreation Season

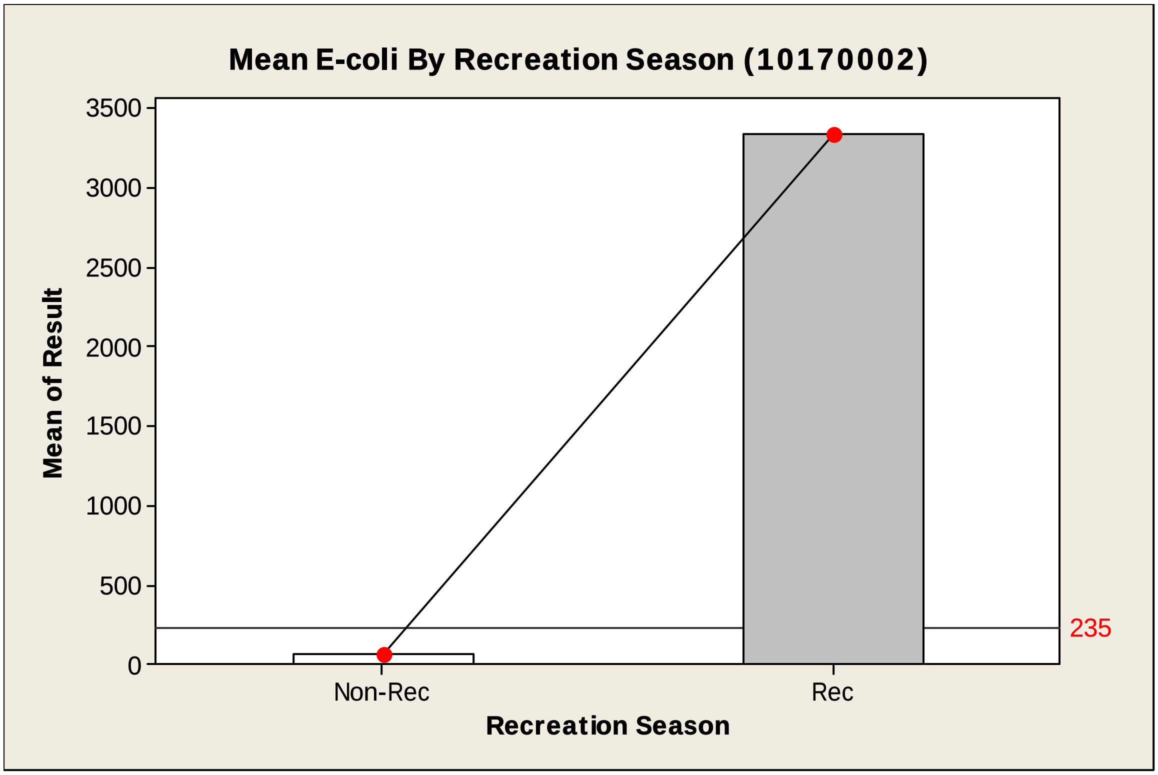

Mean E-coli By Recreation Season (10170001)
400
300
200
100
0
Mean of Result
235
Non-Rec
Rec
Recreation Season

SITE 10170002

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	33	66.3	114.3	9.2	10.0	20.0	82.9	533.6
	Rec	142	3342	9203	9	86	410	2484	80040

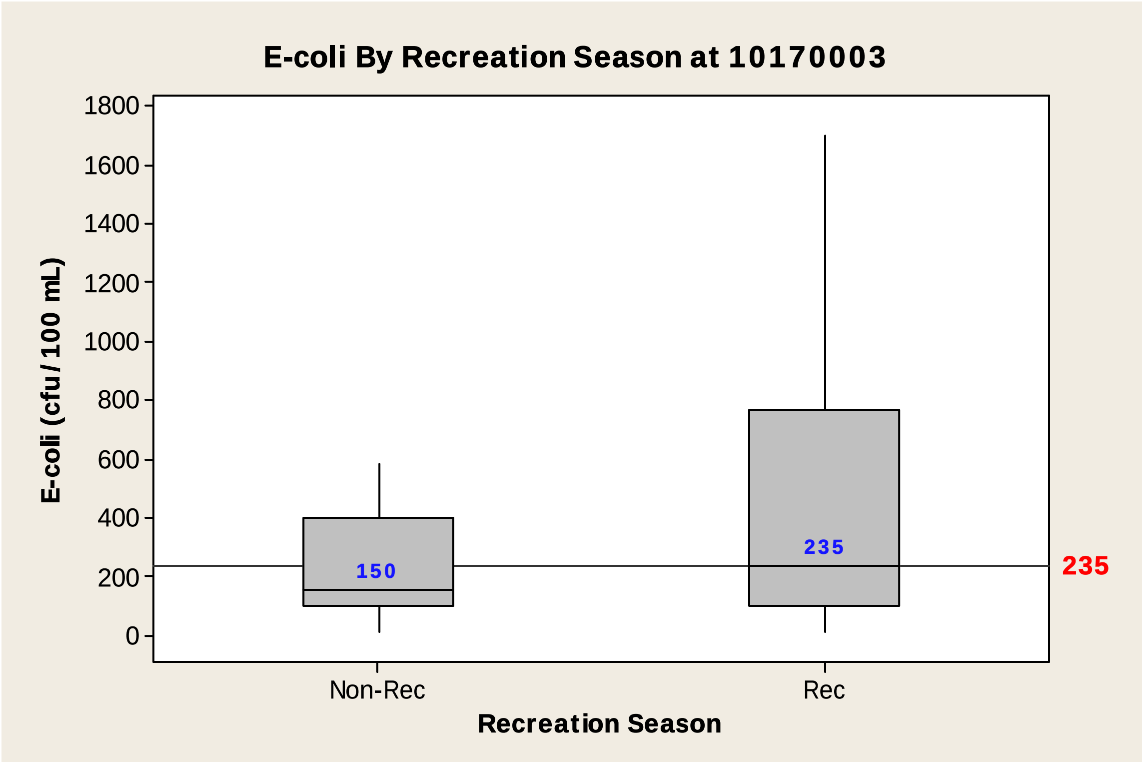


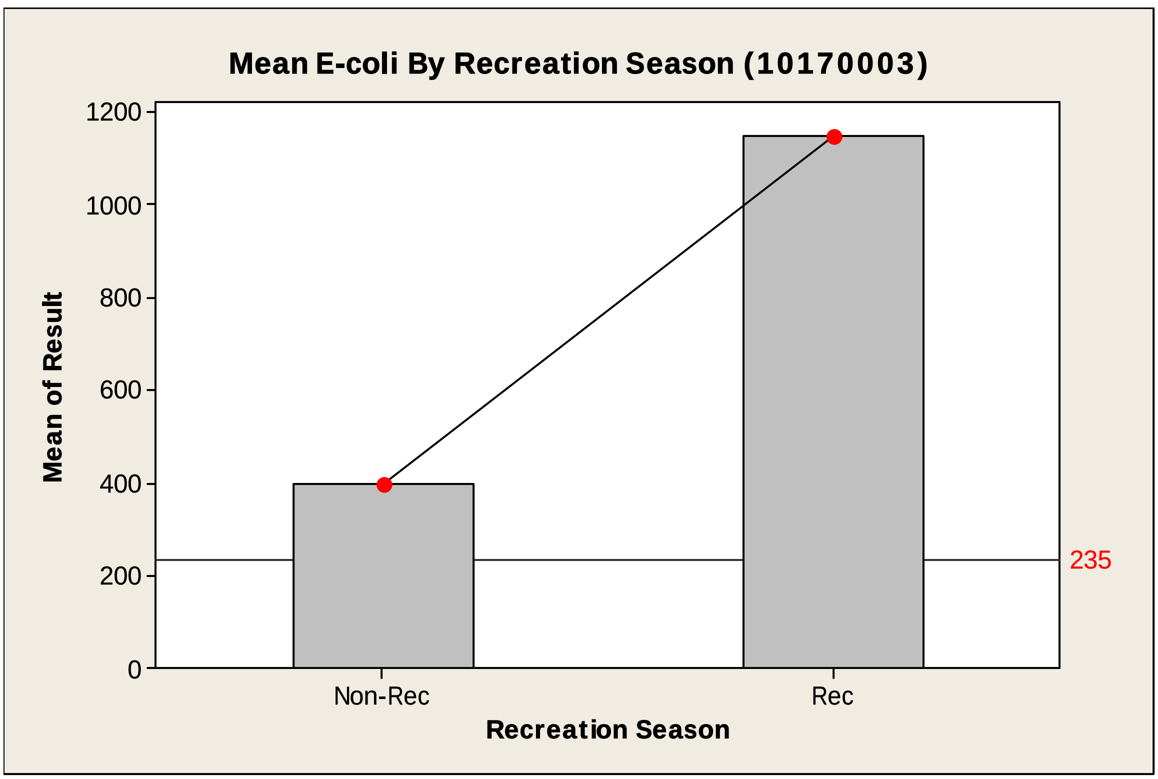


SITE 10170003

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	33	399	635	9	96	150	400	2576
	Rec	94	1149	2332	9	98	235	768	11040

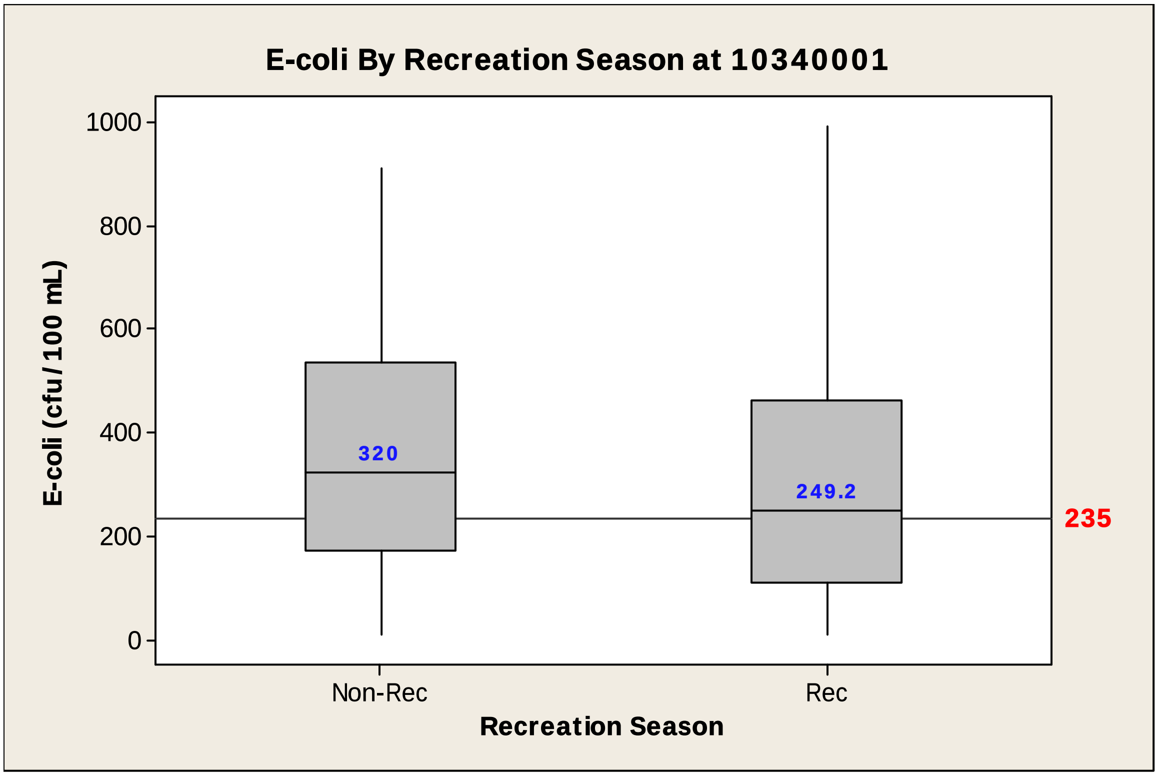

E-coli By Recreation Season at 10170003
E-coli (cfu/100 mL)
1800
1600
1400
1200
1000
800
600
400
200
0
150
235
235
Non-Rec
Rec
Recreation Season

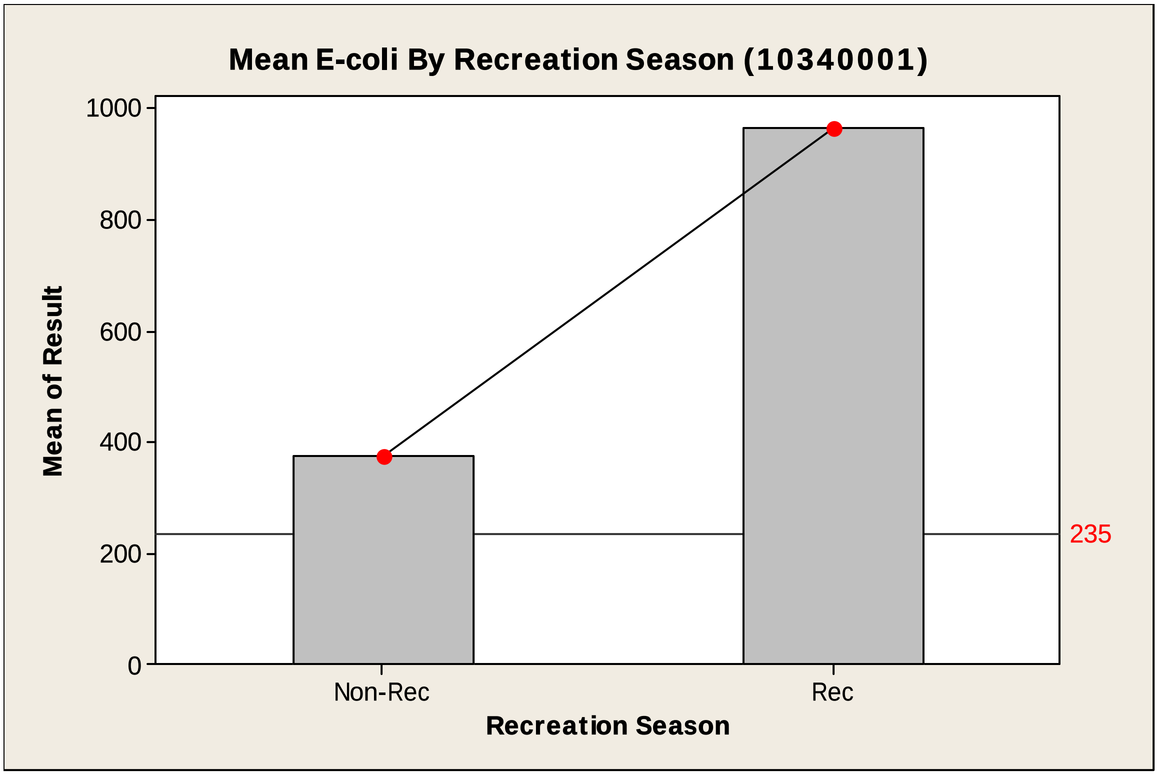

Mean E-coli By Recreation Season (10170003)
Mean of Result
1200
1000
800
600
400
200
0
235
Non-Rec
Rec
Recreation Season

SITE 10340001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	373.3	294.6	10.0	170.0	320.0	533.6	1380.0
	Rec	138	964	4422	9	108	249	463	40480

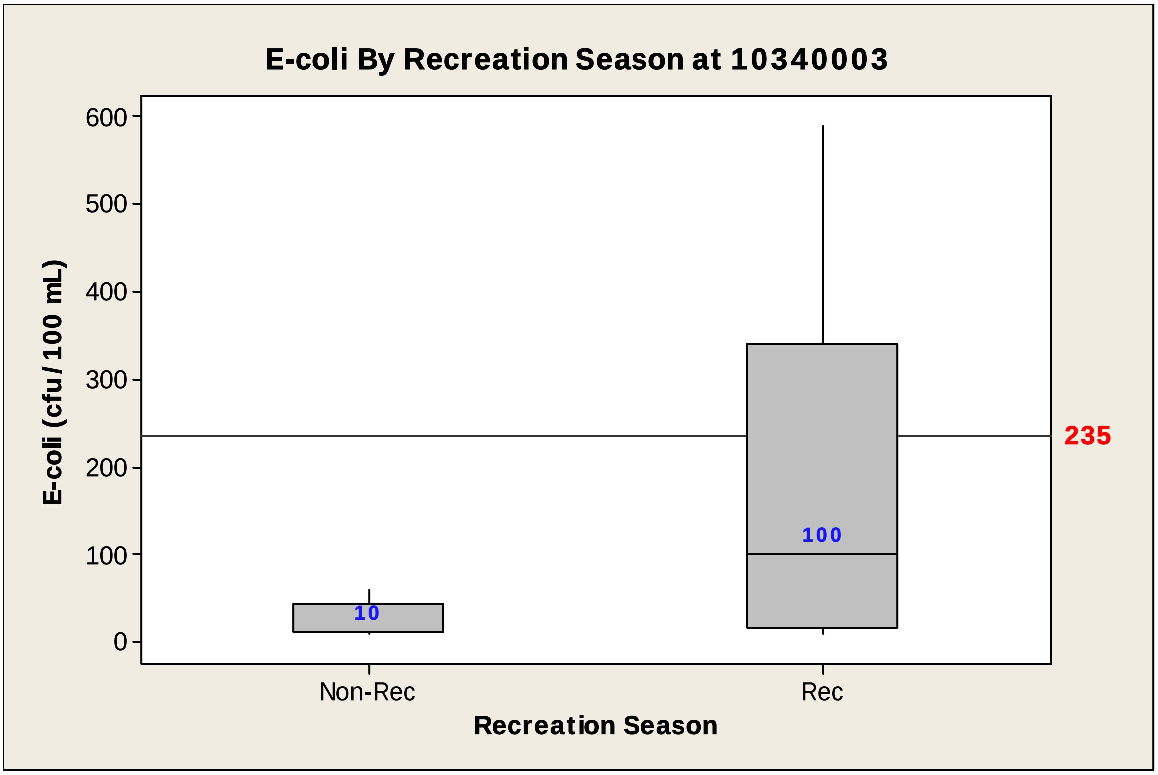


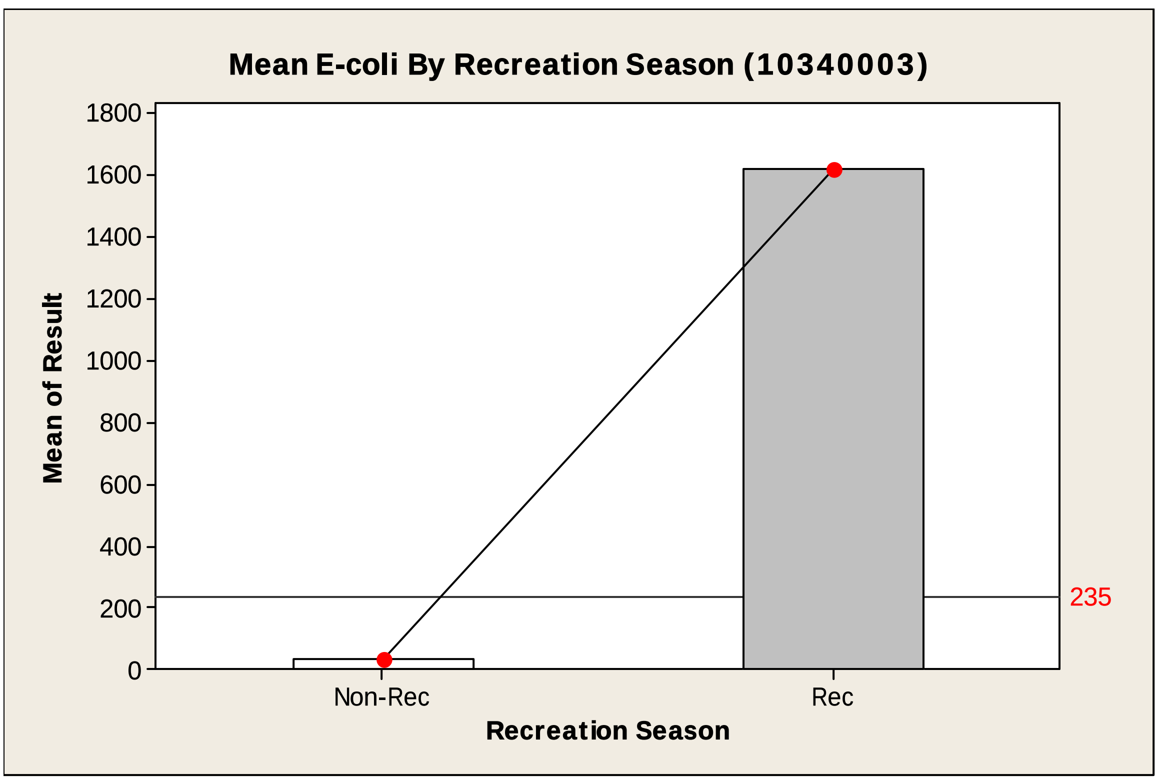


SITE 10340003

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	12	34.0	52.0	9.2	10.0	10.0	42.5	190.0
	Rec	42	1622	5497	9	16	100	340	27600

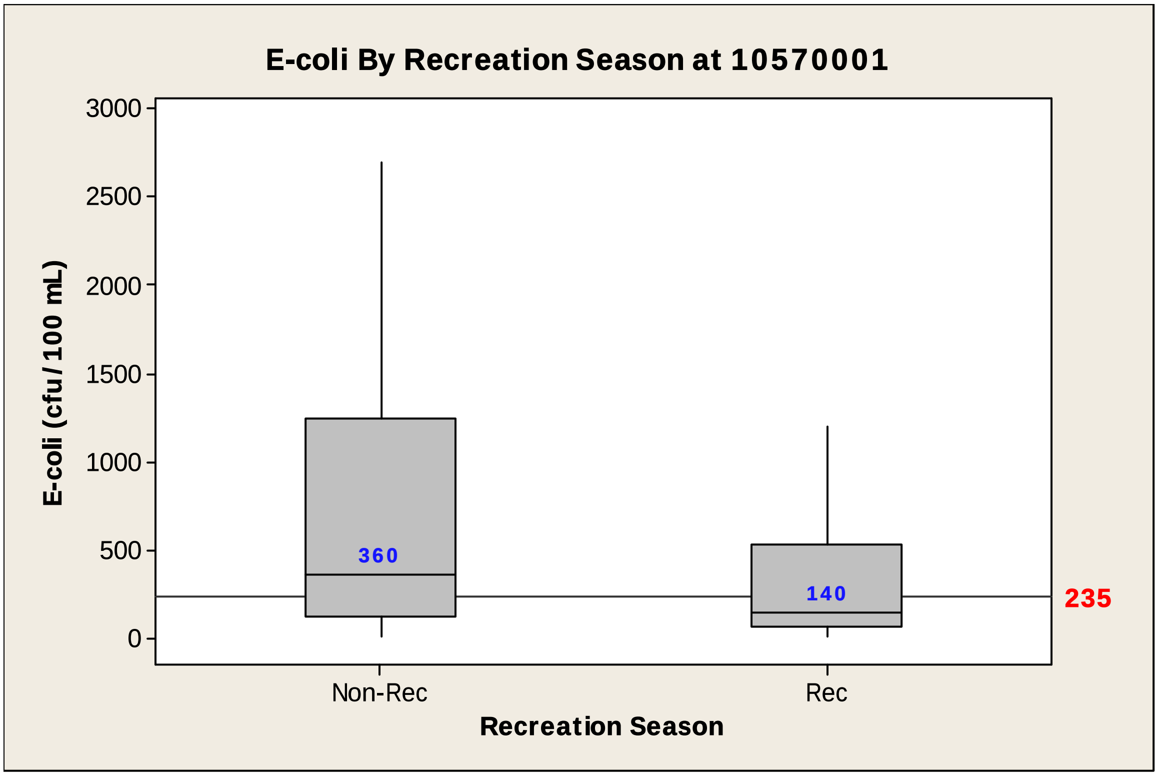

E-coli By Recreation Season at 10340003
E-coli (cfu/ 100 mL)
600
500
400
300
200
100
0
235
100
10
Non-Rec
Rec
Recreation Season

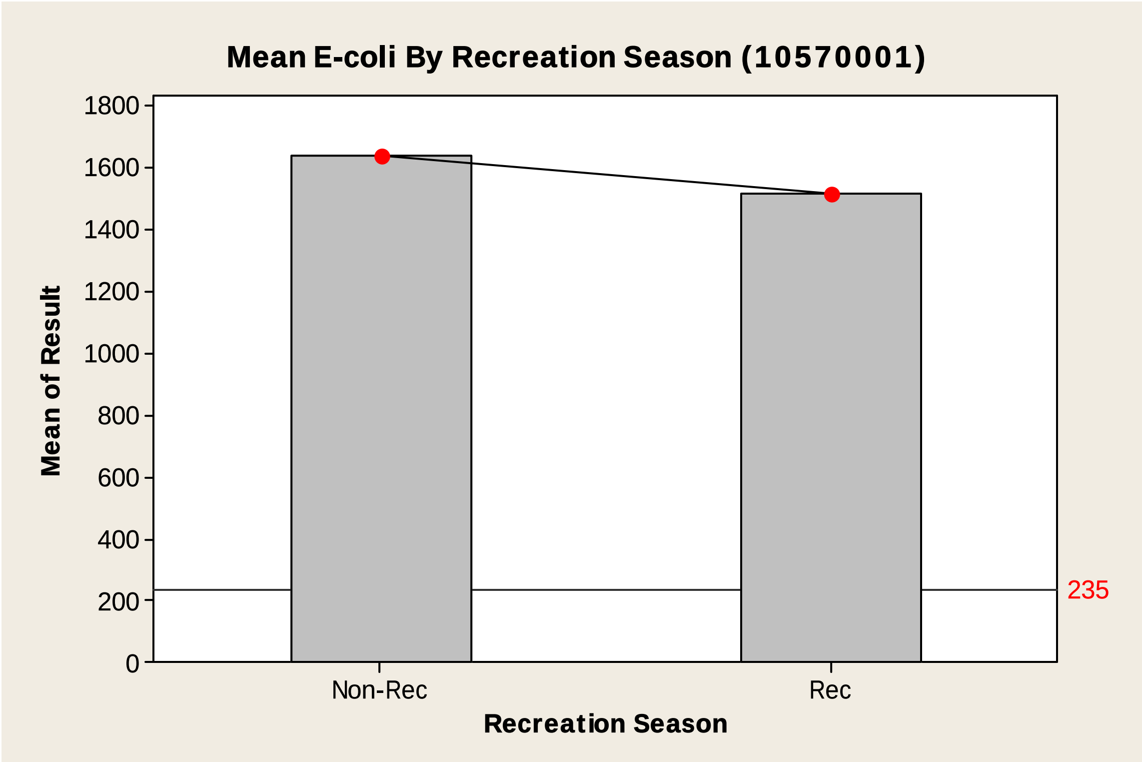

Mean E-coli By Recreation Season (10340003)
Mean of Result
1800
1600
1400
1200
1000
800
600
400
200
0
235
Non-Rec
Rec
Recreation Season

SITE 10570001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	33	1641	3367	10	124	360	1242	14720
	Rec	157	1514	7343	10	62	140	525	82000

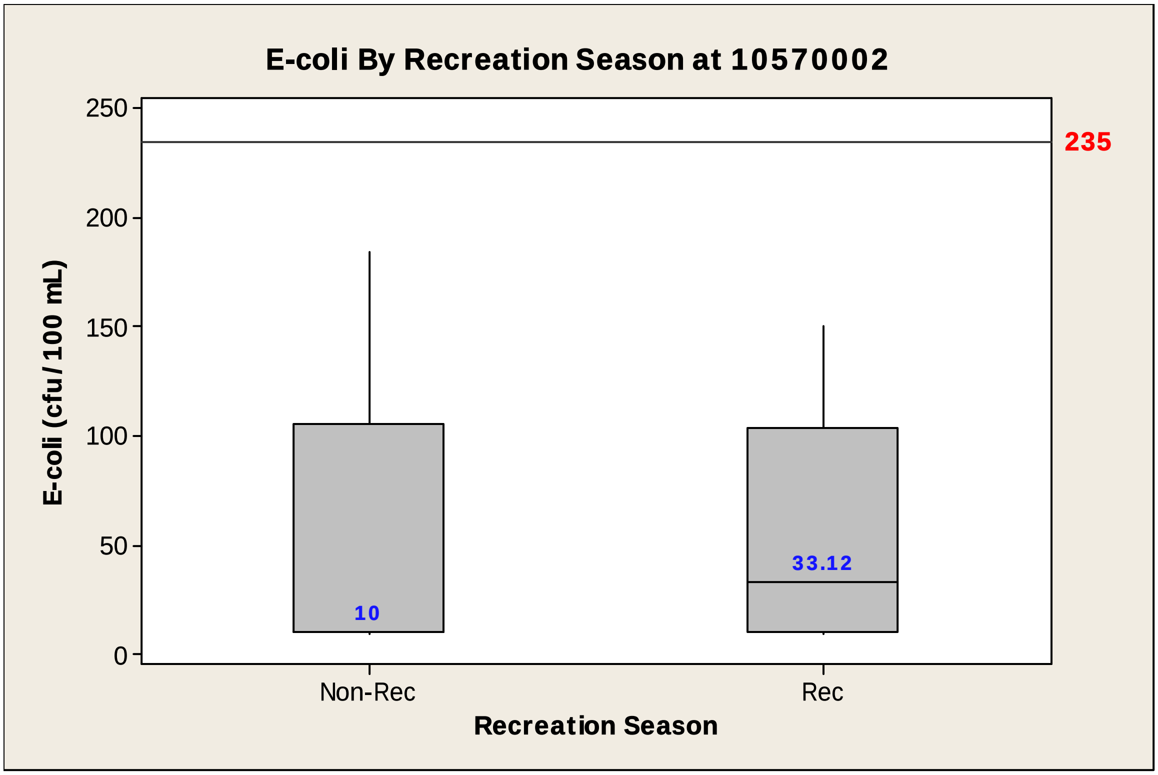


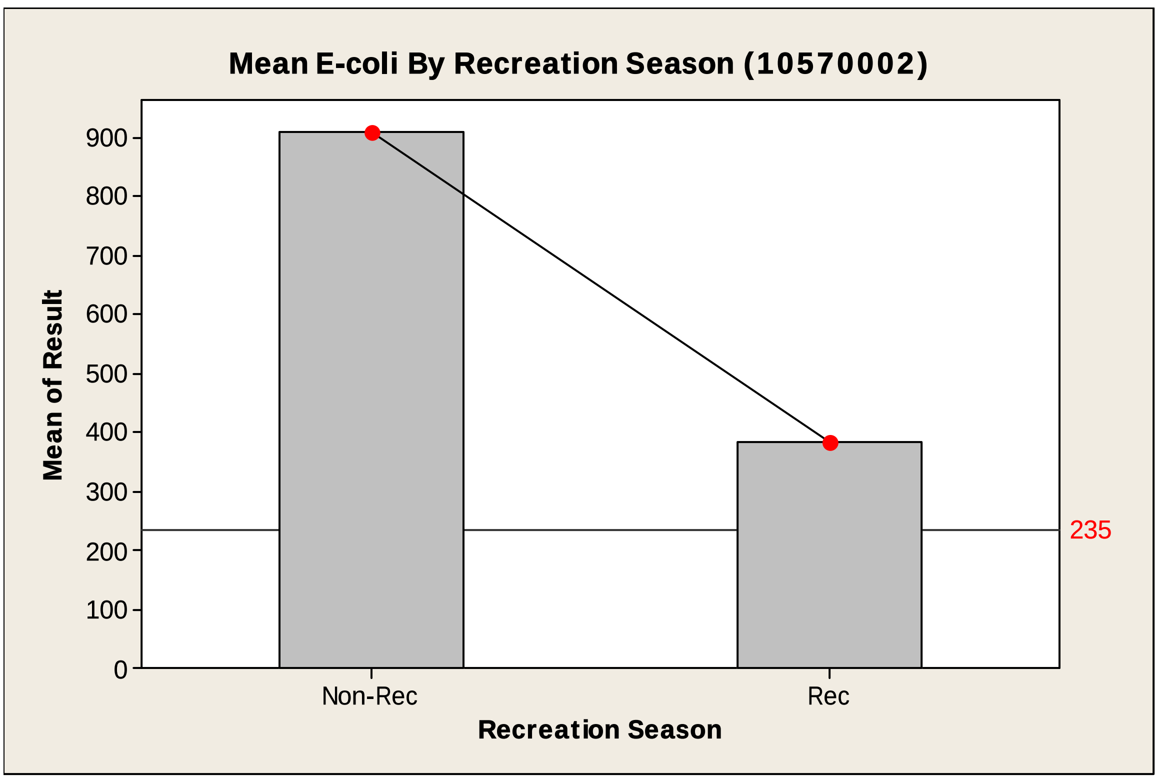


SITE 10570002

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	33	908	3496	9	10	10	105	16560
	Rec	94	382	1168	9	10	33	104	6000

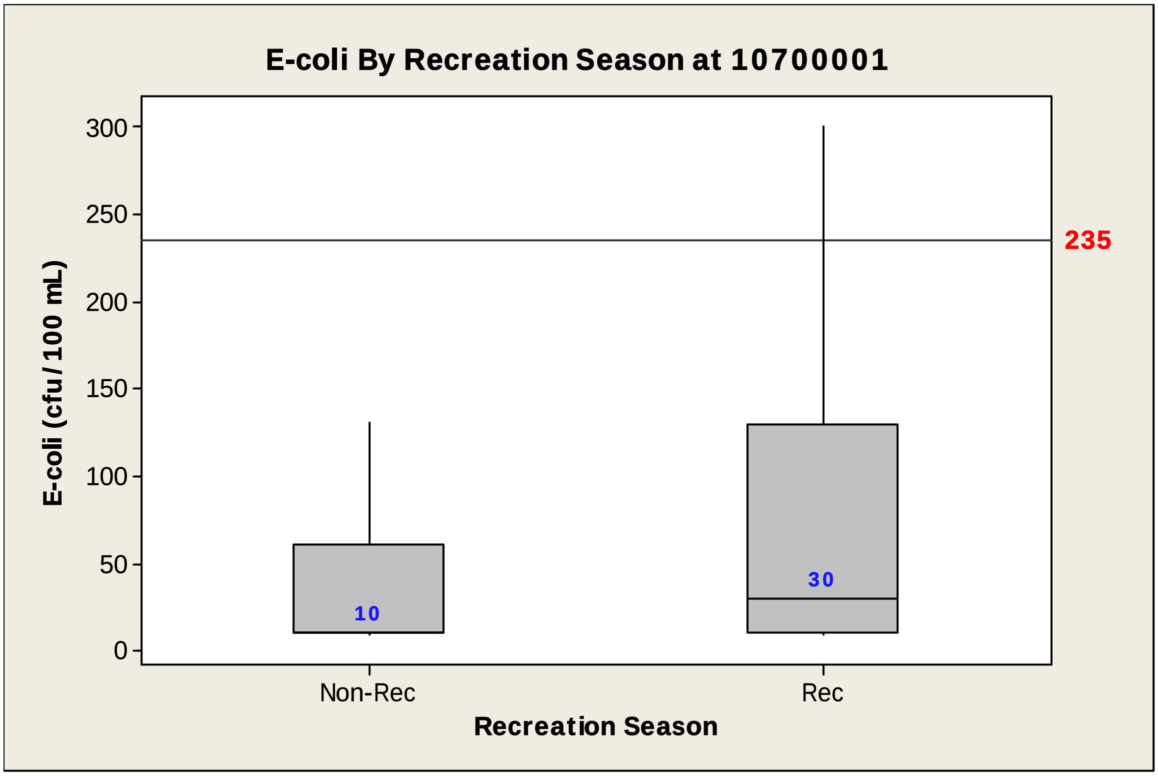

E-coli By Recreation Season at 10570002
E-coli (cfu/100 mL)
250
200
150
100
50
0
235
10
33.12
Non-Rec
Rec
Recreation Season

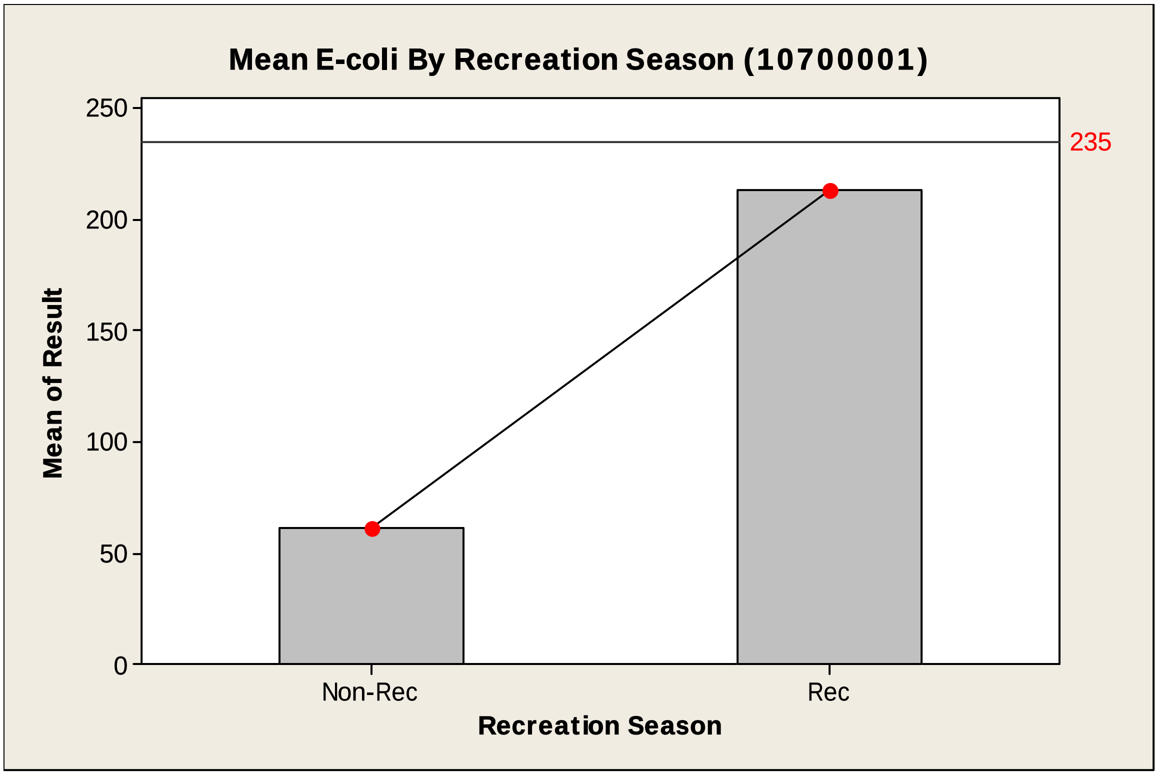

Mean E-coli By Recreation Season (10570002)
Mean of Result
900
800
700
600
500
400
300
200
100
0
235
Non-Rec
Rec
Recreation Season

SITE 10700001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	39	61.5	98.3	9.2	10.0	10.0	60.0	380.0
	Rec	108	212.9	734.1	9.2	10.0	30.0	128.8	5980.0

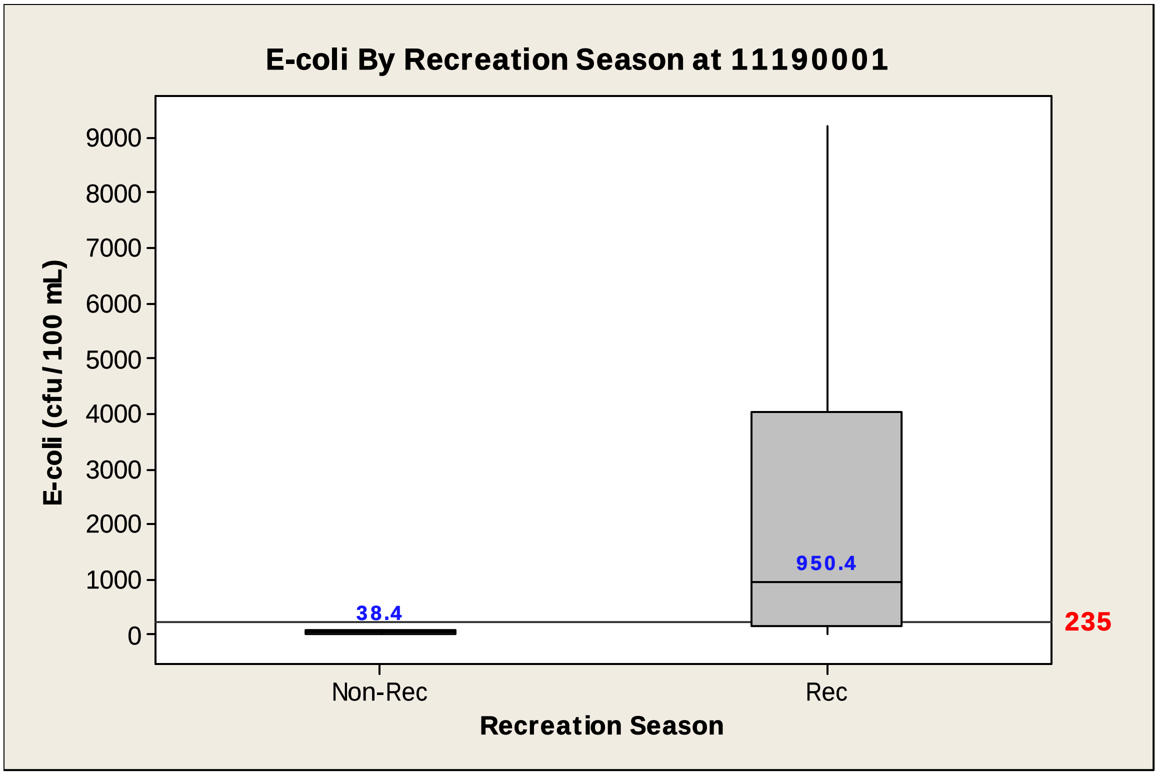


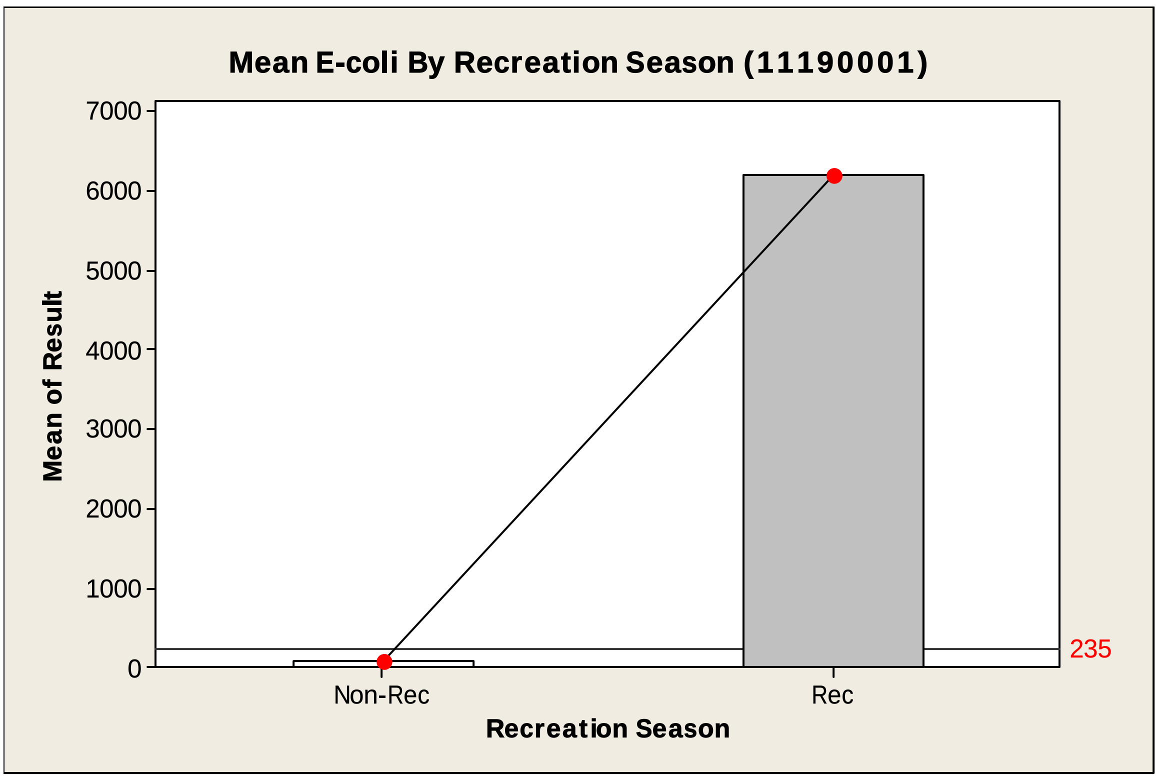


SITE 11190001

Descriptive Statistics: Result

Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	14	70.2	121.4	9.2	10.0	38.4	85.3	478.4
	Rec	118	6183	16425	9	159	950	4012	110400

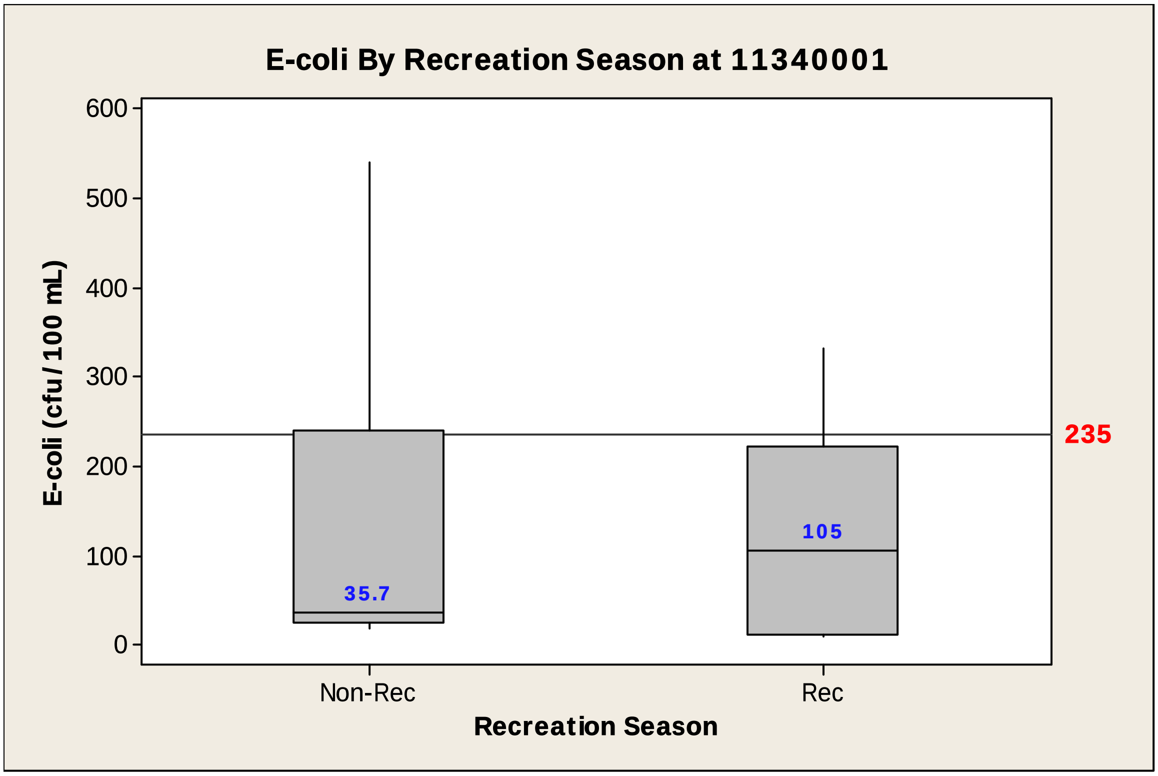

E-coli By Recreation Season at 11190001
E-coli (cfu/100 mL)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
38.4
950.4
235
Non-Rec
Rec
Recreation Season

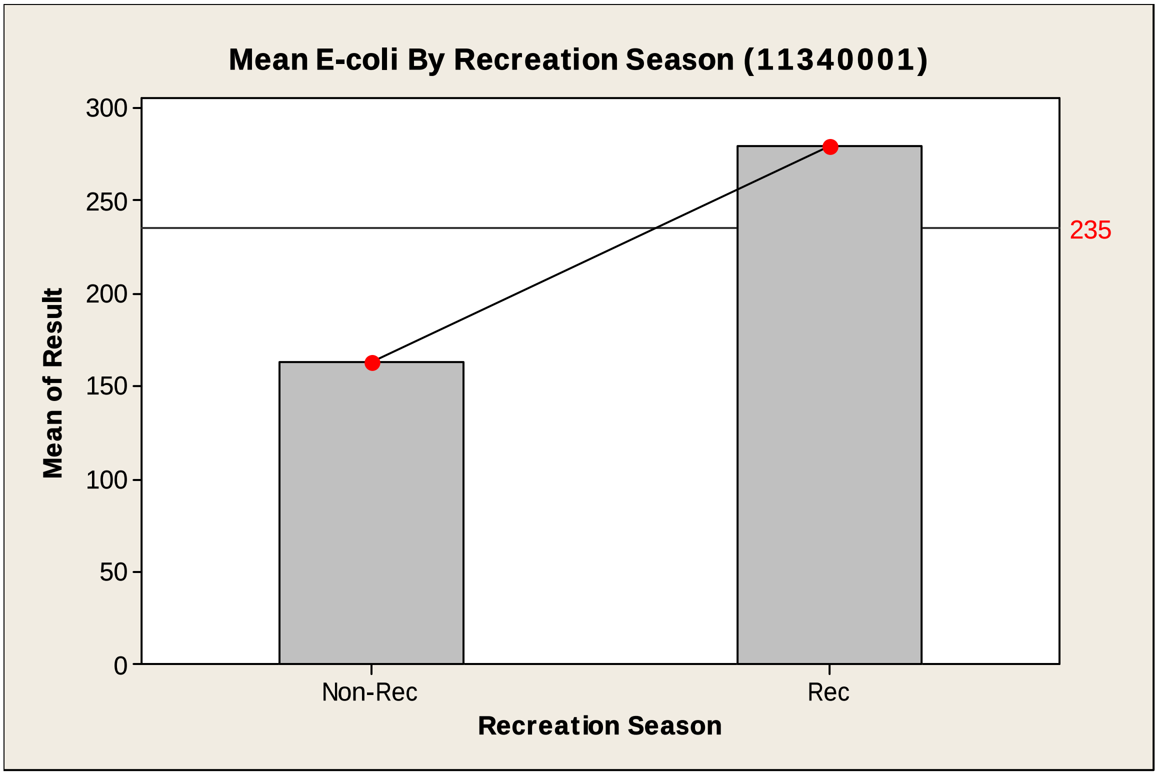

Mean E-coli By Recreation Season (11190001)
Mean of Result
7000
6000
5000
4000
3000
2000
1000
0
235
Non-Rec
Rec
Recreation Season

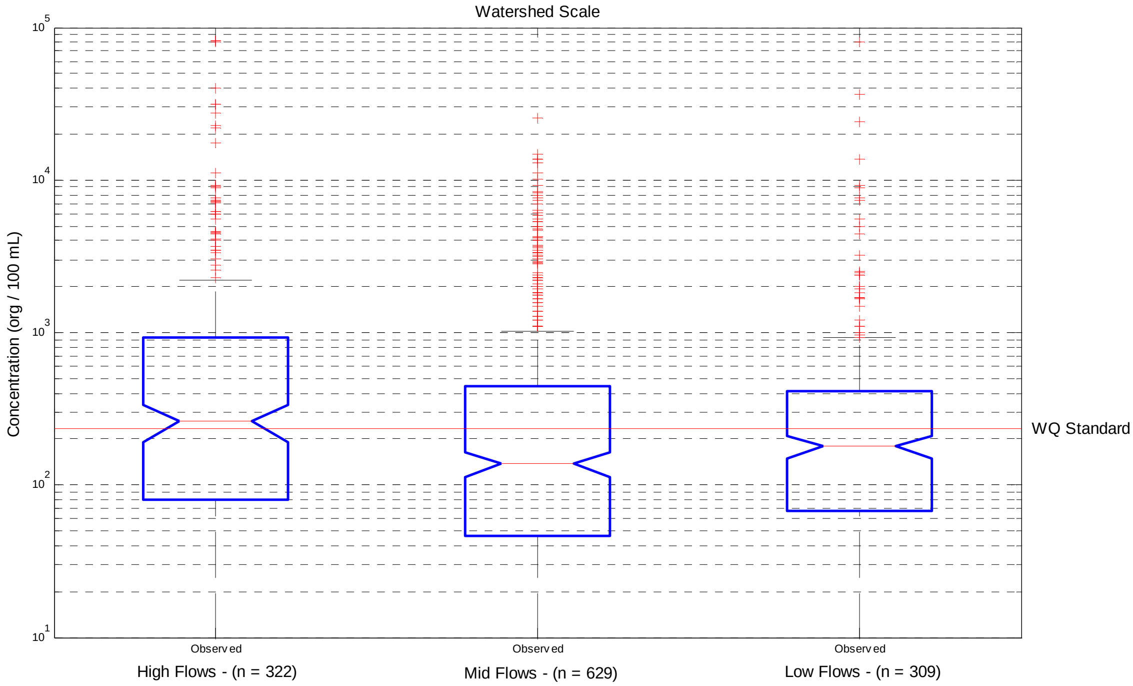
SITE 11340001

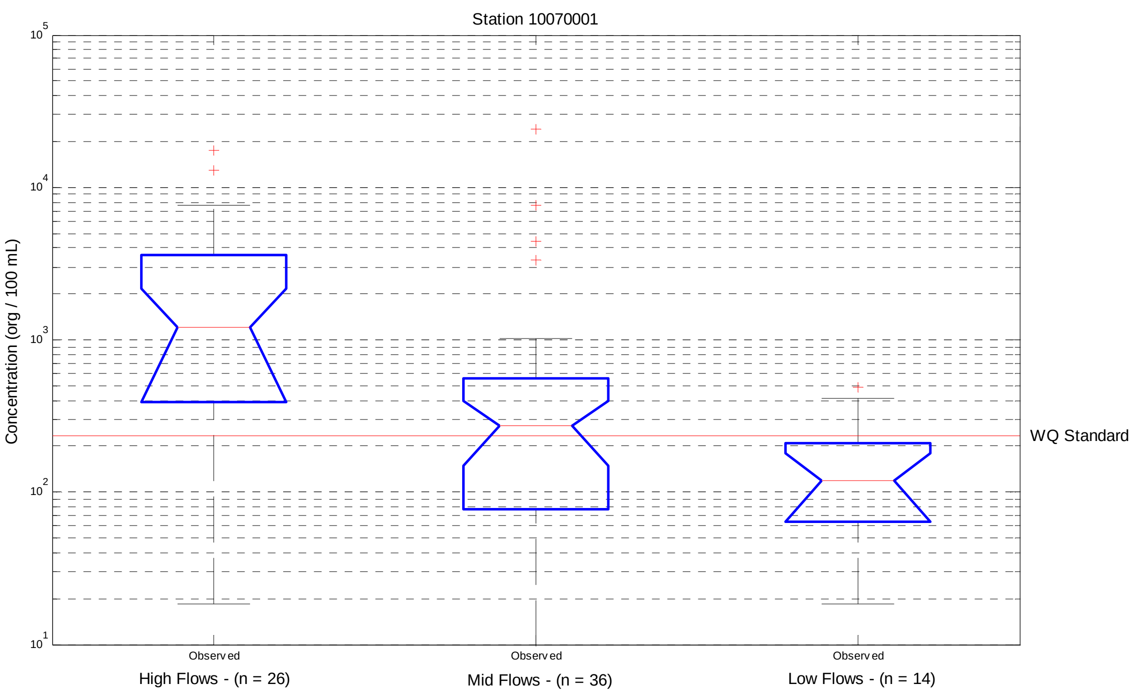
Descriptive Statistics: Result

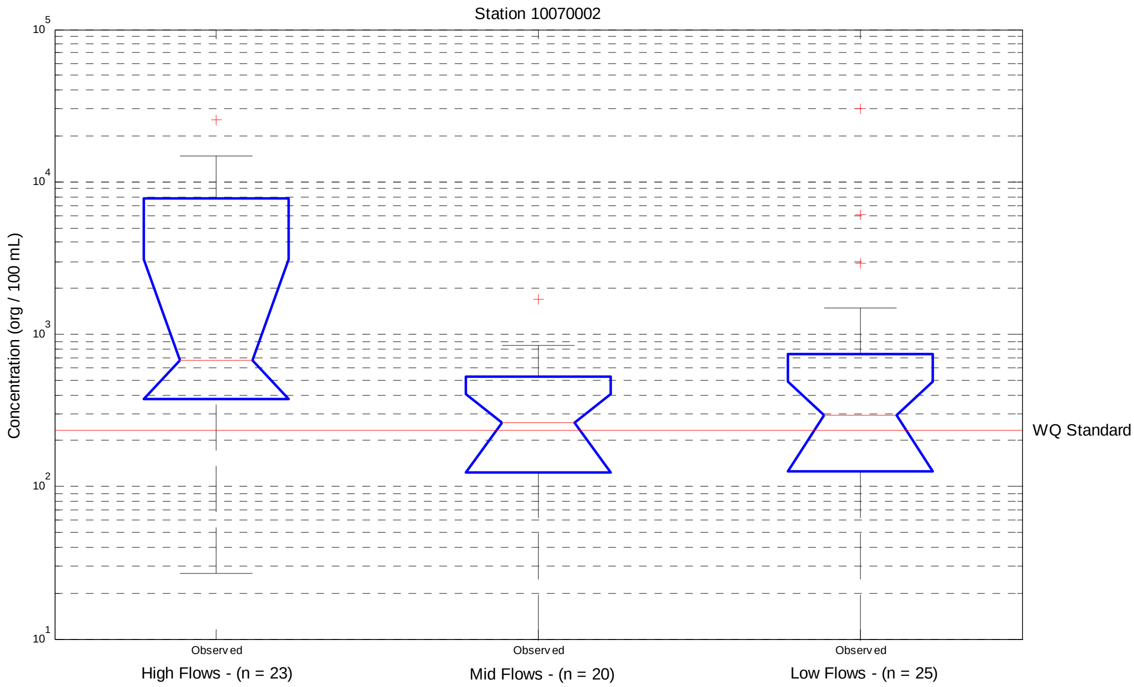
Variable	Recreation Season	Total Count	Mean	StDev	Minimum	Q1	Median	Q3	Maximum
Result	Non-Rec	14	162.5	232.0	18.4	25.3	35.7	239.7	763.6
	Rec	66	279.7	688.0	9.2	10.0	105.0	223.1	4048.0

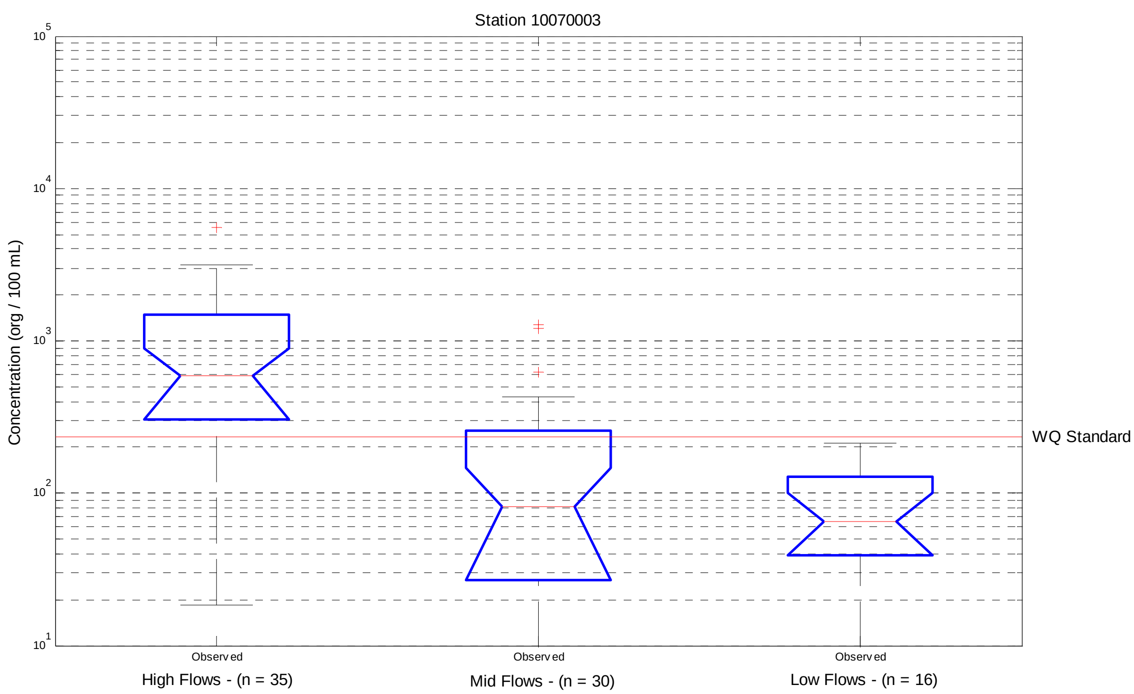


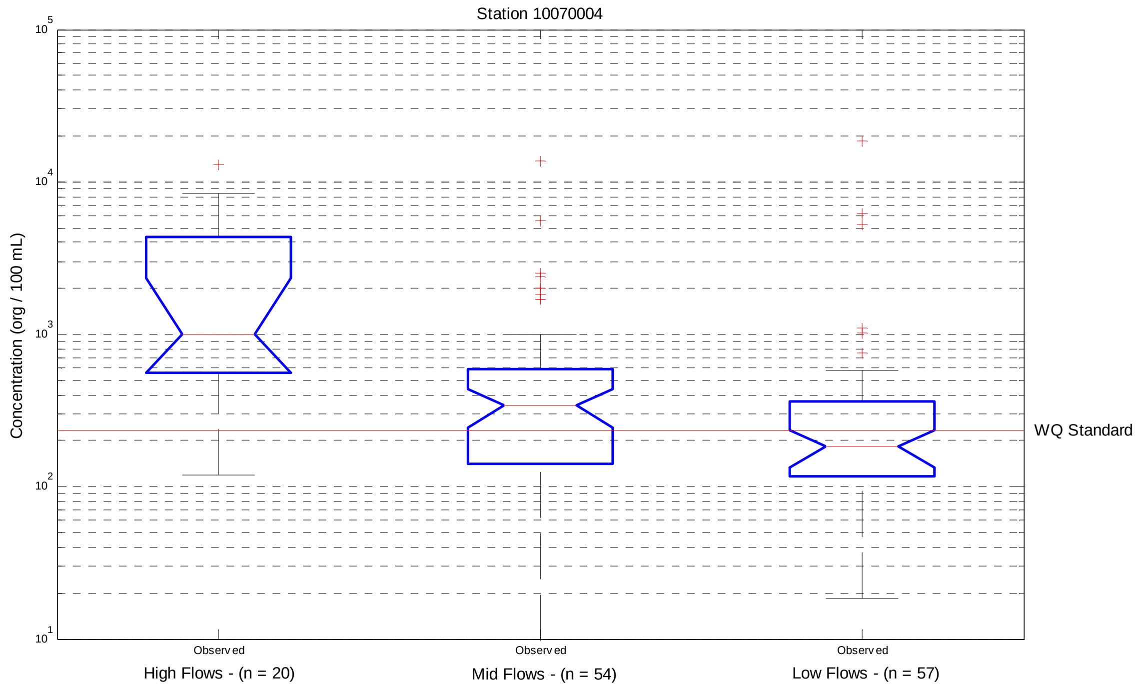

Mean E-coli By Recreation Season (11340001)
300
250
200
150
100
50
0
Mean of Result
235
Non-Rec
Rec
Recreation Season

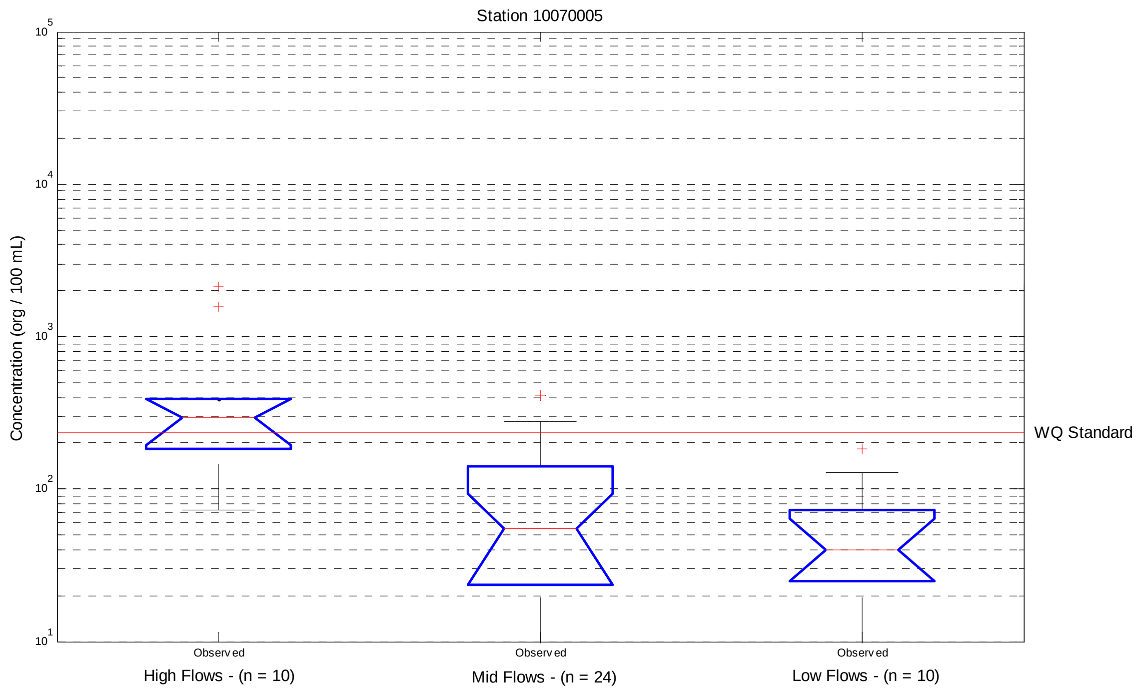

Watershed Scale
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
High Flows - (n = 322)
Observed
Mid Flows - (n = 629)
Observed
Low Flows - (n = 309)

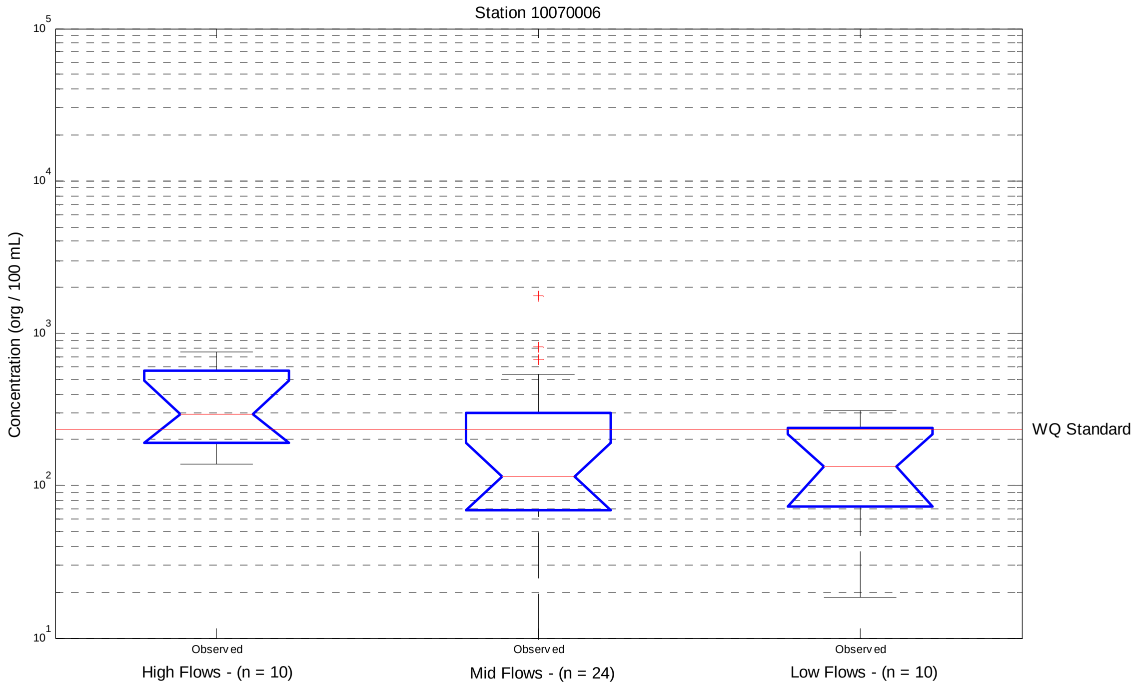

Station 10070001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
High Flows - (n = 26)
Observed
Mid Flows - (n = 36)
Observed
Low Flows - (n = 14)

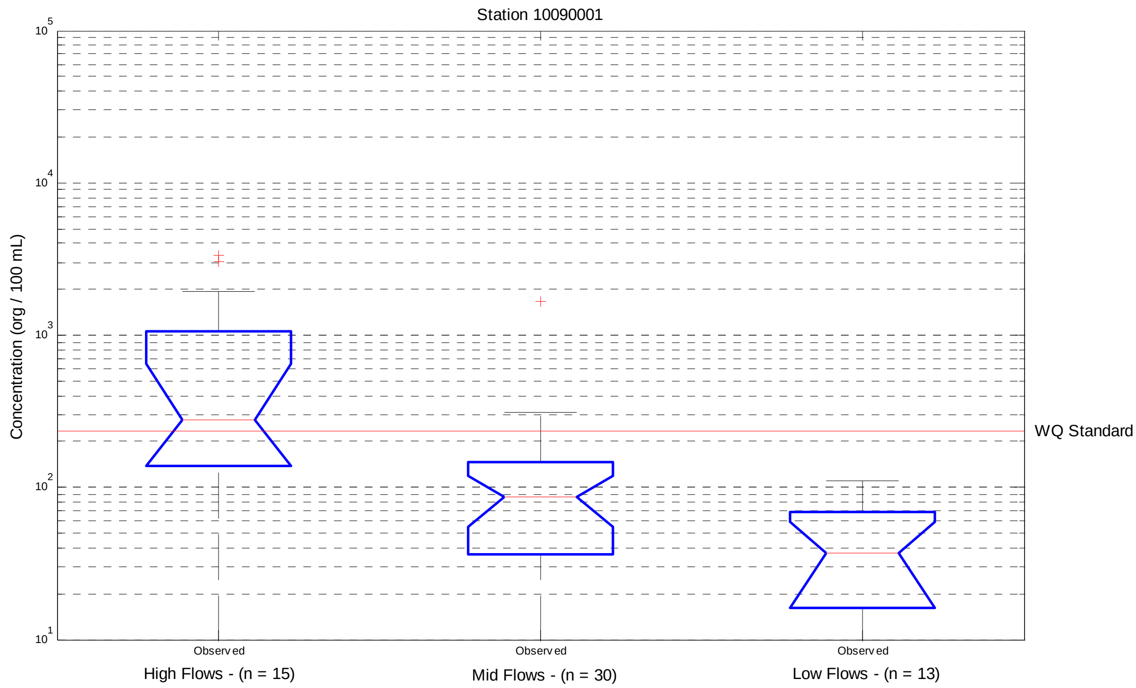

Station 10070002
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 23)
Mid Flows - (n = 20)
Low Flows - (n = 25)

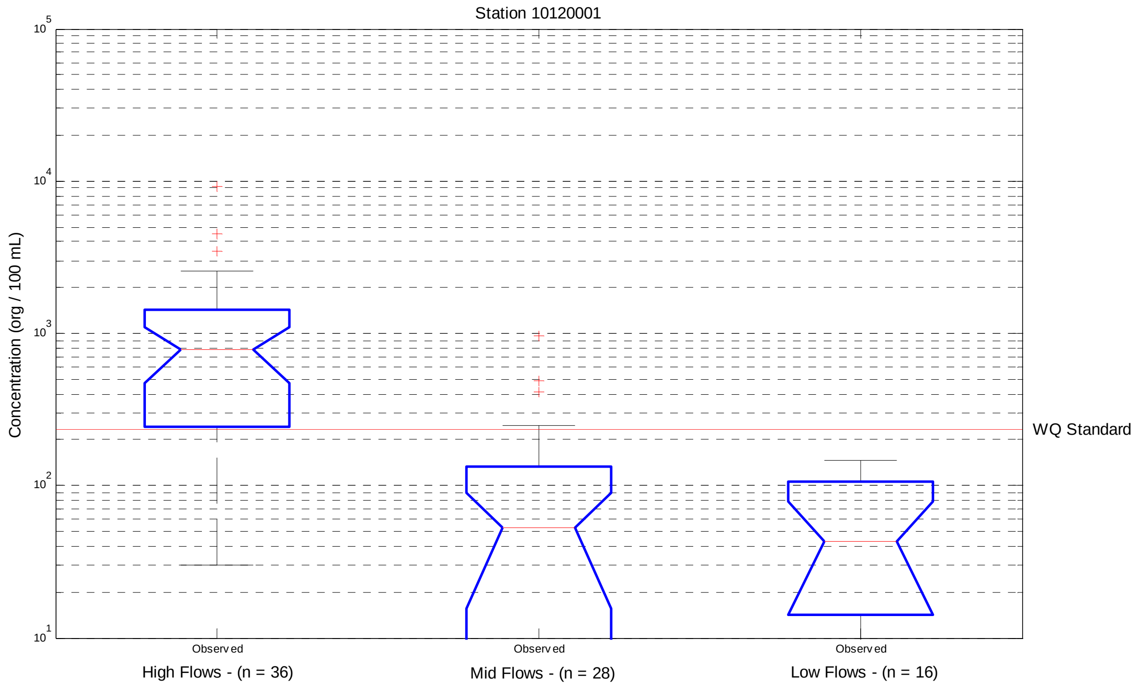

Station 10070003
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 35)
Mid Flows - (n = 30)
Low Flows - (n = 16)

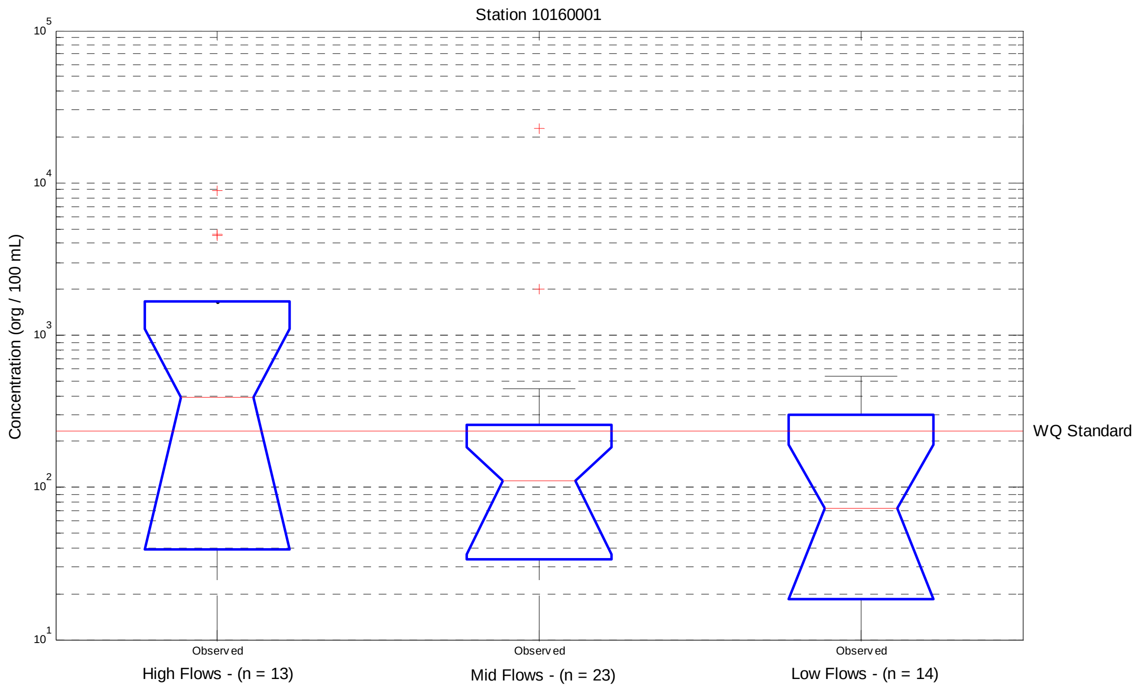

Station 10070004
10^5
10^4
10^3
10^2
10^1
Concentration (org / 100 mL)
WQ Standard
Observed
Observed
Observed
High Flows - (n = 20)
Mid Flows - (n = 54)
Low Flows - (n = 57)

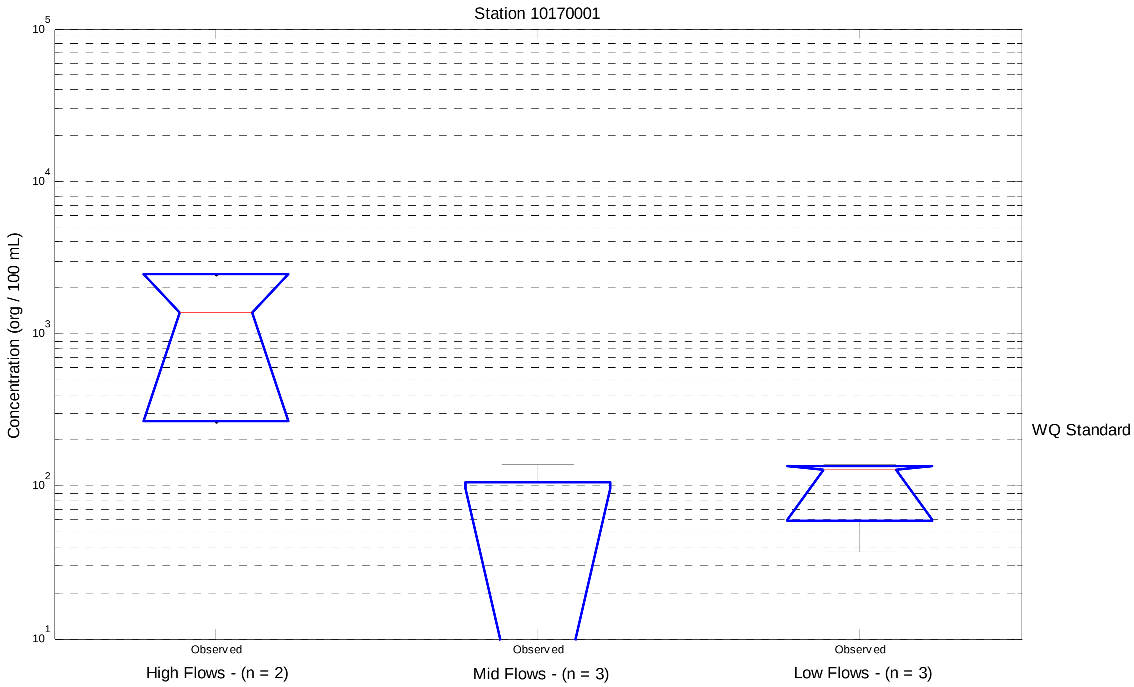

Station 10070005
10^5
10^4
10^3
10^2
10^1
Concentration (org / 100 mL)
WQ Standard
Observed
Observed
Observed
High Flows - (n = 10)
Mid Flows - (n = 24)
Low Flows - (n = 10)

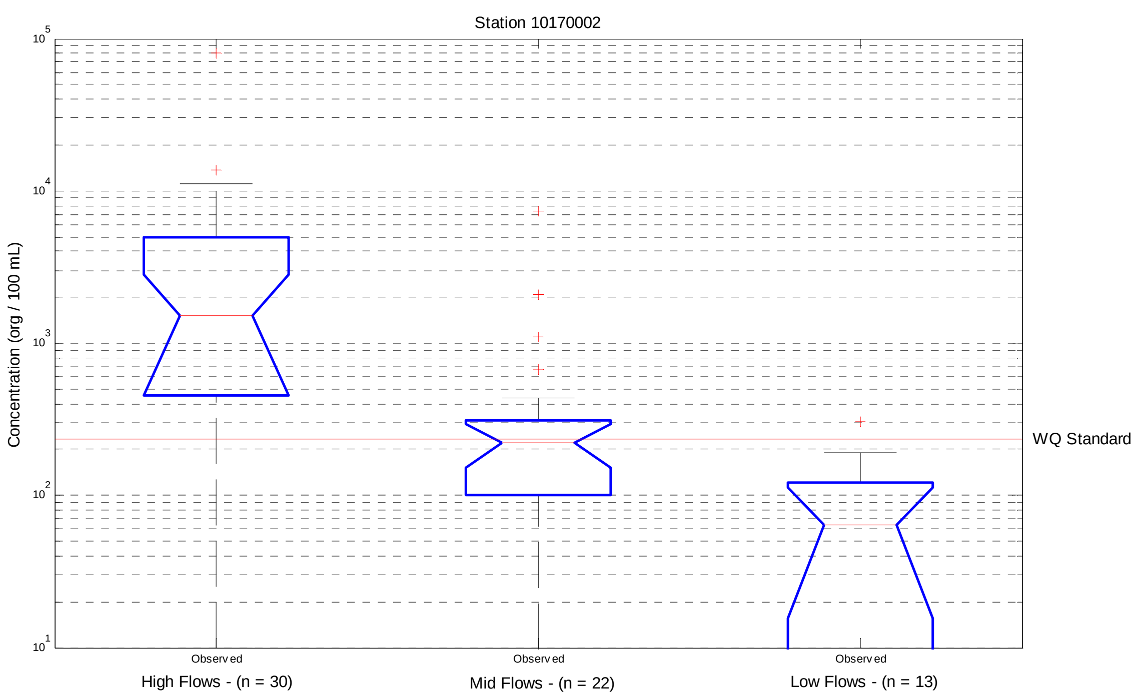

Station 10070006
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 10)
Mid Flows - (n = 24)
Low Flows - (n = 10)

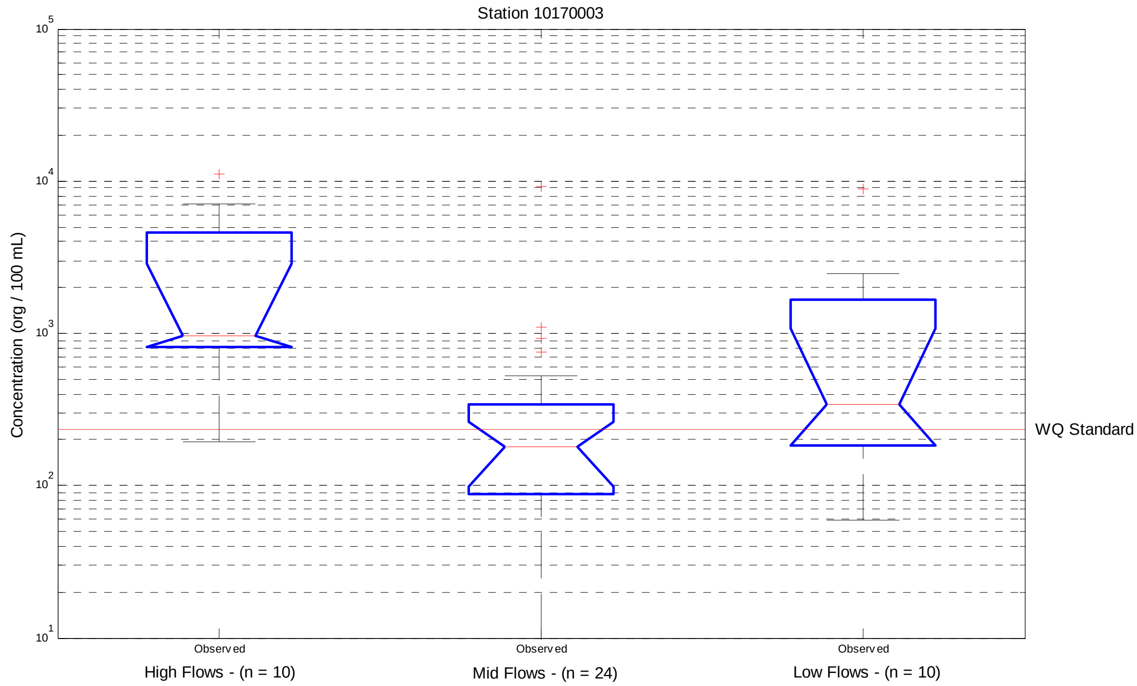

Station 10090001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 15)
Mid Flows - (n = 30)
Low Flows - (n = 13)

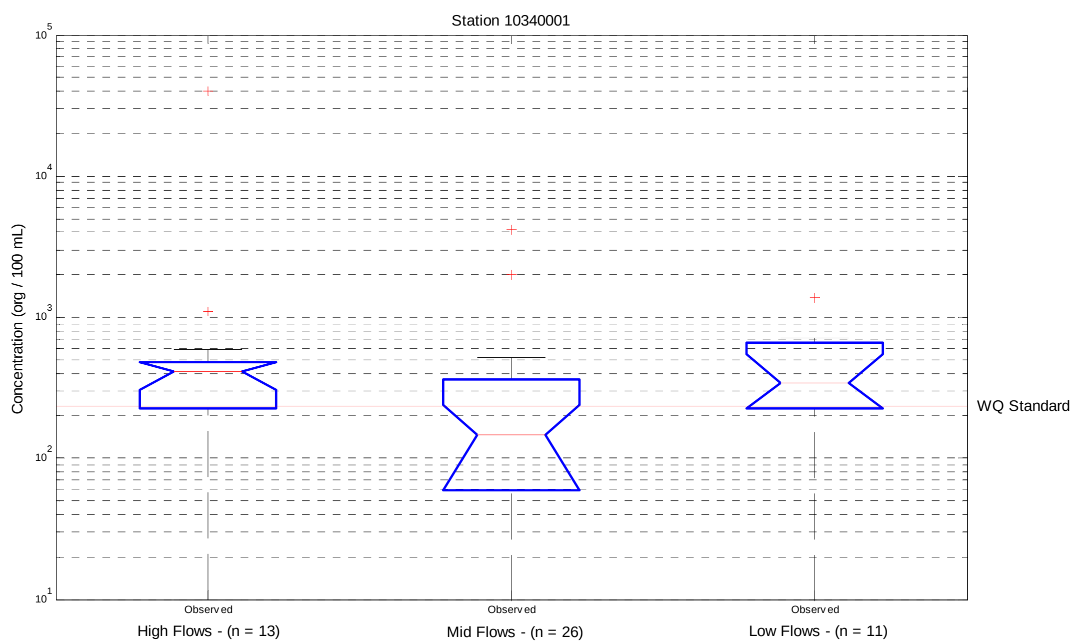

Station 10120001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 36)
Mid Flows - (n = 28)
Low Flows - (n = 16)

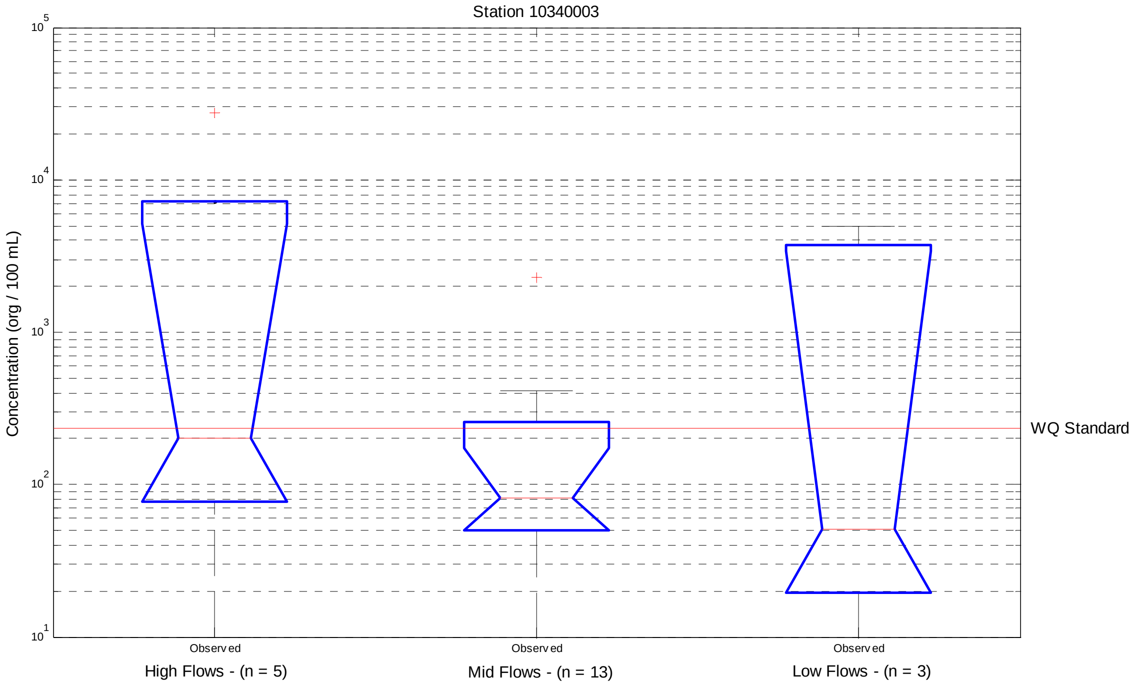

Station 10160001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 13)
Mid Flows - (n = 23)
Low Flows - (n = 14)

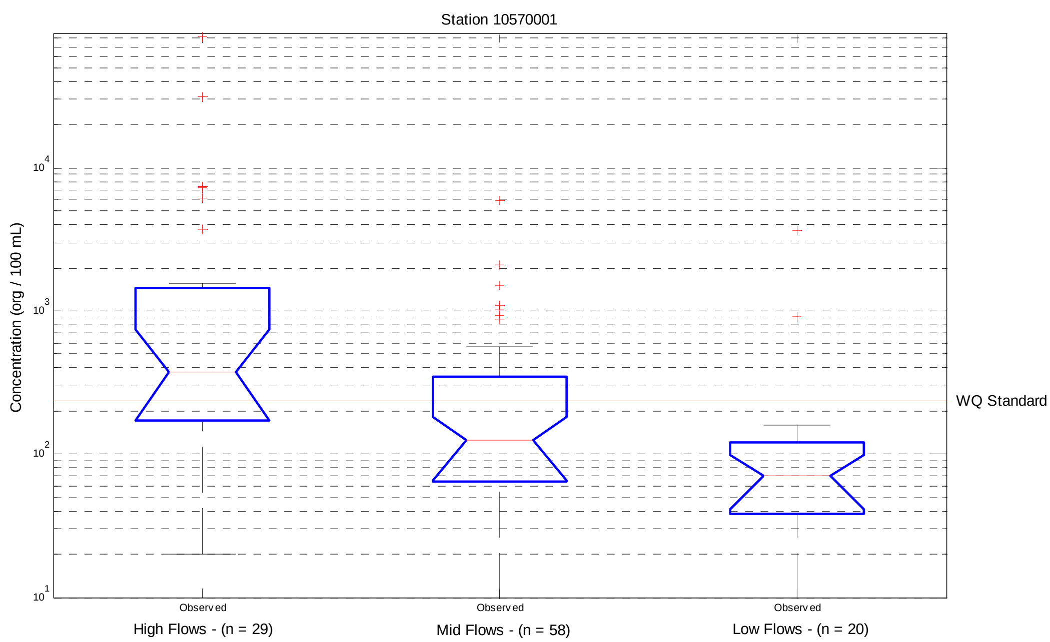

Station 10170001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 2)
Mid Flows - (n = 3)
Low Flows - (n = 3)

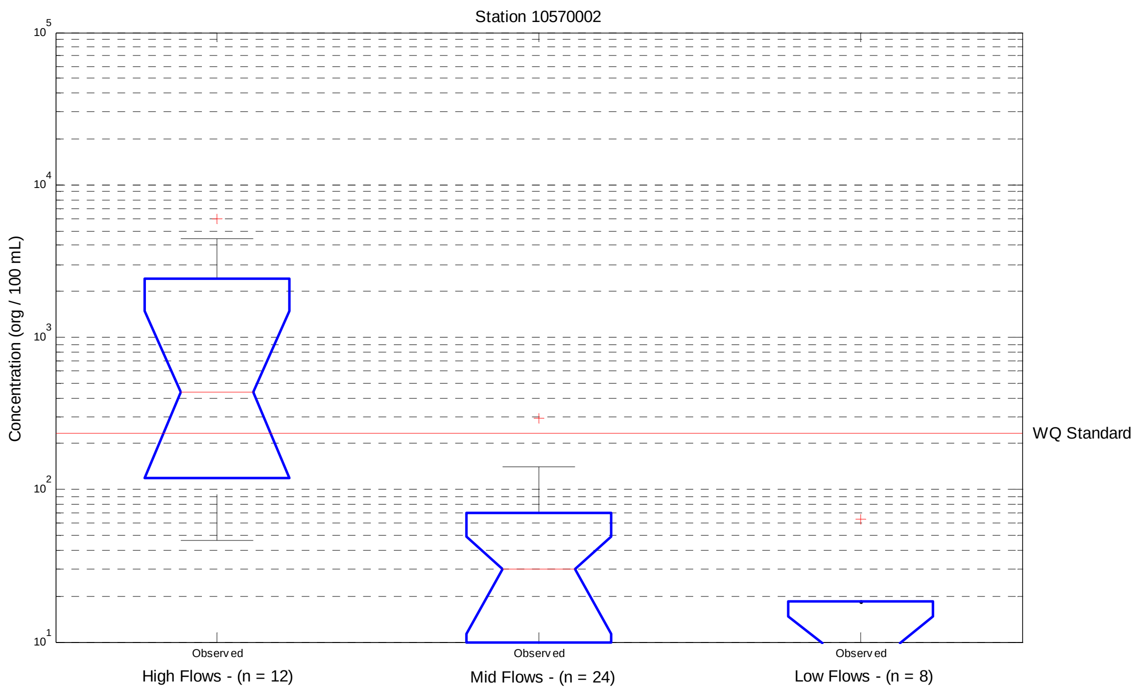

Station 10170002
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 30)
Mid Flows - (n = 22)
Low Flows - (n = 13)

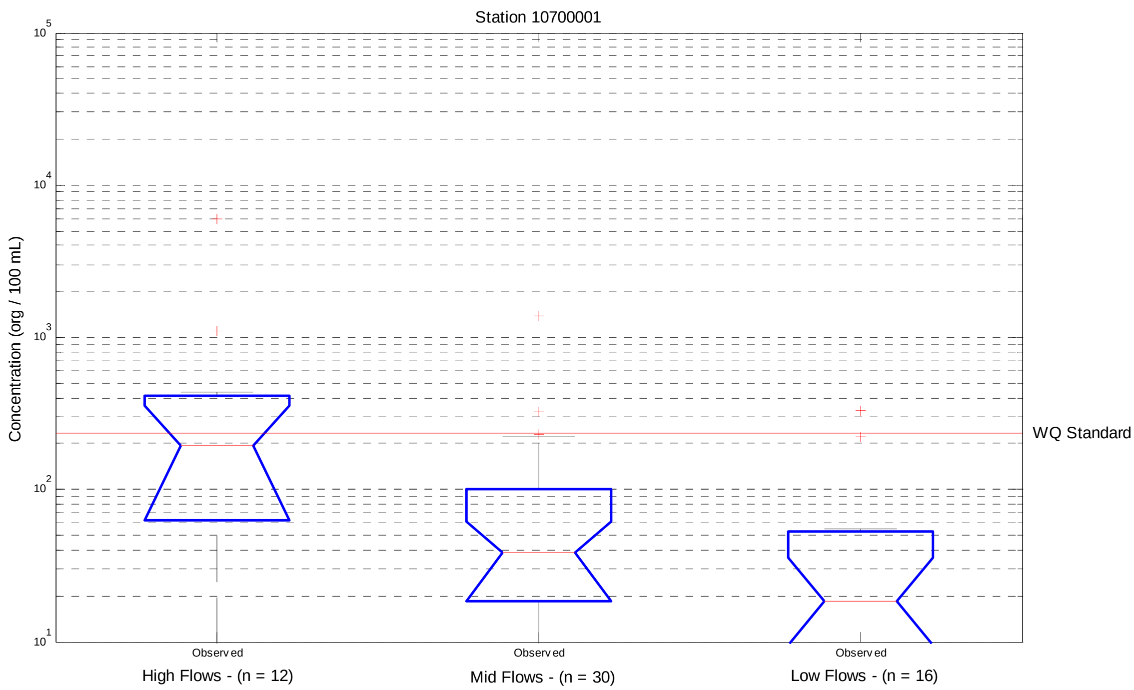

Station 10170003
Concentration (org / 100 mL)
WQ Standard
Observed
High Flows - (n = 10)
Mid Flows - (n = 24)
Low Flows - (n = 10)

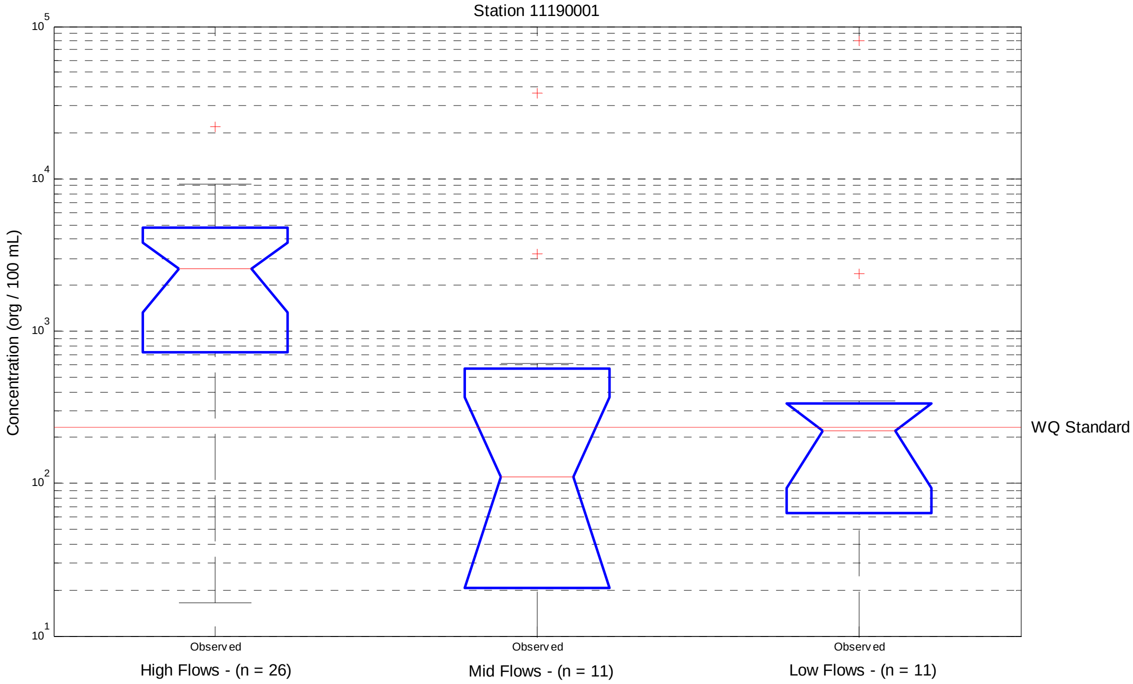

Station 10340001
Concentration (org / 100 mL)
WQ Standard
Observed
High Flows - (n = 13)
Mid Flows - (n = 26)
Low Flows - (n = 11)

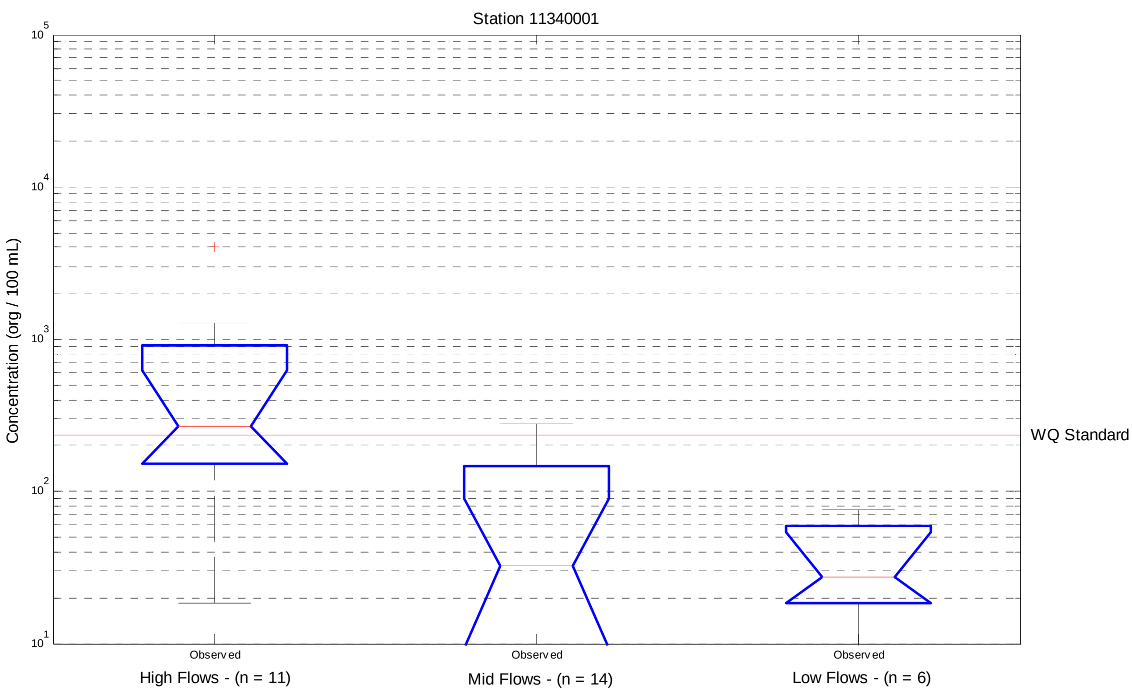

Station 10340003
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 5)
Mid Flows - (n = 13)
Low Flows - (n = 3)

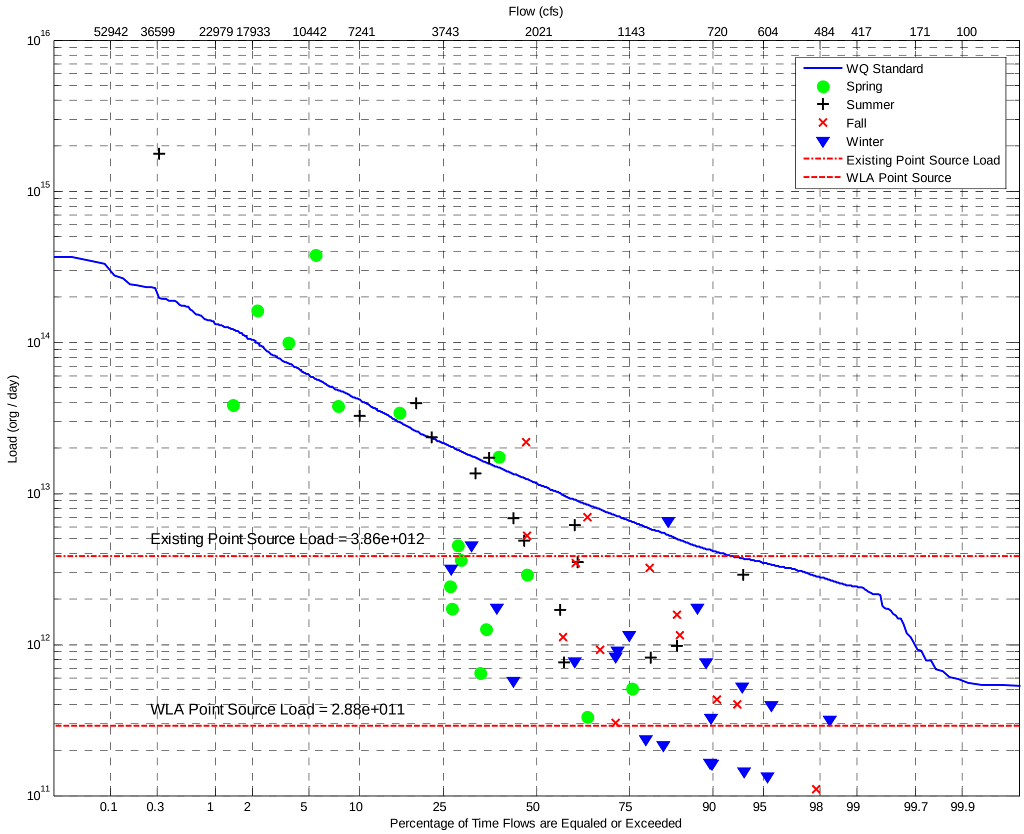

Station 10570001
Concentration (org / 100 mL)
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 29)
Mid Flows - (n = 58)
Low Flows - (n = 20)


Station 10570002
Concentration (org / 100 mL)
WQ Standard
Observed
High Flows - (n = 12)
Mid Flows - (n = 24)
Low Flows - (n = 8)

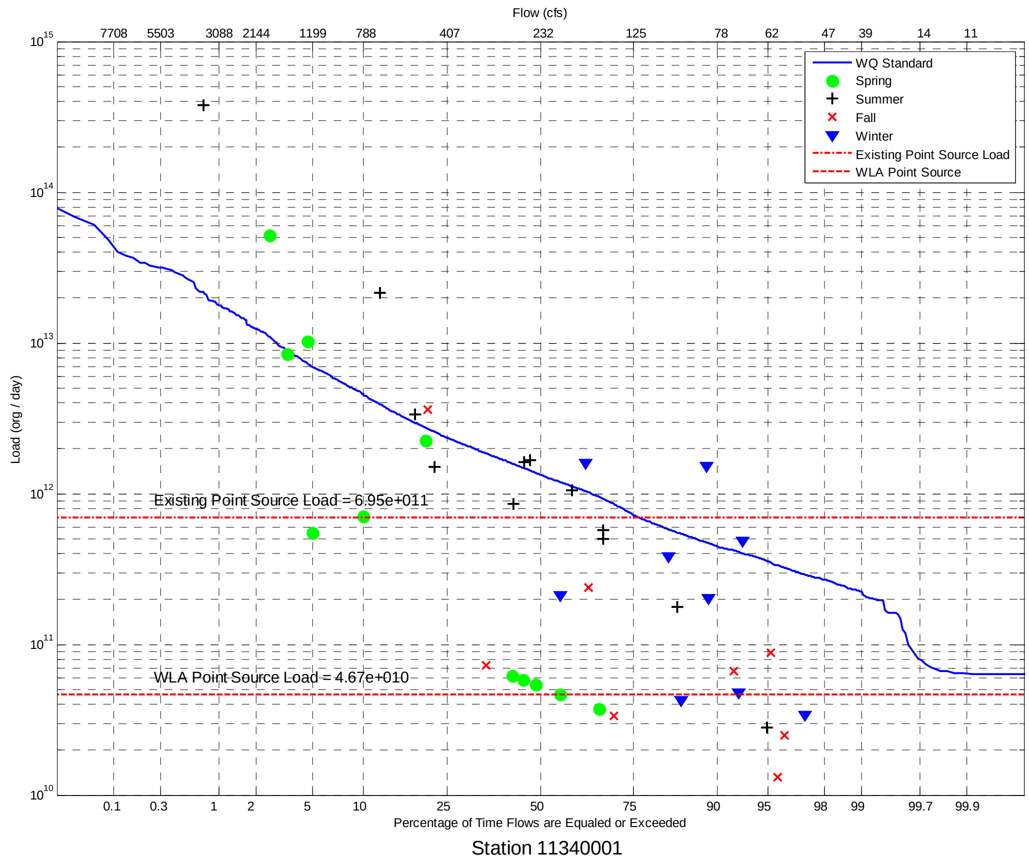

Station 10700001
Concentration (org / 100 mL)
WQ Standard
Observed
High Flows - (n = 12)
Mid Flows - (n = 30)
Low Flows - (n = 16)

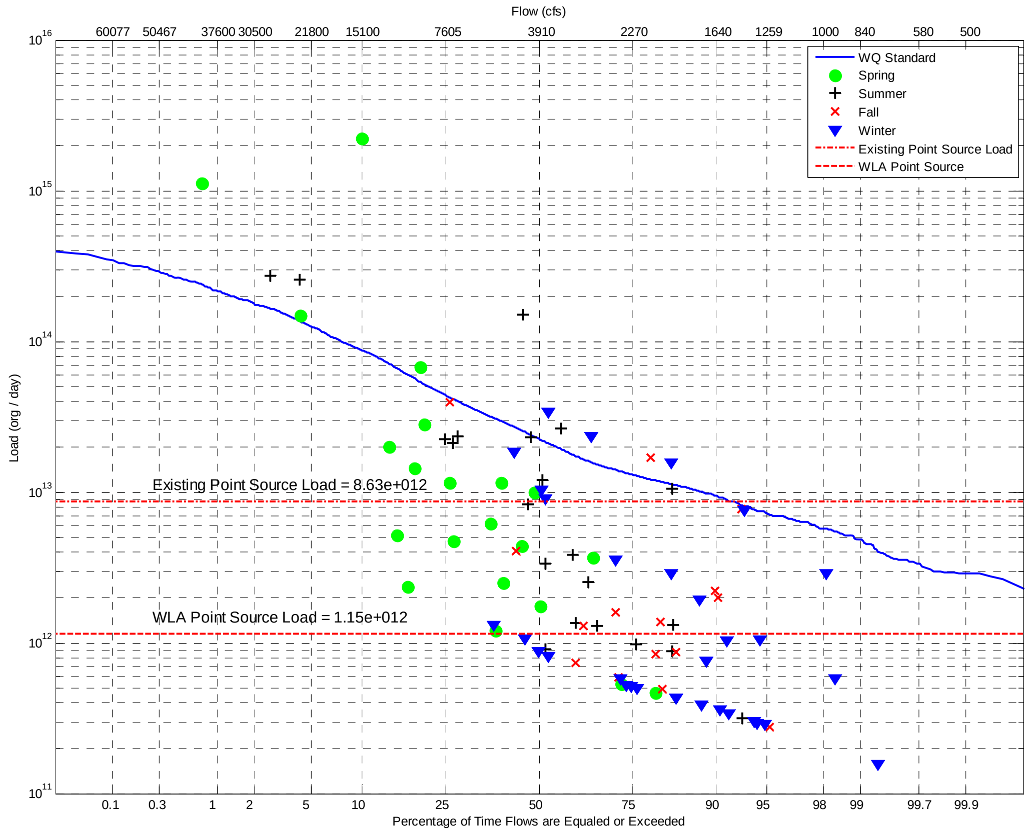

Station 11190001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 26)
Mid Flows - (n = 11)
Low Flows - (n = 11)


Station 11340001
Concentration (org / 100 mL)
10^5
10^4
10^3
10^2
10^1
WQ Standard
Observed
Observed
Observed
High Flows - (n = 11)
Mid Flows - (n = 14)
Low Flows - (n = 6)

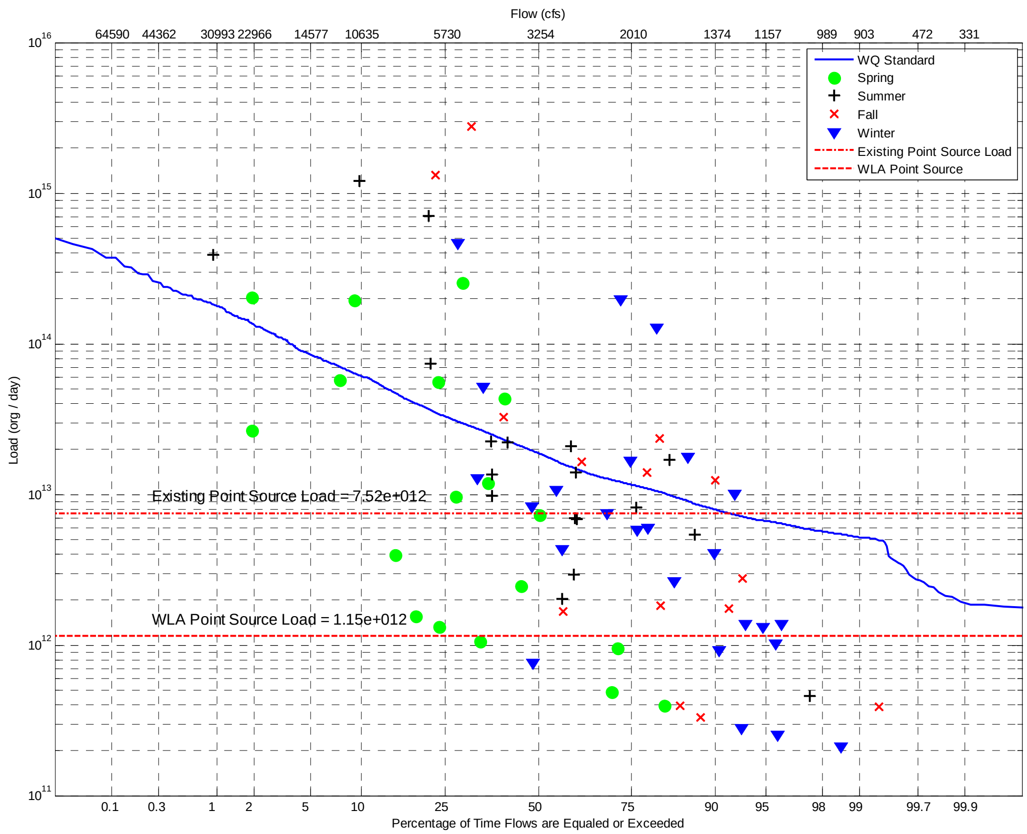


Station 10070005

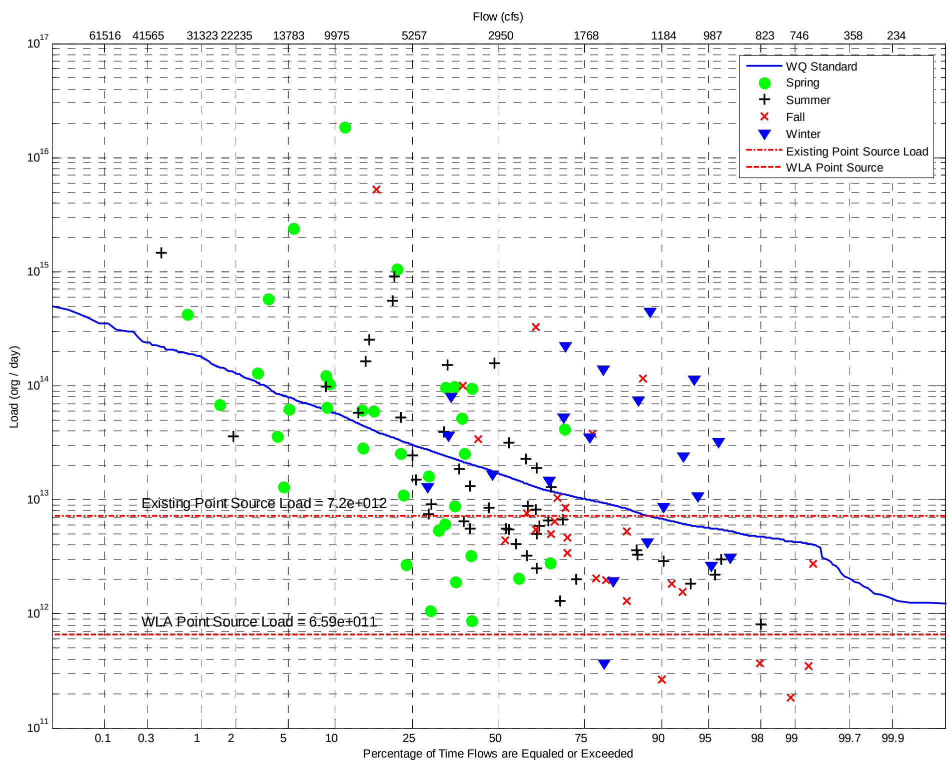

Flow (cfs)
7708
5503
3088
2144
1199
788
407
232
125
78
62
47
39
14
11
WQ Standard
Spring
Summer
Fall
Winter
Existing Point Source Load
WLA Point Source
Existing Point Source Load = 6.95e+011
WLA Point Source Load = 4.67e+010
Load (org / day)
10^{15}
10^{14}
10^{13}
10^{12}
10^{11}
10^{10}
0.1
0.3
1
2
5
10
25
50
75
90
95
98
99
99.7
99.9
Percentage of Time Flows are Equaled or Exceeded
Station 11340001



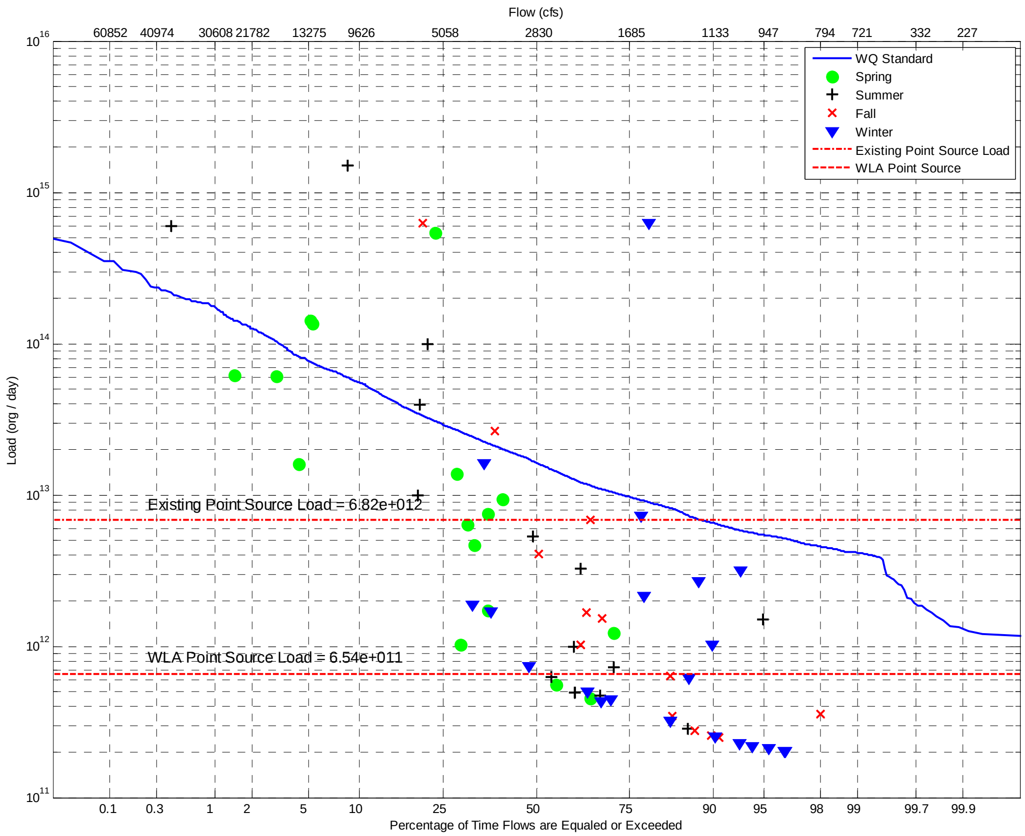
Station 10700001



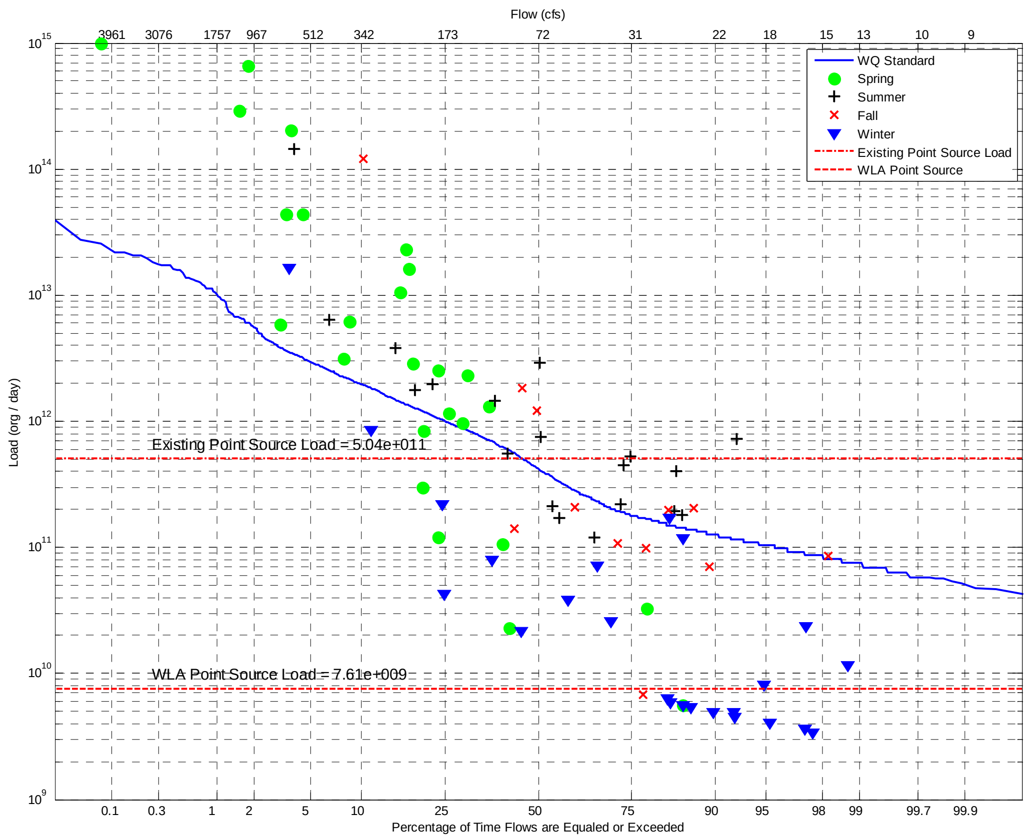
Station 10160001



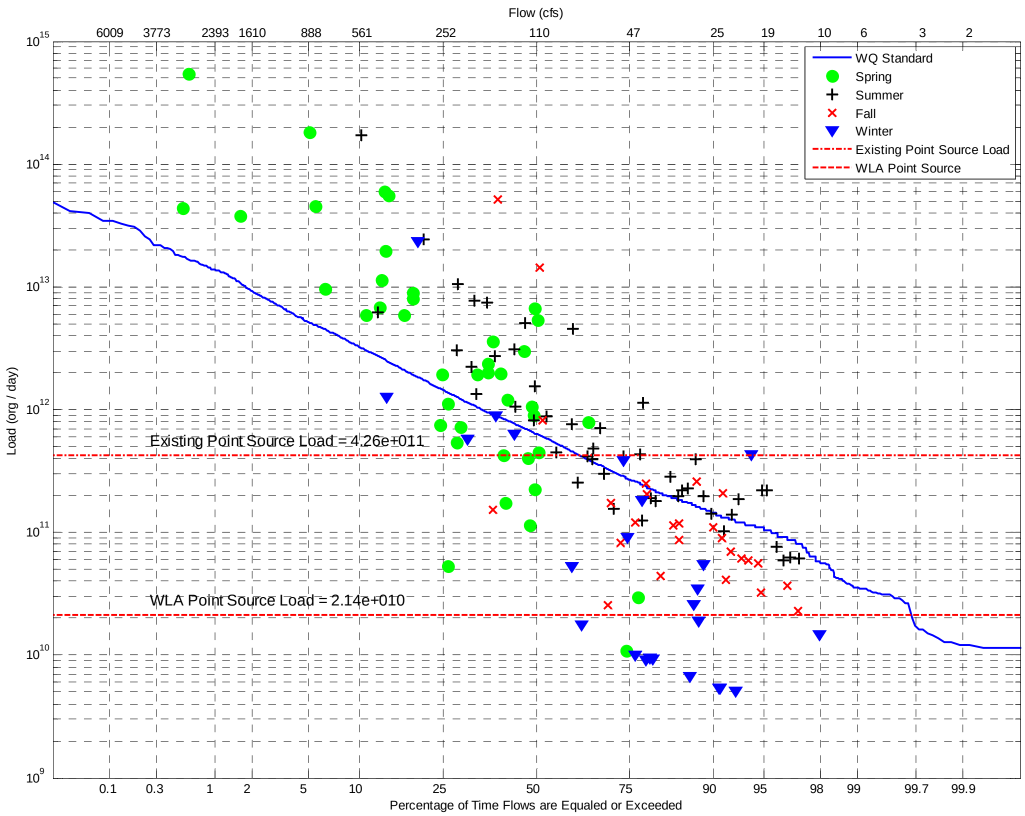
Station 10570001



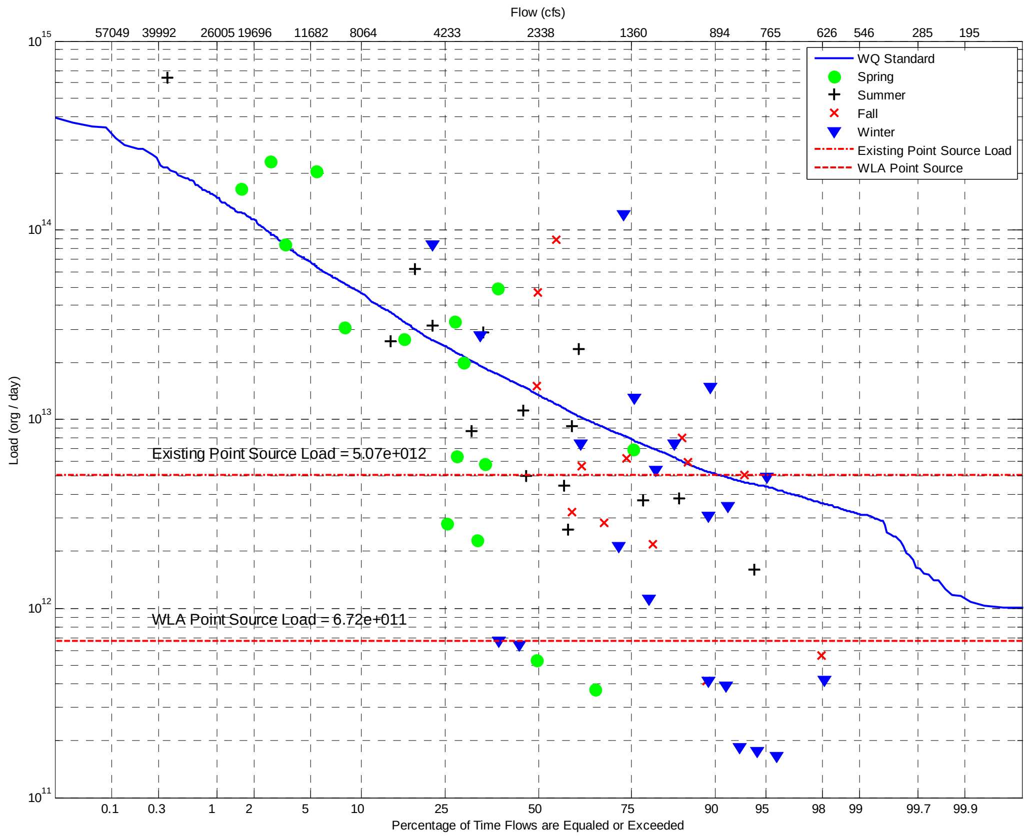
Station 10570002



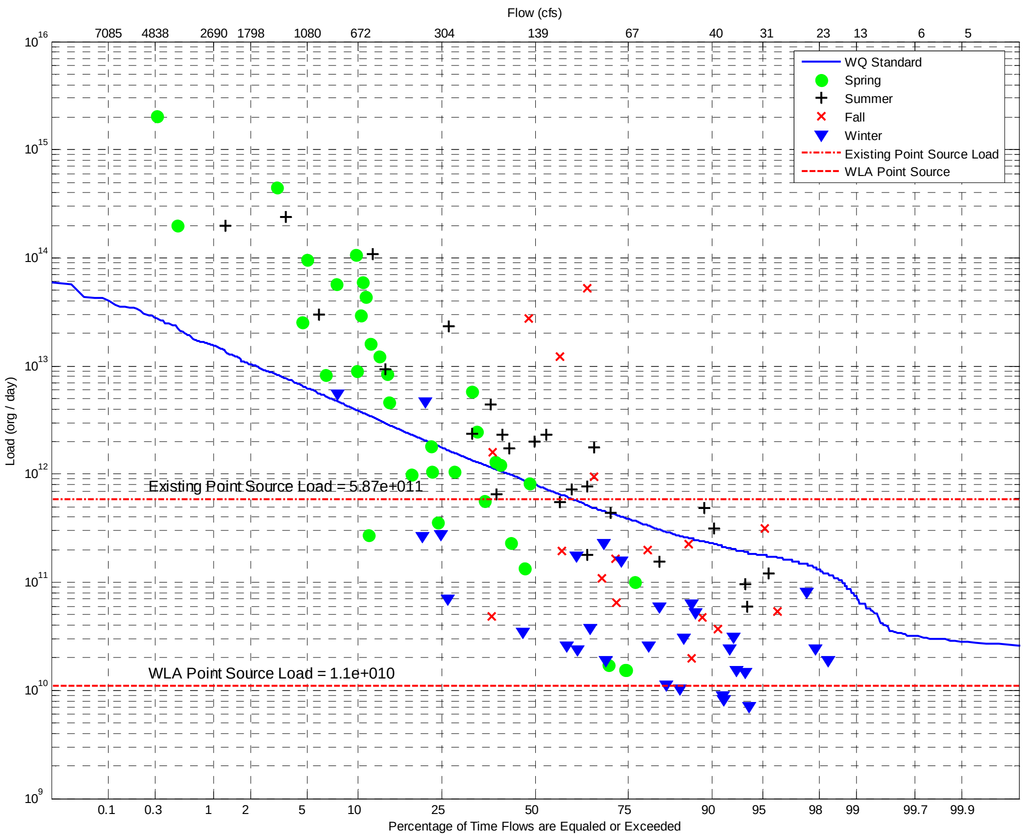
Station 10070002



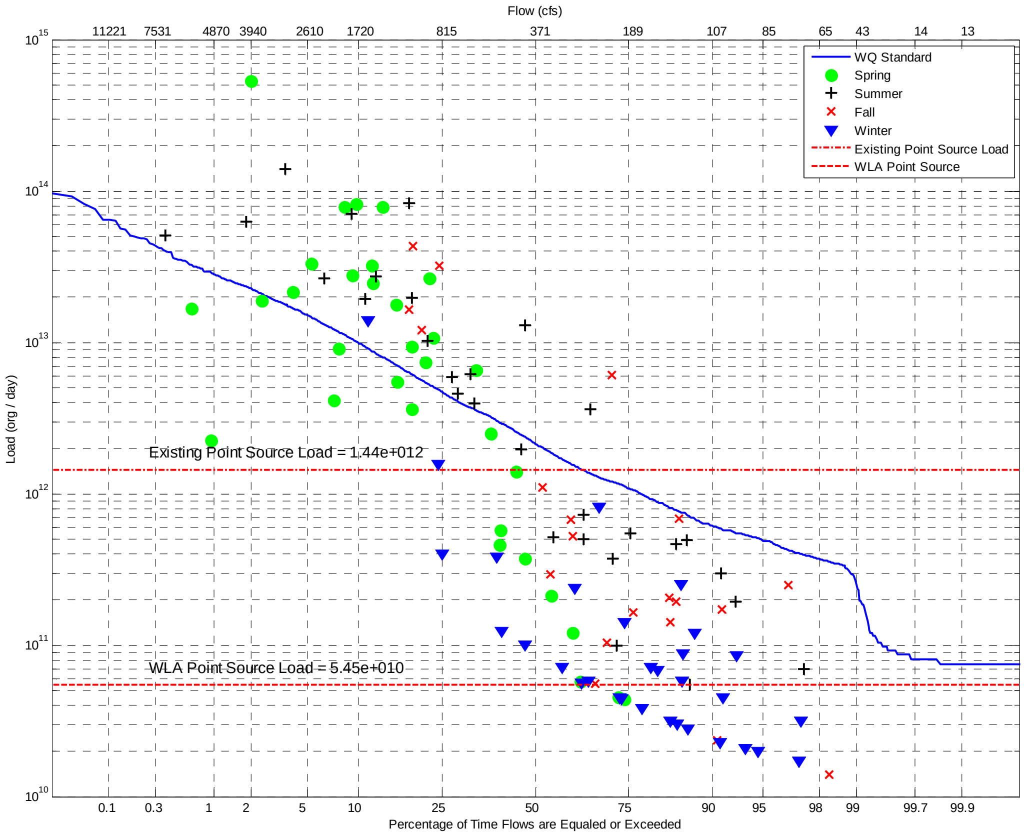
Station 10070004



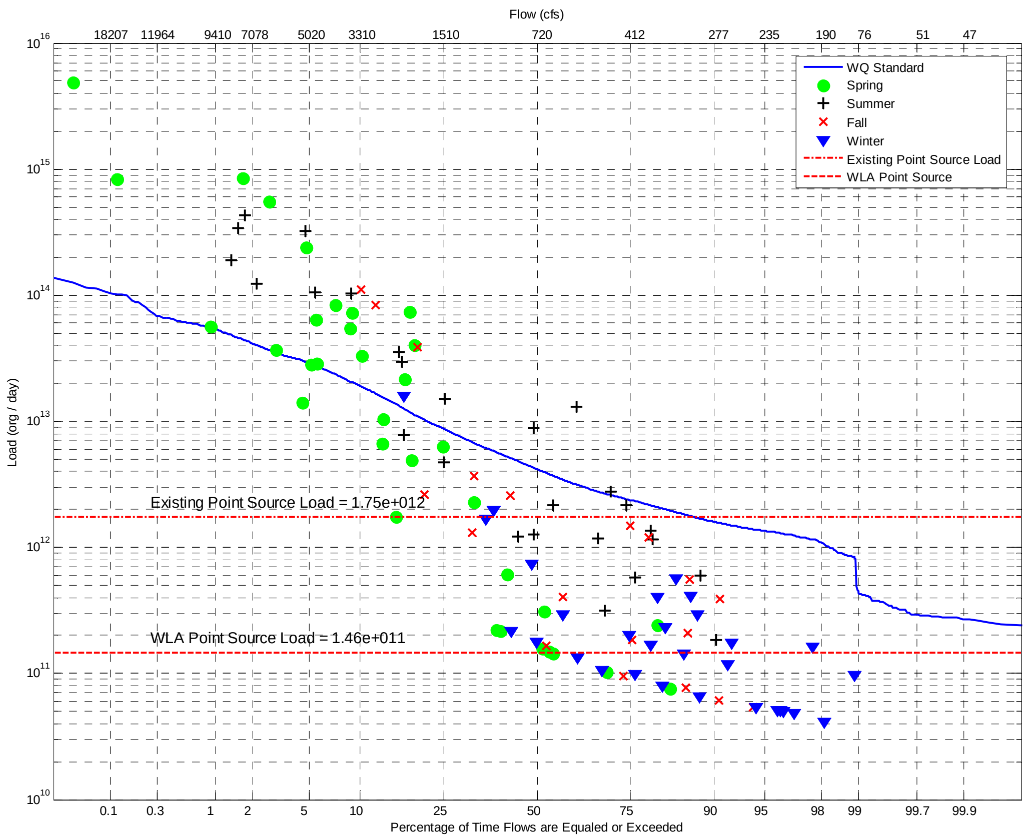
Station 10070006



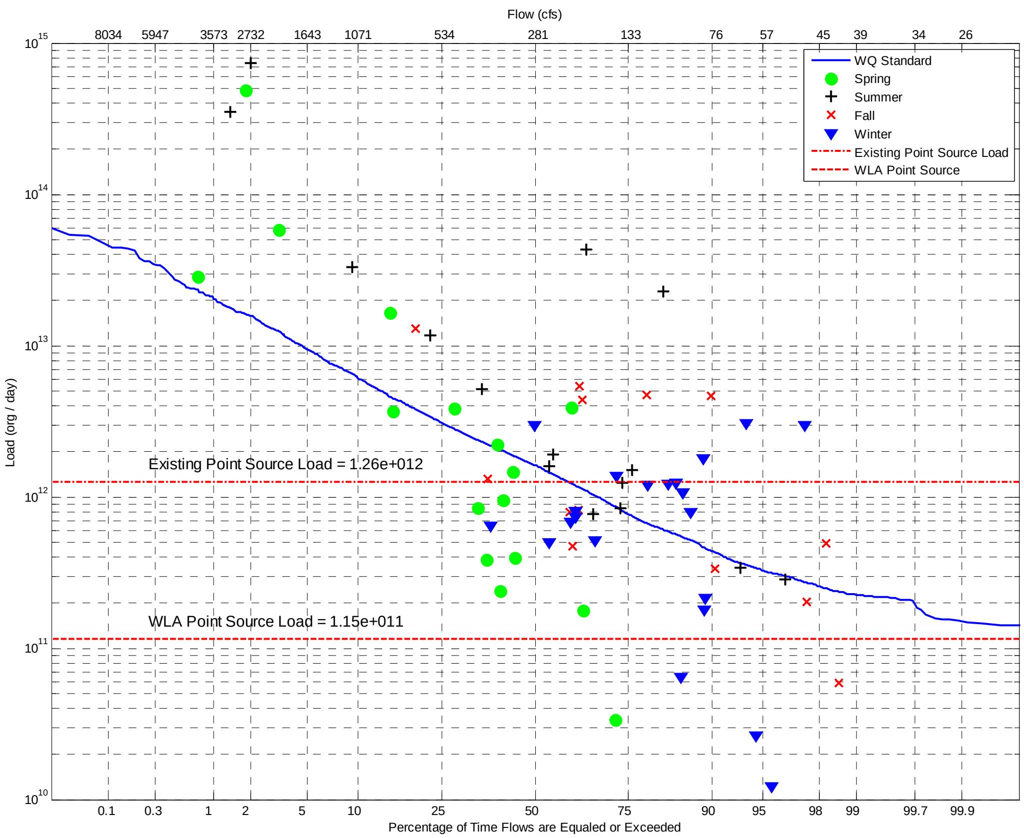
Station 10070001



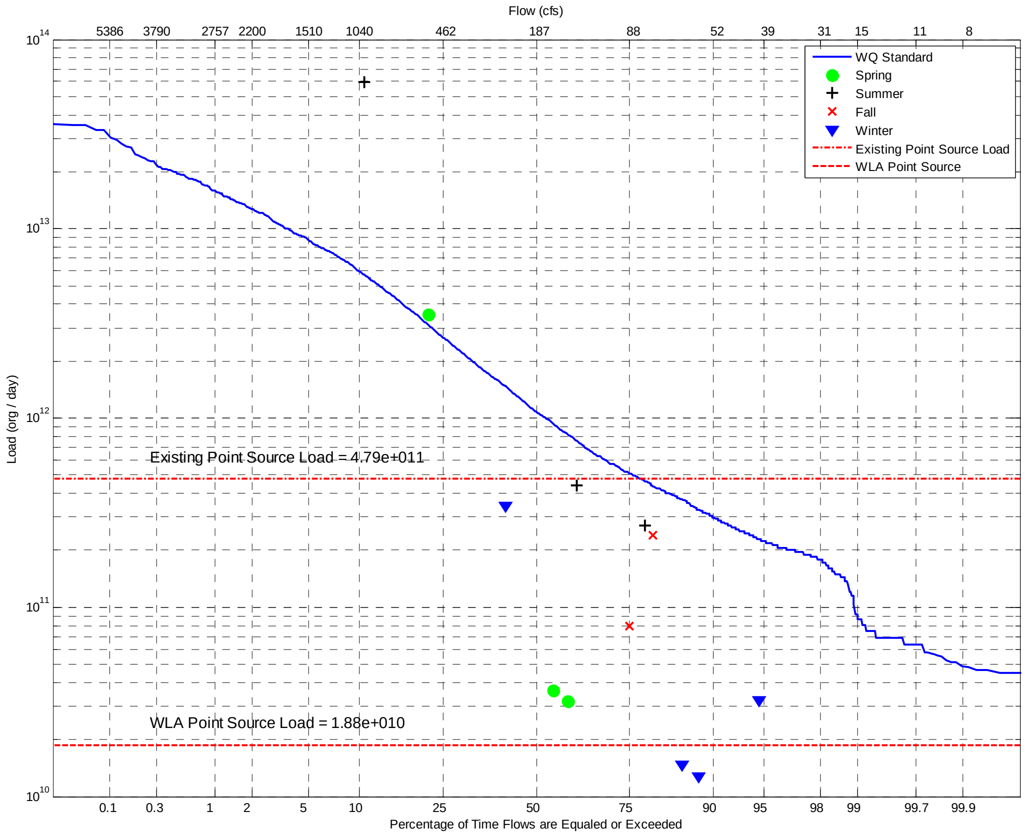
Station 10070003



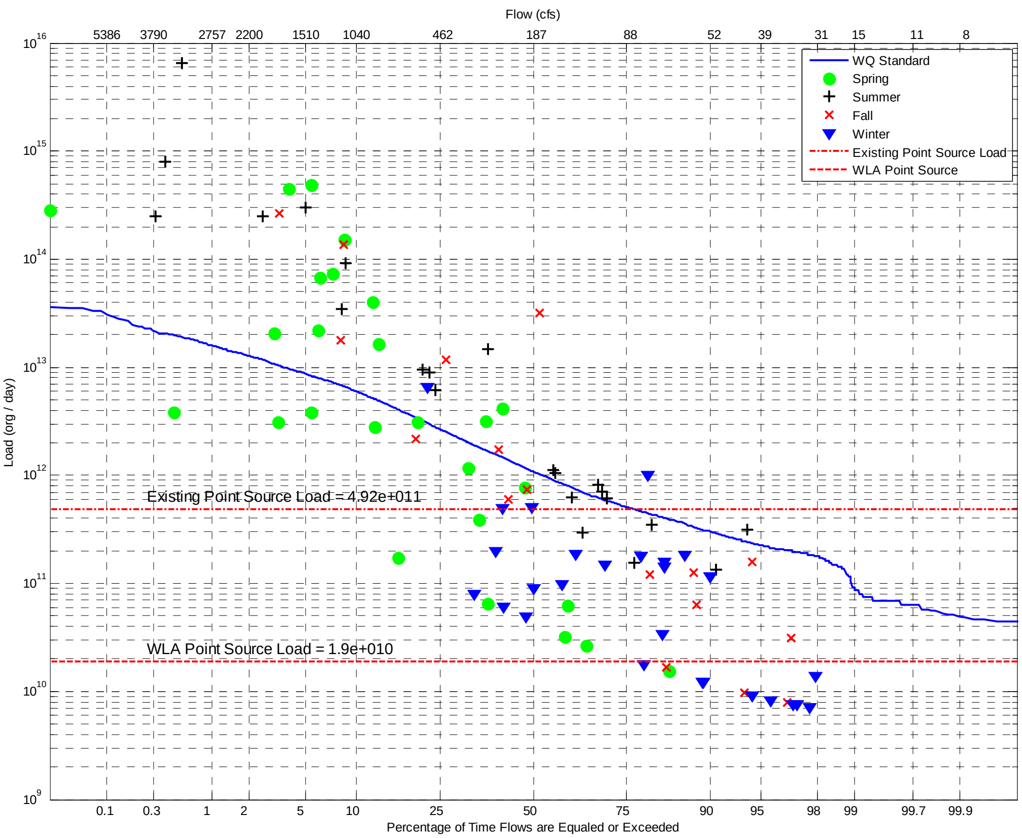
Station 10120001



Station 10170003



Station 10170001



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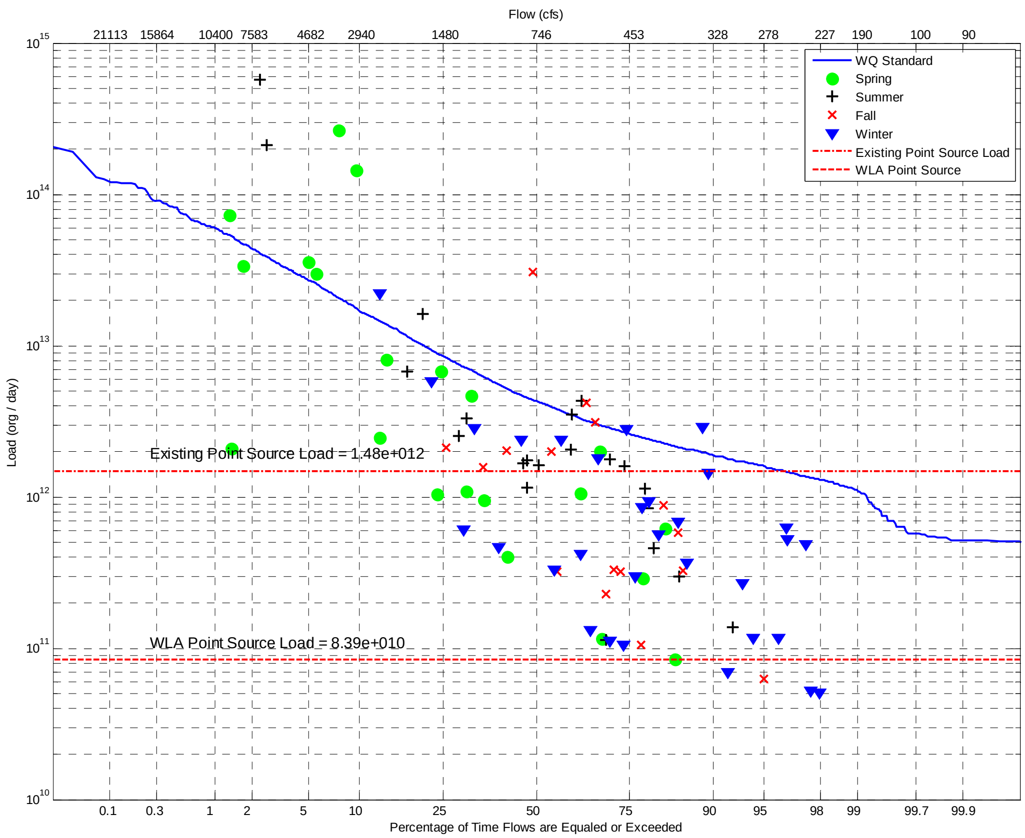

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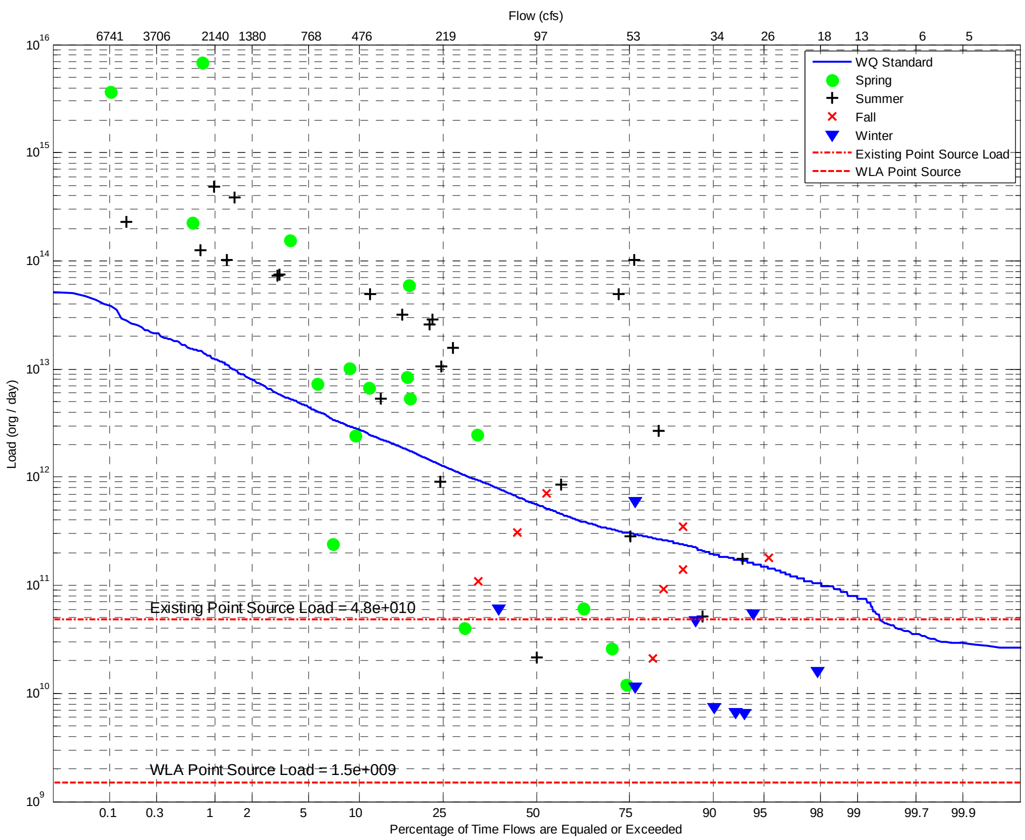

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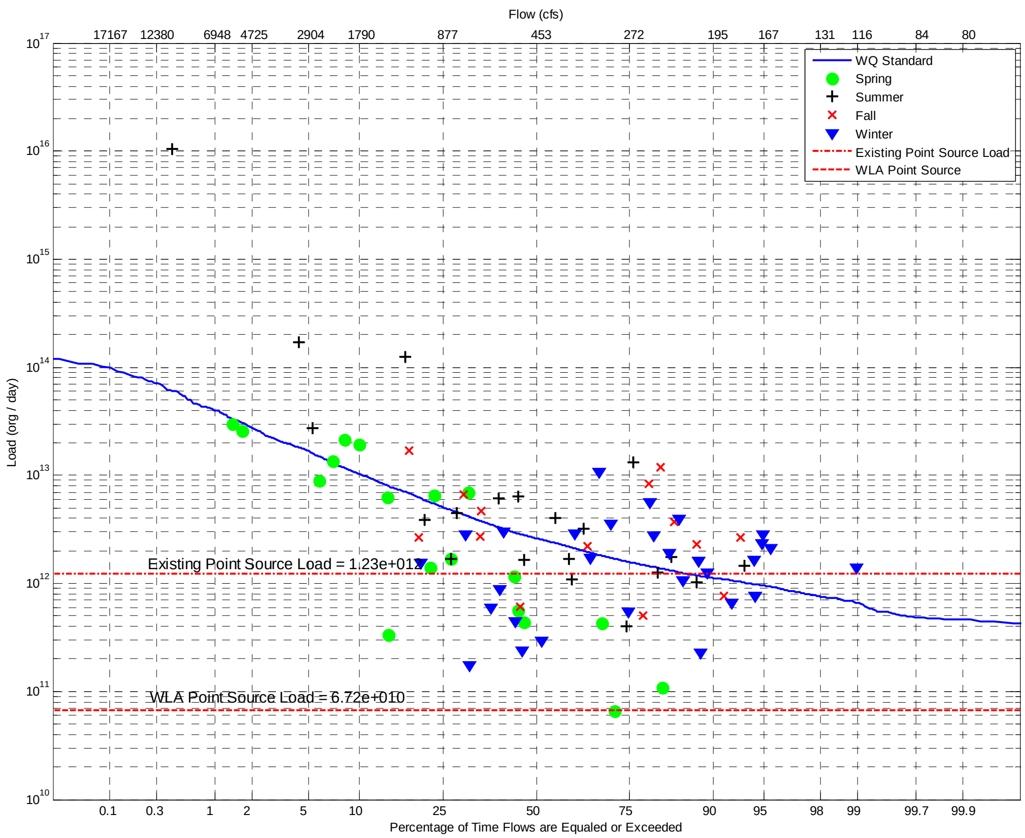

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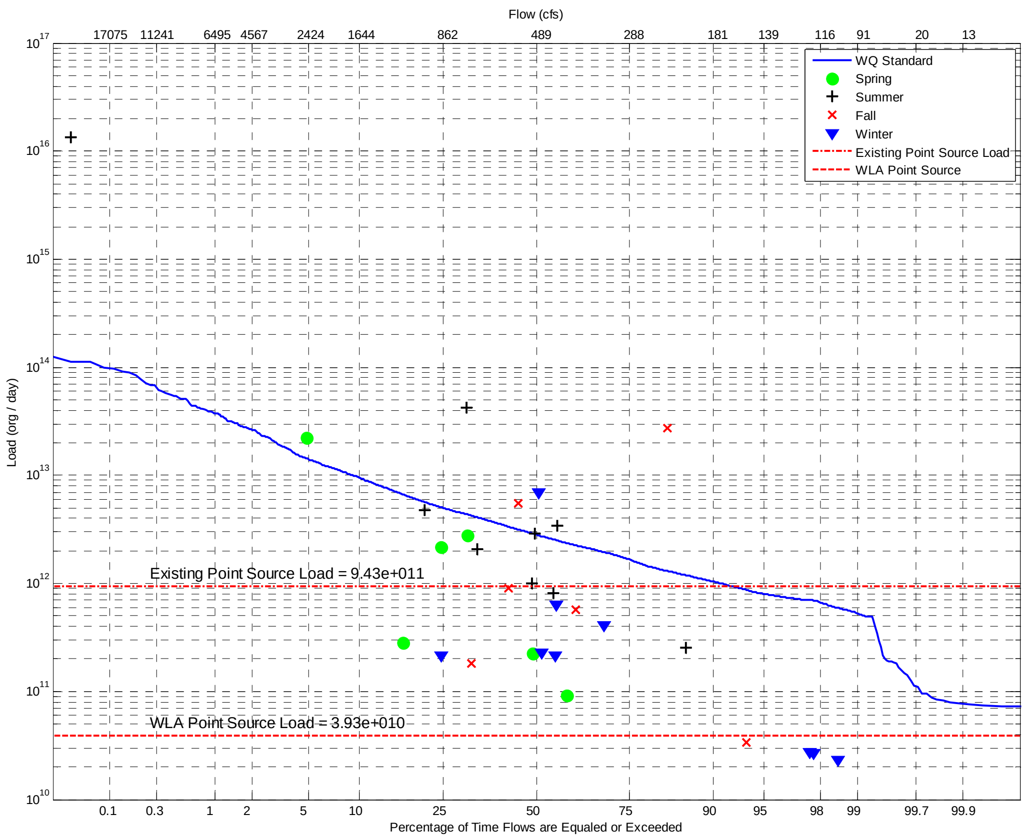

Station 10340003

Appendix D - Waste Load Allocations for NPDES Permits

The WLAs given in these tables are examples based on design flow and Class A1 water quality standards. The TMDL WLAs are set as sums by segment in the test of the TMDL. Individual permit limits are not required in the TMDL and the permitting authority assigns the site specific WLAs "consistent with the assumptions and requirements" contained in the TMDL [40 CFR 122.44(d)(1)(vii)(B)].

CWA Section 303(c)(4) added by PL 100-4] (A) Standard Not Attained. -- For waters identified under paragraph (I)(A) where the applicable water quality standard has not yet bene attained, any effluent limitation based on a total maximum daily load or other waste load allocation established under this section may be revised only if (i) the cumulative effect of all such revised effluent limitations based on such total maximum daily load or waste load allcoation will assure the attainment of such water quality standard, or (ii) the designated use which is not being attained is removed in accordance with regulations established under this section.

Table D -1 WLAs for permitted facilities and future growth.

EPA ID	Facility Name	Flow Type	Flow (MGD)	Disinfect (Y/N)	Estimated Existing Recreational Season *E. coli* Load (cfu/day)	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)
MN0021882*	Blooming Prairie, City of	Continuous	0.889	Y	3.84E+08	n/a	n/a
MN0023612*	Hayfield, City of	Continuous	0.41	Y	5.32E+08	n/a	n/a
MN0063461*	Lansing Township	Controlled	0.026	Y	1.97E+08	n/a	n/a
MN0021601*	Sargeant, City of	Controlled	0.0123	Y	9.31E+06	n/a	n/a
MN0022934*	Brownsdale, City of	Controlled	0.184	Y	1.39E+09	n/a	n/a
MN0025186*	Waltham, City of	Controlled	0.027	Y	2.04E+08	n/a	n/a
MN0022683*	Austin, City of	Continuous	8.475	Y	4.10E+08	n/a	n/a
MN0048992*	Hollandale, City of	Controlled	0.0427	Y	3.23E+08	n/a	n/a
MNG580013*	Elkton, City of	Controlled	0.017	Y	1.29E+08	n/a	n/a
MNG580072*	Rose Creek, City of	Controlled	0.065	Y	4.92E+08	n/a	n/a
MN0040631*	Oakland Sanitary District	Controlled	0.012	Y	9.08E+07	n/a	n/a
MN0022101*	Lyle, City of	Controlled	0.188	Y	1.42E+09	n/a	n/a
IA0033723	St. Ansgar, City of	Controlled	0.18	Y	1.60E+10	8.59E+08	1.60E+09
IA0032956	Osage, City of	Continuous	0.75	Y	6.67E+09	3.58E+09	6.67E+09
IA0064271	Orchard, City of	Controlled	0.013	N	1.76E+10	6.20E+07	1.16E+08
IA0028894	Floyd, City of	Continuous	0.07	Y	6.23E+08	3.34E+08	6.23E+08
IA0003557	Cambrex Charles City, Inc	Continuous	0.25	N	2.52E+11	1.19E+09	2.22E+09
IA0022039	Charles City, City of	Continuous	3.1	Y	2.76E+10	1.48E+10	2.76E+10
IA0024503	Nashua, City of	Continuous	0.212	Y	1.89E+09	1.01E+09	1.89E+09
IA0033693	Plainfield, City of	Controlled	0.034	Y	3.02E+09	1.62E+08	3.02E+08
IA0035254	Stacyville, City of	Controlled	0.158	N	9.38E+10	7.54E+08	1.41E+09
MN0021261*	Adams, City of	Continuous	0.278	Y	1.51E+08	n/a	n/a
IA0033197	Waverly, City of	Continuous	2.33	Y	2.07E+10	1.11E+10	2.07E+10
IA0044156	Denver, City of	Continuous	0.376	N	3.25E+11	1.79E+09	3.34E+09
IA0026506	Janesville, City of	Continuous	0.165	Y	1.47E+09	7.87E+08	1.47E+09
MN0021008*	Geneva, City of	Controlled	0.069	Y	5.22E+18	n/a	n/a

Table D -1 WLAs for permitted facilities and future growth.

EPA ID	Facility Name	Flow Type	Flow (MGD)	Disinfect (Y/N)	Estimated Existing Recreational Season *E. coli* Load (cfu/day)	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)
MN0033740*	MDNR Myre Big Island SP	Controlled	0.01	Y	7.57E+07	n/a	n/a
MN0041092*	Albert Lea, City of	Continuous	18.38	Y	4.50E+09	n/a	n/a
MN0041122*	Hayward, City of	Controlled	0.045	Y	3.41E+08	n/a	n/a
MNG580067*	Clarks Grove, City of	Controlled	0.1164	Y	8.81E+08	n/a	n/a
MN0021245*	Glenville, City of	Controlled	0.13	Y	9.84E+08	n/a	n/a
MNG580042*	Twin Lakes, City of	Controlled	0.03	Y	2.27E+08	n/a	n/a
MNG580065*	MNDOT Albert Lea Travel Info	Controlled	0.977	Y	7.40E+09	n/a	n/a
IA0032395	Northwood, City of	Continuous	0.475	Y	4.23E+09	2.27E+09	4.23E+09
IA0074756	Diamond Jo Worth, LLC	Controlled	0.0217	Y	1.93E+09	1.04E+08	1.93E+08
IA0062529	Grafton, City of	Controlled	0.0283	Y	2.52E+09	1.35E+08	2.52E+08
IA0076635	Kensett, City of	Controlled	0.03	Y	2.67E+09	1.43E+08	2.67E+08
IA0032778	Nora Springs, City of	Controlled	0.301	Y	2.68E+08	1.44E+09	2.68E+09
IA0033383	Plymouth, City of	Controlled	0.0469	N	9.57E+09	2.24E+08	4.17E+08
IA0033383A	Plymouth, City of	Controlled	0.237	N	8.58E+10	1.13E+09	2.11E+09
IA0047830	Manly, City of	Controlled	0.197	N	2.68E+11	9.40E+08	1.75E+09
IA0058432	Rockford, City of	Controlled	0.12	Y	1.07E+10	5.72E+08	1.07E+09
IA0063495	Rock Falls, City of	Controlled	0.0155	Y	1.38E+09	7.39E+07	1.38E+08
MNG550003*	Emmons, City of	Continuous	0.124	Y	1.93E+07	n/a	n/a
IA0068683	Thompson, City of	Controlled	0.0742	N	1.19E+11	3.54E+08	6.60E+08
IA0021563	Forest, City of	Continuous	1.65	Y	1.47E+10	7.87E+09	1.47E+10
IA0036528	Leland, City of	Controlled	0.0335	N	5.16E+10	1.60E+08	2.98E+08
IA0027448	Lake Mills, City of	Continuous	0.75	N	4.28E+11	3.58E+09	6.67E+09
IA0066028	DNR Pilot Knob State Park	Controlled	0.0012	N	6.00E+08	5.72E+06	1.07E+07
IA0058718	Fertile, City of	Controlled	0.056	N	7.20E+10	2.67E+08	4.98E+08
IA0001945	Lehigh Cement Co.	Controlled	0.006	N	7.00E+08	2.86E+07	5.34E+07
IA0063207	Willow Pointe Assist Living Ctr	Continuous	0.015	Y	1.33E+08	7.15E+07	1.33E+08
IA0057169	Mason City, City of	Continuous	11	Y	9.78E+10	5.25E+10	9.79E+10
IA0035432	Greene, City of	Continuous	0.148	N	2.20E+11	7.06E+08	1.32E+09
IA0057207	Marble Rock, City of	Continuous	0.06	N	6.52E+10	2.86E+08	5.34E+08
IA0061344	Rudd, City of	Controlled	0.0565	N	8.62E+10	2.69E+08	5.03E+08
IA0023388	Clarksville, City of	Controlled	0.15	N	2.88E+11	7.15E+08	1.33E+09
IA0033359	Shell Rock, City of	Controlled	0.282	N	2.60E+11	1.35E+09	2.51E+09
IA0033481	Rockwell, City	Continuous	0.152	N	1.98E+11	7.25E+08	1.35E+09
IA0058441	Clear Lake Sanitary District	Controlled	5.7	N	6.37E+11	2.72E+10	5.07E+10
IA0073903	Swaledale, City of	Continuous	0.02	N	3.48E+10	9.54E+07	1.78E+08
IA0036005	Thornton, City OF	Controlled	0.0718	N	1.44E+10	3.42E+08	6.39E+08
IA0036005	Sheffield, City of	Controlled	1.401	N	1.86E+11	6.68E+09	1.25E+10
IA0076724	Meservey, City of	Continuous	0.028	N	5.04E+10	1.34E+08	2.49E+08
IA0036471	Hampton, City of	Controlled	0.711	N	8.44E+11	3.39E+09	6.32E+09
IA0062472	Terrace Hill Sanitary District	Continuous	0.0135	N	3.00E+09	6.44E+07	1.20E+08
IA0062944	Latimer-Coulter, City of	Controlled	0.0789	N	1.07E+11	3.76E+08	7.02E+08
IA0067358	DNR Beeds Lake State Park	Controlled	0.033	N	2.52E+09	1.57E+08	2.94E+08
IA0033316	Dumont, City of	Continuous	0.423	N	1.35E+11	2.02E+09	3.76E+09
IA0042731	Allison, City of	Controlled	0.2	N	2.01E+11	9.54E+08	1.78E+09
IA0035050	Aplington, City of	Continuous	0.35	N	2.11E+11	1.67E+09	3.11E+09
IA0042803	Wellsburg, City of	Continuous	0.19	N	1.43E+11	9.06E+08	1.69E+09
IA0035297	Ackley, City of	Continuous	0.53	Y	4.71E+09	2.53E+09	4.71E+09

Table D -1 WLAs for permitted facilities and future growth.

EPA ID	Facility Name	Flow Type	Flow (MGD)	Disinfect (Y/N)	Estimated Existing Recreational Season *E. coli* Load (cfu/day)	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)
IA0058831	Parkersburg, City of	Continuous	0.489	N	3.78E+11	2.33E+09	4.35E+09
IA0056880	New Hartford, City of	Controlled	0.21	N	1.32E+11	1.00E+09	1.87E+09
IA0036633	Cedar Falls, City of	Continuous	8.8	N	7.29E+12	4.20E+10	7.83E+10
IA0054033	Cedar Falls Mobile Home Village	Continuous	0.032	N	4.80E+09	1.53E+08	2.85E+08
IA0054033A	Cedar Falls Mobile Home Village	Controlled	0.0135	N	2.28E+09	6.44E+07	1.20E+08
IA0022004	Evansdale, City of	Controlled	1.517	N	9.05E+11	7.24E+09	1.35E+10
IA0034231	Elk Run Heights, City of	Continuous	0.281	N	2.10E+11	1.34E+09	2.50E+09
IA0042650	Waterloo, City of	Continuous	34.8	N	1.37E+13	1.66E+11	3.10E+11
IA0063908	Dewar Sanitary District	Continuous	0.03	N	6.10E+09	1.43E+08	2.67E+08
IA0024511	Grundy Center, City of	Controlled	1.2	Y	1.07E+10	5.72E+09	1.07E+10
IA0033308	Reinbeck, City of	Continuous	0.728	N	3.50E+11	3.47E+09	6.48E+09
IA0041254	Holland, City of	Continuous	0.033	N	5.00E+10	1.57E+08	2.94E+08
IA0023311	Dike, City of	Controlled	0.342	N	1.89E+11	1.63E+09	3.04E+09
IA0061689	Dietrick Mobile Home Park, Inc.	Continuous	0.0112	N	3.24E+09	5.34E+07	9.96E+07
IA0027243	Hudson, City of	Controlled	0.5	Y	4.45E+09	2.38E+09	4.45E+09
IA0028177	Gilbertville, City of	Continuous	0.2	Y	1.78E+09	9.54E+08	1.78E+09
IA0074241	Washburn Area - Black Hawk County	Continuous	0.1175	N	2.81E+10	5.60E+08	1.05E+09
IA0028185	Brandon, City of	Controlled	0.04	N	6.22E+10	1.91E+08	3.56E+08
IA0075302	Jesup, City of (South)	Continuous	1.21	N	4.42E+11	5.77E+09	1.08E+10
IA0034355	Conrad, City of	Continuous	0.26	N	2.11E+11	1.24E+09	2.31E+09
IA0058734	Beaman, City of	Continuous	0.0348	N	4.20E+10	1.66E+08	3.10E+08
IA0025330	Gladbrook, City of	Controlled	0.28	N	2.03E+11	1.34E+09	2.49E+09
IA0035033	Traer Municipal Utilities	Continuous	0.608	N	3.19E+11	2.90E+09	5.41E+09
IA0066940	Hickory Hills Park	Controlled	0.0018	N	1.02E+09	8.59E+06	1.60E+07
IA0035963	Laporte City, City of	Controlled	0.566	N	4.55E+11	2.70E+09	5.03E+09
IA0056804	Garrison, City of	Continuous	0.068	Y	6.05E+09	3.24E+08	6.05E+08
IA0059153	Mount Auburn, City of	Controlled	0.21	N	3.20E+10	1.00E+09	1.87E+09
IA0035891	Vinton, City of	Controlled	1.79	N	1.02E+12	8.54E+09	1.59E+10
IA0059072	Urbana, City of	Continuous	0.101	Y	8.98E+08	4.82E+08	8.98E+08
IA0003727	IP&L- Duane Arnolf Energy Center	Continuous	0.054	Y	4.80E+08	2.58E+08	4.80E+08
IA0074420	Center Points, City of (North)	Continuous	0.195	Y	1.73E+09	9.30E+08	1.73E+09
IA0078425	DNR Pleasant Creek State Rec	Continuous	0.0009	Y	8.01E+07	4.29E+06	8.01E+06
IA0078433	DNR Pleasant Creek State Rec	Controlled	0.0028	Y	2.49E+08	1.34E+07	2.49E+07
IA0021067	Center Points, City of (North)	Controlled	0.2	N	4.01E+11	9.54E+08	1.78E+09
IA0059081	Walker, City of	Continuous	0.092	N	1.50E+11	4.39E+08	8.18E+08
IA0074276	Benton Commerce Village	Controlled	0.0511	Y	4.55E+08	2.44E+08	4.55E+08
IA0020796	Atkins, City of	Continuous	0.27	N	1.95E+11	1.29E+09	2.40E+09
IA0047872	Palo, City of	Continuous	0.1	Y	8.89E+08	4.77E+08	8.90E+08
IA0077330	Country Aire Trailer Court	Continuous	0.01	N	2.04E+09	4.77E+07	8.90E+07
IA0033332	Shellsburg, City of	Controlled	0.48	N	1.88E+11	2.29E+09	4.27E+09

Table D -1 WLAs for permitted facilities and future growth.

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IA0043664	Newhall, City of	Continuous	0.305	N	1.77E+11	1.45E+09	2.71E+09
IA0025984	Keystone, City of	Continuous	0.14	N	1.72E+10	6.68E+08	1.25E+09
IA0025984A	Keystone, City of	Continuous	0.295	N	1.37E+11	1.41E+09	2.62E+09
IA0030660	Blairstown, City of	Continuous	0.276	N	1.36E+11	1.32E+09	2.46E+09
IA0033341	Van Home, City of	Continuous	0.387	N	1.43E+11	1.85E+09	3.44E+09
IA0036943	Norway, City of	Continuous	0.0888	N	1.20E+11	4.24E+08	7.90E+08
IA0060694	Fairfax, City of	Continuous	0.0872	N	1.78E+11	4.16E+08	7.76E+08
IA0042641	Cedar Rapids, City of	Continuous	56	Y	4.98E+11	2.67E+11	4.98E+11
IA0024431	Alburnett, City of	Continuous	0.085	N	1.12E+11	4.05E+08	7.56E+08
IA0066818	Linn County WWTF	Controlled	0.0545	N	6.10E+09	2.60E+08	4.85E+08
IA0023710	Mount Vernon, City of	Controlled	1.436	Y	1.28E+10	6.85E+09	1.28E+10
IA0025909	Lisbon, City of	Continuous	0.12	Y	1.07E+09	5.72E+08	1.07E+09
IA0025909A	Lisbon, City of	Continuous	0.4	Y	3.56E+09	1.91E+09	3.56E+09
IA0062987	Martelle, City of	Continuous	0.08	N	5.60E+10	3.82E+08	7.12E+08
IA0064726	Springville, City of	Controlled	0.3	N	2.18E+11	1.43E+09	2.67E+09
IA0065609	Carlton Mobile Home Court	Controlled	0.005	N	1.44E+09	2.38E+07	4.45E+07
IA0076732	Four Oaks Group Home - Bertram Campus	Controlled	0.006	N	1.44E+09	2.86E+07	5.34E+07
IA0032727	Tipton, City of (West)	Continuous	4.14	Y	1.01E+10	1.97E+10	3.68E+10
IA0069043	Home Oil Station, Inc.	Continuous	0.0068	Y	6.05E+08	3.24E+07	6.05E+07
IA0071056	Hwh Corporation	Controlled	0.008	Y	7.12E+07	3.82E+07	7.12E+07
IA0071056A	Hwh Corporation	Continuous	0.0041	Y	3.65E+07	1.96E+07	3.65E+07
IA0033758	Stanwood, City of	Continuous	0.5	N	1.36E+11	2.38E+09	4.45E+09
IA0070998	Atalissa, City of	Continuous	0.031	N	5.66E+10	1.48E+08	2.76E+08
IA0021971	Bennett, City of	Continuous	0.06	N	7.90E+10	2.86E+08	5.34E+08
IA0068781	Iowa Dot Rest Area #04-I80	Controlled	0.0148	N	6.04E+09	7.06E+07	1.32E+08
IA0070581	Tipton, City of (East)	Continuous	0.6	N	6.31E+11	2.86E+09	5.34E+09
IA0032921	Wilton, City of	Continuous	0.685	N	5.66E+11	3.27E+09	6.09E+09
IA0033464	Stockton, City of	Controlled	0.04	N	3.64E+10	1.91E+08	3.56E+08
IA0061891	Walcott, City of (South)	Continuous	0.437	N	7.04E+10	2.08E+09	3.89E+09
IA0064351	Walcott, City of (North)	Continuous	0.254	N	3.06E+11	1.21E+09	2.26E+09
IA0064891	Durant, City of	Continuous	0.3	N	3.35E+11	1.43E+09	2.67E+09
IA0031691	West Liberty, City of	Continuous	1.57	Y	1.40E+10	7.49E+09	1.40E+10
IA0032859	West Branch, City of	Continuous	0.792	Y	7.05E+09	3.78E+09	7.05E+09
IA0036561	Nichols, City of	Controlled	0.045	N	7.48E+10	2.15E+08	4.00E+08
IA0067946	West Branch Mobile Home Village	Controlled	0.0318	N	1.27E+10	1.52E+08	2.83E+08
IA0069566	KOA Kampgrounds of Iowa - Cedar County	Controlled	0.0058	N	2.40E+09	2.77E+07	5.16E+07
MS4 Communities**							
MS400251*	MS4 - Austin	Event Based				n/a	n/a
MS400263*	MS4 - Albert Lea	Event Based				n/a	n/a
IA0078263	MS4 - Cedar Falls	Event Based				**	**
IA0078280	MS4 - Elk Run Heights	Event Based				**	**
IA0078310	MS4 - Raymond	Event Based				**	**
IA0078654	MS4 - Evansdale	Event Based				**	**
IA0078301	MS4 - Waterloo	Event Based				**	**

Table D -1 WLAs for permitted facilities and future growth.

EPA ID	Facility Name	Flow Type	Flow (MGD)	Disinfect (Y/N)	Estimated Existing Recreational Season *E. coli* Load (cfu/day)	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)
IA0078816	MS4 - Robins	Event Based				**	**
IA0078743	MS4 - Hiawatha	Event Based				**	**
IA0075566	MS4 - Cedar Rapids	Event Based				**	**
IA0078689	MS4 - Marion	Event Based				**	**
Unsewered Iowa Communities used to calculate WLA reserve							
Future	Carpenter	Unknown					
Future	Mitchell	Unknown					
Future	Mona	Unknown					
Future	Otranto	Unknown					
Future	Toeterville	Unknown					
Segment Total	02-CED-0110_3		0.014			6.68E+07	1.25E+08
Future	Little Cedar	Unknown					
Future	Meyer	Unknown					
Future	New Haven	Unknown					
Future	Rock Creek	Unknown					
Segment Total	02-CED-0110_2		0.006			2.86E+07	5.34E+07
Future	Portland	Unknown					
Future	USD 1/Cerro Gordo	Unknown					
Future	USD 10/Cerro Gordo	Unknown					
Future	USD 2/Cerro Gordo	Unknown					
Future	USD 3/Cerro Gordo	Unknown					
Future	Miller	Unknown					
Future	Scarville	Unknown					
Future	USD 2/Winnebago	Unknown					
Future	USD 3/Winnebago	Unknown					
Future	Bolan	Unknown					
Future	Hanlontown	Unknown					
Future	Joice	Unknown					
Segment Total	02-SHL-0020_1		0.034			1.62E+08	3.02E+08
Future	Benson	Unknown					
Future	E. Cedar Wapsi Rd./ Moline Rd.	Unknown					
Future	Finchford	Unknown					
Future	Marrow Heights	Unknown					
Future	Waverly Road	Unknown					
Future	Aredale	Unknown					
Future	Austinville	Unknown					
Future	Bristow	Unknown					
Future	Kesley	Unknown					
Future	Burchinal	Unknown					
Future	Dougherty	Unknown					
Future	Bassett	Unknown					
Future	Chickasaw	Unknown					
Future	USD 9/Chickasaw	Unknown					
Future	Wood Haven	Unknown					
Future	Colwell	Unknown					
Future	South Gates Bridge	Unknown					

Table D -1 WLAs for permitted facilities and future growth.

EPA ID	Facility Name	Flow Type	Flow (MGD)	Disinfect (Y/N)	Estimated Existing Recreational Season *E. coli* Load (cfu/day)	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)
Future	Bradford	Unknown					
Future	Chapin	Unknown					
Future	Faulkner	Unknown					
Future	Geneva	Unknown					
Future	Hansell	Unknown					
Future	Stout	Unknown					
Future	Robertson	Unknown					
Segment Total	02-CED-0050L_0		0.075			3.58E+08	6.67E+08
Future	Newell Ave./Raymond Rd.	Unknown					
Future	Prosperity Farms	Unknown					
Future	Raymar	Unknown					
Future	Voorheis	Unknown					
Future	Fern	Unknown					
Future	Buckingham	Unknown					
Future	Dinsdale	Unknown					
Segment Total	02-CED-0040_1		0.012			5.72E+07	1.07E+08

* As this TMDL is written for the state of Iowa, WLAs are not assigned to Minnesota facilities.

** MS4 numeric WLAs are calculated by basin. For numeric WLAs see segment specific information in the TMDL.

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
MN0021882*	Blooming Prairie, City of	n/a	n/a	10	x	x		x	x	x	x	x	x	
MN0023612*	Hayfield, City of	n/a	n/a	10	x	x		x	x	x	x	x	x	
MN0063461*	Lansing Township	n/a	n/a	20	x	x		x	x	x	x	x	x	
MN0021601*	Sargeant, City of	n/a	n/a	21	x	x		x	x	x	x	x	x	
MN0022934*	Brownsdale, City of	n/a	n/a	21	x	x		x	x	x	x	x	x	
MN0025186*	Waltham, City of	n/a	n/a	21	x	x		x	x	x	x	x	x	
MN0022683*	Austin, City of	n/a	n/a	40	x	x		x	x	x	x	x	x	
MN0048992*	Hollandale, City of	n/a	n/a	51	x	x		x	x	x	x	x	x	
MNG580013*	Elkton, City of	n/a	n/a	61	x	x		x	x	x	x	x	x	
MNG580072*	Rose Creek, City of	n/a	n/a	61	x	x		x	x	x	x	x	x	
MN0040631*	Oakland Sanitary District	n/a	n/a	71	x	x		x	x	x	x	x	x	
MN0022101*	Lyle, City of	n/a	n/a	92	x	x		x	x	x	x	x	x	
IA0033723	St. Ansgar, City of	8.59E+08	1.60E+09	100	x	x		x	x	x	x	x	x	
IA0032956	Osage, City of	3.58E+09	6.67E+09	110	x	x		x	x	x	x	x	x	
IA0064271	Orchard, City of	6.20E+07	1.16E+08	110	x	x		x	x	x	x	x	x	
IA0028894	Floyd, City of	3.34E+08	6.23E+08	130		x		x	x	x	x	x	x	
IA0003557	Cambrex Charles City, Inc	1.19E+09	2.22E+09	140				x	x	x	x	x	x	
IA0022039	Charles City, City of	1.48E+10	2.76E+10	140				x	x	x	x	x	x	
IA0024503	Nashua, City of	1.01E+09	1.89E+09	160				x	x	x	x	x	x	
IA0033693	Plainfield, City of	1.62E+08	3.02E+08	160				x	x	x	x	x	x	
IA0035254	Stacyville, City of	7.54E+08	1.41E+09	161				x	x	x	x	x	x	
MN0021261*	Adams, City of	n/a	n/a	161				x	x	x	x	x	x	
IA0033197	Waverly, City of	1.11E+10	2.07E+10	170				x	x	x	x	x	x	
IA0044156	Denver, City of	1.79E+09	3.34E+09	181				x	x	x	x	x	x	
IA0026506	Janesville, City of	7.87E+08	1.47E+09	190				x	x	x	x	x	x	
MN0021008*	Geneva, City of	n/a	n/a	191			x	x	x	x	x	x	x	
MN0033740*	MDNR Myre Big Island SP	n/a	n/a	191			x	x	x	x	x	x	x	
MN0041092*	Albert Lea, City of	n/a	n/a	191			x	x	x	x	x	x	x	
MN0041122*	Hayward, City of	n/a	n/a	191			x	x	x	x	x	x	x	
MNG580067*	Clarks Grove, City of	n/a	n/a	191			x	x	x	x	x	x	x	
MN0021245*	Glenville, City of	n/a	n/a	192			x	x	x	x	x	x	x	
MNG580042*	Twin Lakes, City of	n/a	n/a	192			x	x	x	x	x	x	x	

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
MNG580065*	MNDOT Albert Lea Travel Info	n/a	n/a	192			x	x	x	x	x	x	x	
IA0032395	Northwood, City of	2.27E+09	4.23E+09	193			x	x	x	x	x	x	x	
IA0074756	Diamond Jo Worth, LLC	1.04E+08	1.93E+08	193			x	x	x	x	x	x	x	
IA0062529	Grafton, City of	1.35E+08	2.52E+08	195			x	x	x	x	x	x	x	
IA0076635	Kensett, City of	1.43E+08	2.67E+08	195			x	x	x	x	x	x	x	
IA0032778	Nora Springs, City of	1.44E+09	2.68E+09	196			x	x	x	x	x	x	x	
IA0033383	Plymouth, City of	2.24E+08	4.17E+08	196			x	x	x	x	x	x	x	
IA0033383A	Plymouth, City of	1.13E+09	2.11E+09	196			x	x	x	x	x	x	x	
IA0047830	Manly, City of	9.40E+08	1.75E+09	196			x	x	x	x	x	x	x	
IA0058432	Rockford, City of	5.72E+08	1.07E+09	196			x	x	x	x	x	x	x	
IA0063495	Rock Falls, City of	7.39E+07	1.38E+08	196			x	x	x	x	x	x	x	
MNG550003*	Emmons, City of	n/a	n/a	197			x	x	x	x	x	x	x	
IA0068683	Thompson, City of	3.54E+08	6.60E+08	198			x	x	x	x	x	x	x	
IA0021563	Forest, City of	7.87E+09	1.47E+10	199			x	x	x	x	x	x	x	
IA0036528	Leland, City of	159782231.4	298006542.7	199			x	x	x	x	x	x	x	
IA0027448	Lake Mills, City of	3577214136	6671788269	201			x	x	x	x	x	x	x	
IA0066028	DNR Pilot Knob State Park	5723542.617	10674861.23	201			x	x	x	x	x	x	x	
IA0058718	Fertile, City of	2.67E+08	4.98E+08	202			x	x	x	x	x	x	x	
IA0001945	Lehigh Cement Co.	2.86E+07	5.34E+07	203			x	x	x	x	x	x	x	
IA0063207	Willow Pointe Assist Living Ctr	7.15E+07	1.33E+08	204			x	x	x	x	x	x	x	
IA0057169	Mason City, City of	5.25E+10	9.79E+10	205				x	x	x	x	x	x	
IA0035432	Greene, City of	7.06E+08	1.32E+09	207				x	x	x	x	x	x	
IA0057207	Marble Rock, City of	2.86E+08	5.34E+08	207				x	x	x	x	x	x	
IA0061344	Rudd, City of	2.69E+08	5.03E+08	208				x	x	x	x	x	x	
IA0023388	Clarksville, City of	7.15E+08	1.33E+09	212				x	x	x	x	x	x	
IA0033359	Shell Rock, City of	1.35E+09	2.51E+09	213				x	x	x	x	x	x	
IA0033481	Rockwell, City	7.25E+08	1.35E+09	214				x	x	x	x	x	x	
IA0058441	Clear Lake Sanitary District	2.72E+10	5.07E+10	214				x	x	x	x	x	x	
IA0073903	Swaledale, City of	9.54E+07	1.78E+08	214				x	x	x	x	x	x	
IA0036005	Thornton, City OF	3.42E+08	6.39E+08	215				x	x	x	x	x	x	
IA0036005	Sheffield, City of	6.68E+09	1.25E+10	215				x	x	x	x	x	x	
IA0076724	Meservey, City of	1.34E+08	2.49E+08	215				x	x	x	x	x	x	

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
IA0036471	Hampton, City of	3.39E+09	6.32E+09	217				x	x	x	x	x	x	
IA0062472	Terrace Hill Sanitary District	6.44E+07	1.20E+08	217				x	x	x	x	x	x	
IA0062944	Latimer-Coulter, City of	3.76E+08	7.02E+08	217				x	x	x	x	x	x	
IA0067358	DNR Beeds Lake State Park	1.57E+08	2.94E+08	218				x	x	x	x	x	x	
IA0033316	Dumont, City of	2.02E+09	3.76E+09	223				x	x	x	x	x	x	
IA0042731	Allison, City of	9.54E+08	1.78E+09	232				x	x	x	x	x	x	
IA0035050	Aplington, City of	1.67E+09	3.11E+09	233				x	x	x	x	x	x	
IA0042803	Wellsburg, City of	9.06E+08	1.69E+09	234				x	x	x	x	x	x	
IA0035297	Ackley, City of	2.53E+09	4.71E+09	235				x	x	x	x	x	x	
IA0058831	Parkersburg, City of	2.33E+09	4.35E+09	236				x	x	x	x	x	x	
IA0056880	New Hartford, City of	1.00E+09	1.87E+09	240					x	x	x	x	x	
IA0036633	Cedar Falls, City of	4.20E+10	7.83E+10	241					x	x	x	x	x	
IA0054033	Cedar Falls Mobile Home Village	1.53E+08	2.85E+08	241					x	x	x	x	x	
IA0054033A	Cedar Falls Mobile Home Village	6.44E+07	1.20E+08	250					x	x	x	x	x	
IA0022004	Evansdale, City of	7.24E+09	1.35E+10	250					x	x	x	x	x	
IA0034231	Elk Run Heights, City of	1.34E+09	2.50E+09	250					x	x	x	x	x	
IA0042650	Waterloo, City of	1.66E+11	3.10E+11	250					x	x	x	x	x	
IA0063908	Dewar Sanitary District	1.43E+08	2.67E+08	251					x	x	x	x	x	
IA0024511	Grundy Center, City of	5.72E+09	1.07E+10	251					x	x	x	x	x	
IA0033308	Reinbeck, City of	3.47E+09	6.48E+09	251					x	x	x	x	x	
IA0041254	Holland, City of	1.57E+08	2.94E+08	252					x	x	x	x	x	
IA0023311	Dike, City of	1.63E+09	3.04E+09	252					x	x	x	x	x	
IA0061689	Dietrick Mobile Home Park, Inc.	5.34E+07	9.96E+07	254					x	x	x	x	x	
IA0027243	Hudson, City of	2.38E+09	4.45E+09	260					x	x	x	x	x	
IA0028177	Gilbertville, City of	9.54E+08	1.78E+09	260					x	x	x	x	x	
IA0074241	Washburn Area - Black Hawk County	5.60E+08	1.05E+09	280						x	x	x	x	
IA0028185	Brandon, City of	1.91E+08	3.56E+08	280						x	x	x	x	
IA0075302	Jesup, City of (South)	5.77E+09	1.08E+10	281						x	x	x	x	
IA0034355	Conrad, City of	1.24E+09	2.31E+09	281						x	x	x	x	
IA0058734	Beaman, City of	1.66E+08	3.10E+08	282						x	x	x	x	
IA0025330	Gladbrook, City of	1.34E+09	2.49E+09	282						x	x	x	x	

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
IA0035033	Traer Municipal Utilities	2.90E+09	5.41E+09	283						x	x	x	x	
IA0066940	Hickory Hills Park	8.59E+06	1.60E+07	284						x	x	x	x	
IA0035963	Laporte City, City of	2.70E+09	5.03E+09	290						x	x	x	x	
IA0056804	Garrison, City of	3.24E+08	6.05E+08	290						x	x	x	x	
IA0059153	Mount Auburn, City of	1.00E+09	1.87E+09	300						x	x	x	x	
IA0035891	Vinton, City of	8.54E+09	1.59E+10	300						x	x	x	x	
IA0059072	Urbana, City of	4.82E+08	8.98E+08	310						x	x	x	x	
IA0003727	IP&L- Duane Arnolf Energy Center	2.58E+08	4.80E+08	310						x	x	x	x	
IA0074420	Center Points, City of (Nouth)	9.30E+08	1.73E+09	310						x	x	x	x	
IA0078425	DNR Pleasant Creek State Rec	4.29E+06	8.01E+06	310						x	x	x	x	
IA0078433	DNR Pleasant Creek State Rec	1.34E+07	2.49E+07	311						x	x	x	x	
IA0021067	Center Points, City of (North)	9.54E+08	1.78E+09	311						x	x	x	x	
IA0059081	Walker, City of	4.39E+08	8.18E+08	311						x	x	x	x	
IA0074276	Benton Commerce Village	2.44E+08	4.55E+08	320						x	x	x	x	
IA0020796	Atkins, City of	1.29E+09	2.40E+09	320						x	x	x	x	
IA0047872	Palo, City of	4.77E+08	8.90E+08	320						x	x	x	x	
IA0077330	Country Aire Trailer Court	4.77E+07	8.90E+07	321						x	x	x	x	
IA0033332	Shellsburg, City of	2.29E+09	4.27E+09	321							x	x	x	
IA0043664	Newhall, City of	1.45E+09	2.71E+09	341							x	x	x	
IA0025984	Keystone, City of	6.68E+08	1.25E+09	341							x	x	x	
IA0025984A	Keystone, City of	1.41E+09	2.62E+09	341							x	x	x	
IA0030660	Blairstown, City of	1.32E+09	2.46E+09	341							x	x	x	
IA0033341	Van Home, City of	1.85E+09	3.44E+09	342							x	x	x	
IA0036943	Norway, City of	4.24E+08	7.90E+08	343							x	x	x	
IA0060694	Fairfax, City of	4.16E+08	7.76E+08	350								x	x	
IA0042641	Cedar Rapids, City of	2.67E+11	4.98E+11	351								x	x	
IA0024431	Alburnett, City of	4.05E+08	7.56E+08	351								x	x	
IA0066818	Linn County WWTF	2.60E+08	4.85E+08	360									x	
IA0023710	Mount Vernon, City of	6.85E+09	1.28E+10	360									x	
IA0025909	Lisbon, City of	5.72E+08	1.07E+09	360									x	
IA0025909A	Lisbon, City of	1.91E+09	3.56E+09	361									x	

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
IA0062987	Martelle, City of	3.82E+08	7.12E+08	361									x	
IA0064726	Springville, City of	1.43E+09	2.67E+09	361									x	
IA0065609	Carlton Mobile Home Court	2.38E+07	4.45E+07	361									x	
IA0076732	Four Oaks Group Home - Bertram Campus	2.86E+07	5.34E+07	390										x
IA0032727	Tipton, City of (West)	1.97E+10	3.68E+10	390										x
IA0069043	Home Oil Station, Inc.	3.24E+07	6.05E+07	390										x
IA0071056	Hwh Corporation	3.82E+07	7.12E+07	390										x
IA0071056A	Hwh Corporation	1.96E+07	3.65E+07	391										x
IA0033758	Stanwood, City of	2.38E+09	4.45E+09	400										x
IA0070998	Atalissa, City of	1.48E+08	2.76E+08	401										x
IA0021971	Bennett, City of	2.86E+08	5.34E+08	401										x
IA0068781	Iowa Dot Rest Area #04-I80	7.06E+07	1.32E+08	401										x
IA0070581	Tipton, City of (East)	2.86E+09	5.34E+09	402										x
IA0032921	Wilton, City of	3.27E+09	6.09E+09	402										x
IA0033464	Stockton, City of	1.91E+08	3.56E+08	402										x
IA0061891	Walcott, City of (South)	2.08E+09	3.89E+09	402										x
IA0064351	Walcott, City of (North)	1.21E+09	2.26E+09	402										x
IA0064891	Durant, City of	1.43E+09	2.67E+09	402										x
IA0031691	West Liberty, City of	7.49E+09	1.40E+10	411										x
IA0032859	West Branch, City of	3.78E+09	7.05E+09	411										x
IA0036561	Nichols, City of	2.15E+08	4.00E+08	411										x
IA0067946	West Branch Mobile Home Village	1.52E+08	2.83E+08	411										x
IA0069566	KOA Kampgrounds of Iowa - Cedar County	2.77E+07	5.16E+07	411										
MS4 Communities**														
MS400251	MS4 - Austin	n/a	n/a		x	x		x	x	x	x	x	x	
MS400263	MS4 - Albert Lea	n/a	n/a				x	x	x	x	x	x	x	
IA0078263	MS4 - Cedar Falls								x	x	x	x	x	
IA0078280	MS4 - Elk Run Heights								x	x	x	x	x	
IA0078310	MS4 - Raymond								x	x	x	x	x	

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
IA0078654	MS4 - Evansdale								x	x	x	x	x	
IA0078301	MS4 - Waterloo								x	x	x	x	x	
IA0078816	MS4 - Robins										x	x	x	
IA0078743	MS4 - Hiawatha										x	x	x	
IA0075566	MS4 - Cedar Rapids										x	x	x	
IA0078689	MS4 - Marion												x	
Unsewered Iowa Communities used to calculate WLA reserve														
Future	Carpenter													
Future	Mitchell													
Future	Mona													
Future	Otranto													
Future	Toeterville													
Segment Total	02-CED-0110_3	6.68E+07	1.25E+08											
Future	Little Cedar													
Future	Meyer													
Future	New Haven													
Future	Rock Creek													
Segment Total	02-CED-0110_2	2.86E+07	5.34E+07											
Future	Portland													
Future	USD 1/Cerro Gordo													
Future	USD 10/Cerro Gordo													
Future	USD 2/Cerro Gordo													
Future	USD 3/Cerro Gordo													
Future	Miller													
Future	Scarville													
Future	USD 2/Winnebago													
Future	USD 3/Winnebago													
Future	Bolan													
Future	Hanlontown													
Future	Joice													
Segment Total	02-SHL-0020_1	1.62E+08	3.02E+08											
Future	Benson													

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
Future	E. Cedar Wapsi Rd./ Moline Rd.													
Future	Finchford													
Future	Marrow Heights													
Future	Waverly Road													
Future	Aredale													
Future	Austinville													
Future	Bristow													
Future	Kesley													
Future	Burchinal													
Future	Dougherty													
Future	Bassett													
Future	Chickasaw													
Future	USD 9/Chickasaw													
Future	Wood Haven													
Future	Colwell													
Future	South Gates Bridge													
Future	Bradford													
Future	Chapin													
Future	Faulkner													
Future	Geneva													
Future	Hansell													
Future	Stout													
Future	Robertson													
Segment Total	02-CED-0050L_0	3.58E+08	6.67E+08											
Future	Newell Ave./Raymond Rd.													
Future	Prosperity Farms													
Future	Raymar													
Future	Voorheis													
Future	Fern													
Future	Buckingham													
Future	Dinsdale													

Table D-2 NPDES Facilities with WLA and HSPF reach location.

EPA ID	Facility Name	Geometric Mean WLA *E. coli* (cfu/day)	Daily Maximum WLA *E. coli* (cfu/day)	HSPF Reach ID	TMDL Drainage Area 1	TMDL Drainage Area 2	TMDL Drainage Area 3	TMDL Drainage Area 4	TMDL Drainage Area 5	TMDL Drainage Area 6	TMDL Drainage Area 7	TMDL Drainage Area 8	TMDL Drainage Area 9	Below last TMDL Segment
Segment Total	02-CED-0040_1	5.72E+07	1.07E+08											

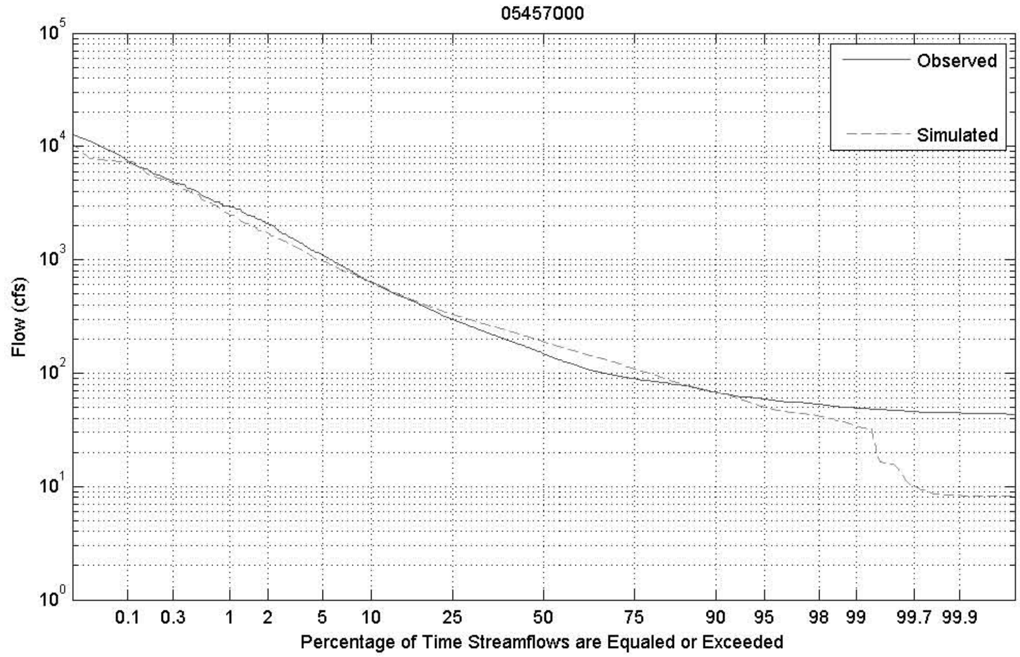
* As this TMDL is written for the state of Iowa, WLAs are not assigned to Minnesota facilities.

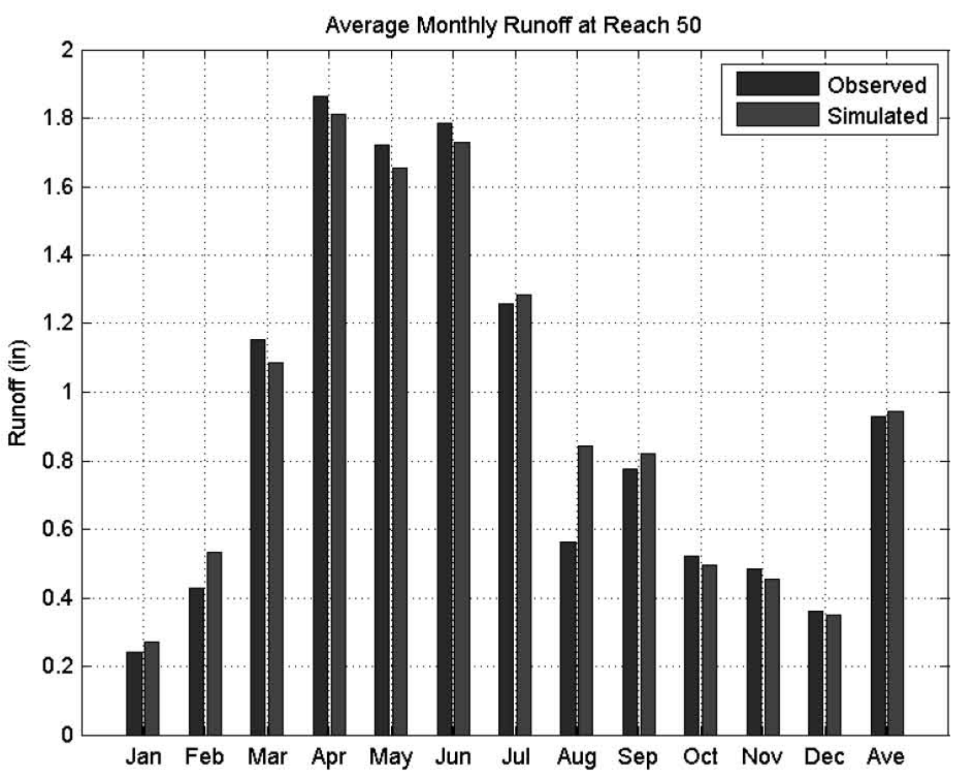
** MS4 numeric WLAs are calculated by basin. For numeric WLAs see segment specific information in the TMDL.

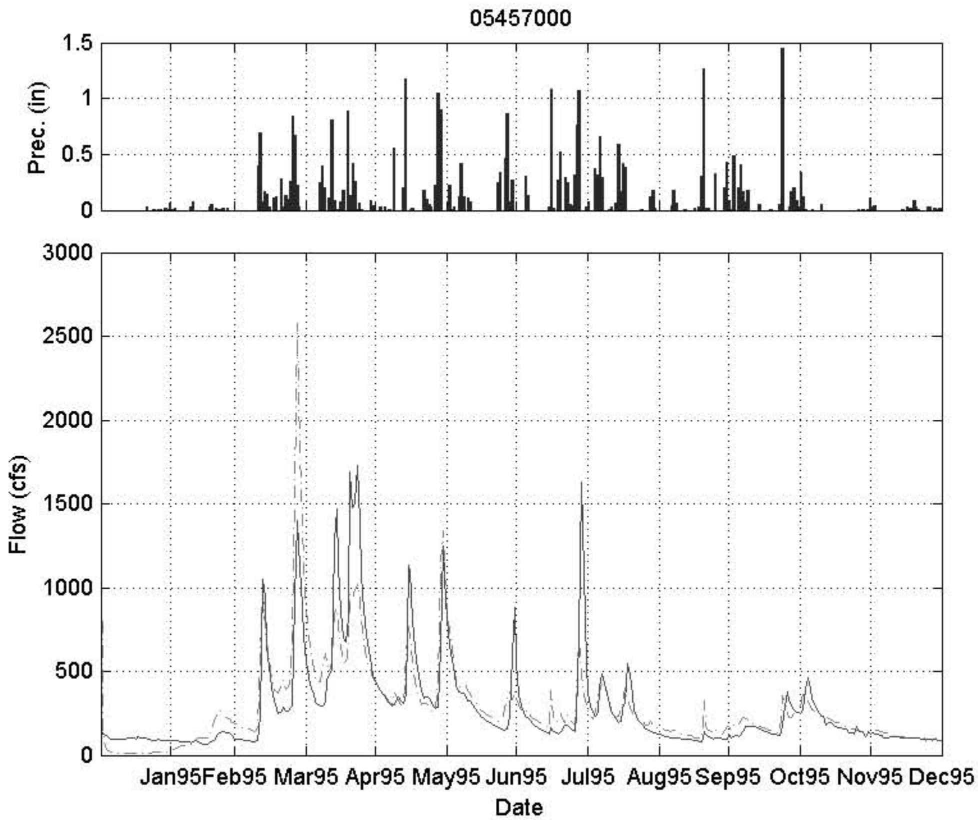
Appendix E — Flow and Water Quality Calibration/Verification (1995-2005)

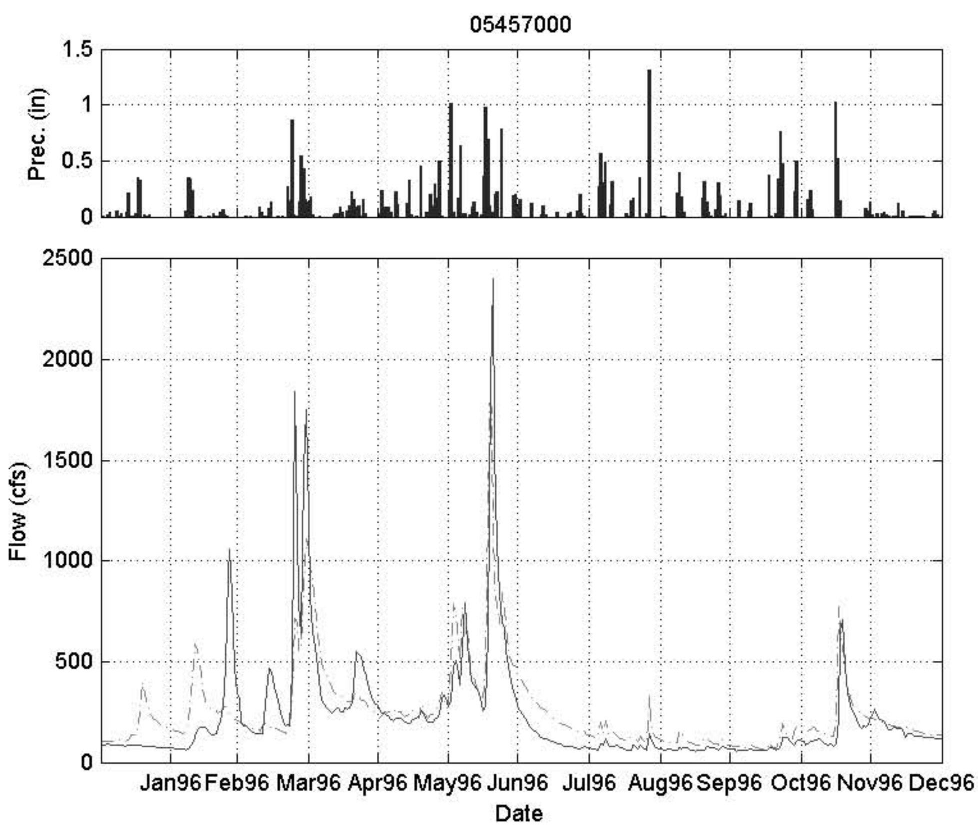
Station	Monthly Runoff % Errors												
	Jan	Feb	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Avg
5457000	12.43	24.32	-5.93	-2.79	-3.86	-3.21	2.08	49.94	5.68	-5.50	-5.91	-3.06	1.55
5457700	-10.39	-4.07	-7.96	0.74	-3.50	0.88	13.72	32.82	7.96	2.29	6.24	2.99	2.27
5458000	38.85	0.58	-19.16	-18.82	-6.50	-9.39	15.95	77.18	33.00	21.18	10.55	31.66	1.85
5458300	-4.82	-18.71	36.22	3.97	-6.81	3.10	15.64	8.71	1.37	-11.44	-3.19	-3.18	2.20
5458500	2.61	8.89	4.71	-3.39	-4.59	-3.80	3.40	27.85	9.83	-6.16	-2.37	-1.81	1.16
5458900	6.65	21.61	6.32	-6.47	-0.83	-11.91	-21.52	9.55	35.07	-16.19	-11.74	0.87	-4.14
5459500	28.82	44.54	10.71	-1.30	-5.00	-7.18	-0.19	8.34	-6.94	-16.89	1.73	9.23	0.20
5462000	14.53	30.87	6.46	-6.19	1.52	-4.33	-2.48	9.01	3.83	-14.91	-8.19	4.36	0.10
5463000	10.02	-2.37	27.64	3.12	-16.86	-11.93	-21.95	2.53	40.45	-12.45	7.13	35.28	-4.11
5463500	2.51	-27.80	14.00	6.60	-5.59	-14.83	-17.78	28.30	56.71	32.70	60.33	90.42	0.06
5464000	2.03	13.22	2.21	-7.91	-1.38	-5.62	-10.74	2.68	5.32	-17.01	-8.23	4.23	-3.59
5464220	107.24	-6.01	46.06	14.44	5.96	-16.20	-31.97	-16.73	21.76	34.40	15.77	74.93	2.85
5464500	2.02	7.71	4.23	-5.31	-0.91	-6.78	-11.82	1.99	6.15	-10.27	-4.52	6.13	-2.96
5465000	15.21	12.69	4.66	-4.10	-3.45	-7.91	-12.10	5.42	17.35	0.87	3.71	13.60	-1.03
Min	-10.39	-27.80	-19.16	-18.82	-16.86	-16.20	-31.97	-16.73	-6.94	-17.01	-11.74	-3.18	-4.14
Max	107.24	44.54	46.06	14.44	5.96	3.10	15.95	77.18	56.71	34.40	60.33	90.42	2.85
Mean	16.27	7.53	9.30	-1.96	-3.70	-7.08	-5.70	17.69	16.97	-1.38	4.38	18.98	-0.26

Station	Expert System Percent Errors							
	Total (inches)	10 % High (inches)	25 % High (inches)	50 % Low (inches)	25 % Low (inches)	10 % Low (inches)	Storm Volume (inches)	Average Storm Peak (cfs)
5457000	1.55	-10.32	-6.11	19.11	-1.73	-20.13	-23.11	-28.31
5457700	2.27	-4.65	-3.34	10.65	-2.89	-18.96	-15.39	-9.10
5458000	1.85	-14.77	-10.48	49.54	47.15	32.64	-15.54	-22.40
5458300	2.20	2.54	0.35	2.04	-8.49	-16.11	-5.21	-6.72
5458500	1.16	-4.96	-3.99	9.57	-2.93	-16.36	-14.84	-11.00
5458900	-4.14	-5.11	-8.01	3.60	1.50	-5.94	-15.96	18.83
5459500	0.20	0.14	-4.72	21.18	-0.36	-17.09	-9.97	16.20
5462000	0.10	-0.82	-3.04	8.09	-4.53	-17.54	-5.74	28.39
5463000	-4.11	-8.46	-7.03	0.35	-7.21	-23.43	-12.98	-21.05
5463500	0.06	-12.32	-9.58	29.06	17.20	19.03	-10.42	0.53
5464000	-3.59	0.80	-3.52	-1.40	-8.26	-12.23	-8.71	19.77
5464220	2.85	-5.25	-3.65	32.29	25.02	13.00	0.27	-18.88
5464500	-2.96	-0.02	-3.96	0.18	-2.28	1.87	-20.62	-1.16
5465000	-1.03	-0.63	-3.92	7.48	5.36	-2.62	-22.51	-7.19
Min	-4.14	-14.77	-10.48	-1.40	-8.49	-23.43	-23.11	-28.31
Max	2.85	2.54	0.35	49.54	47.15	32.64	0.27	28.39
Mean	-0.20	-4.86	-5.16	14.17	4.01	-6.25	-12.17	-2.68


05457000
Observed
Simulated
Flow (cfs)
10^5
10^4
10^3
10^2
10^1
10^0
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded


Average Monthly Runoff at Reach 50
Observed
Simulated
Runoff (in)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave


05457000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date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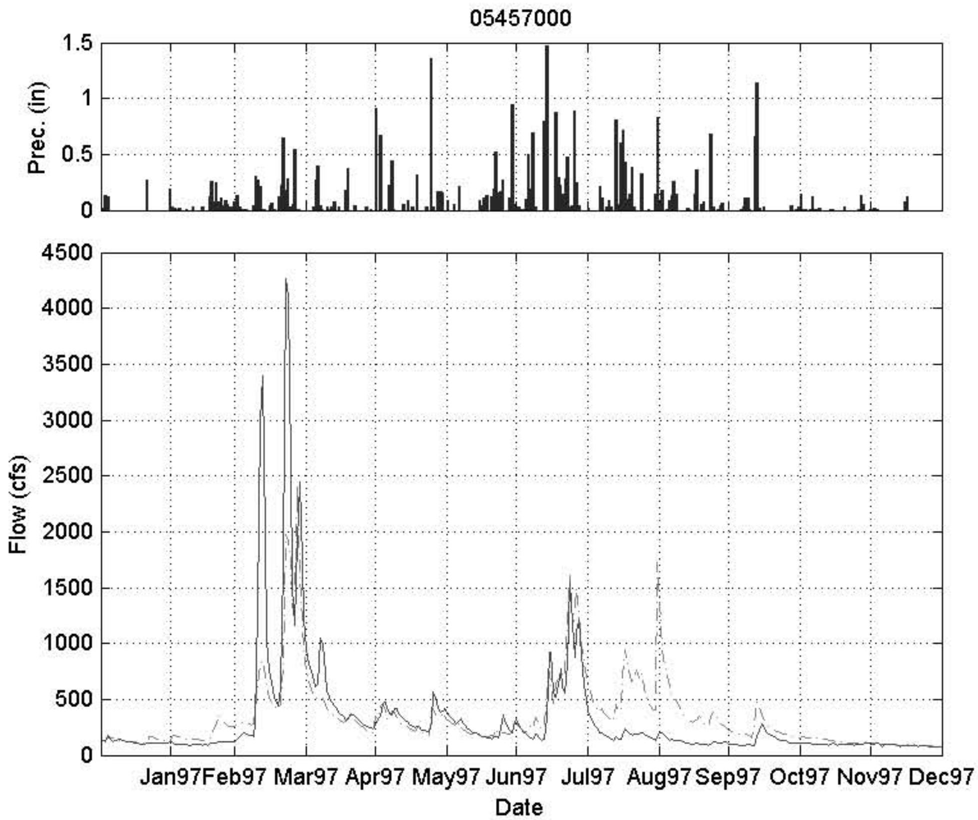
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
2500
2000
1500
1000
500
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date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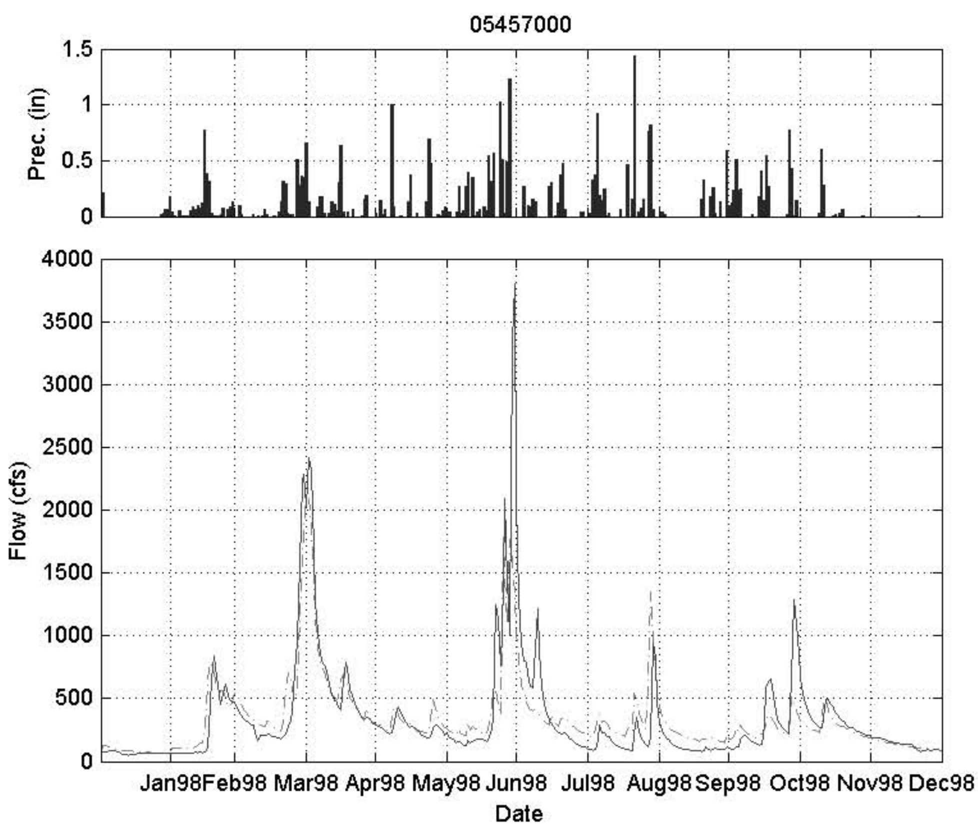
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date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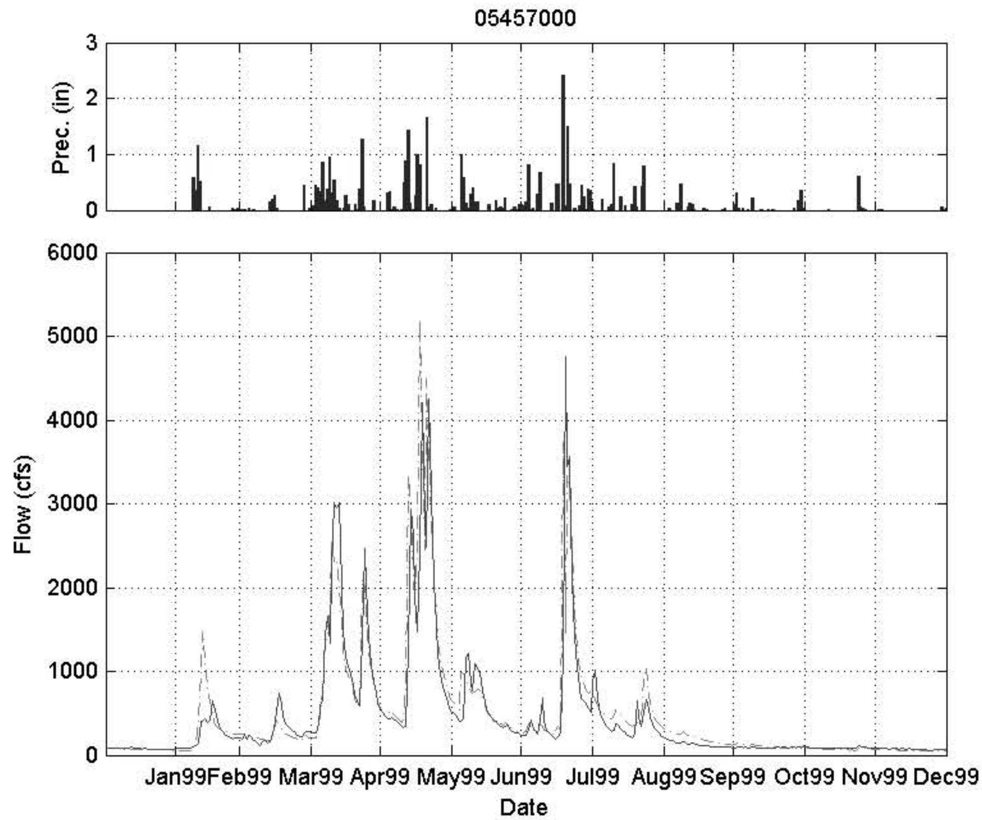
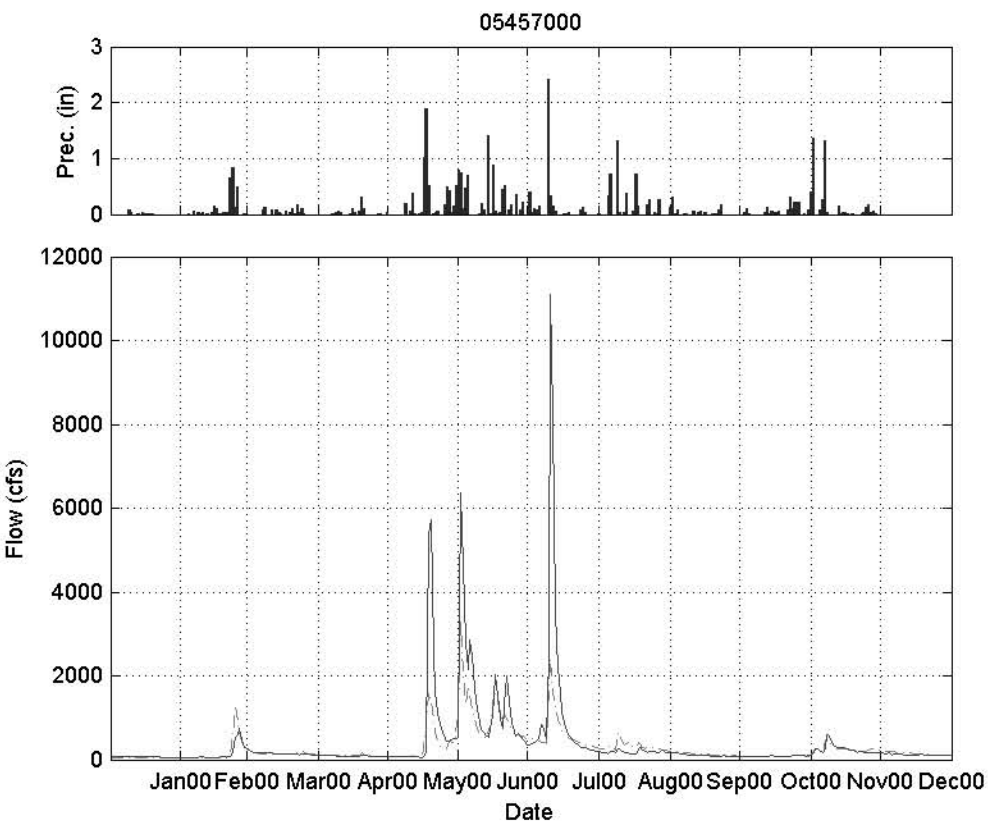
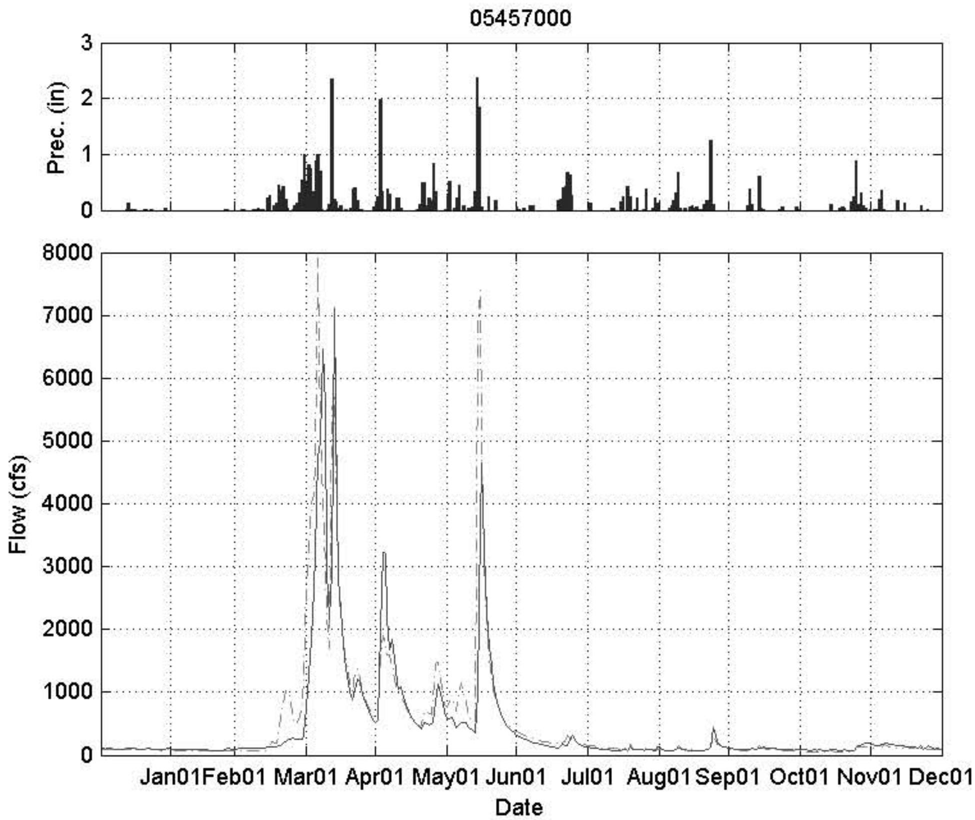
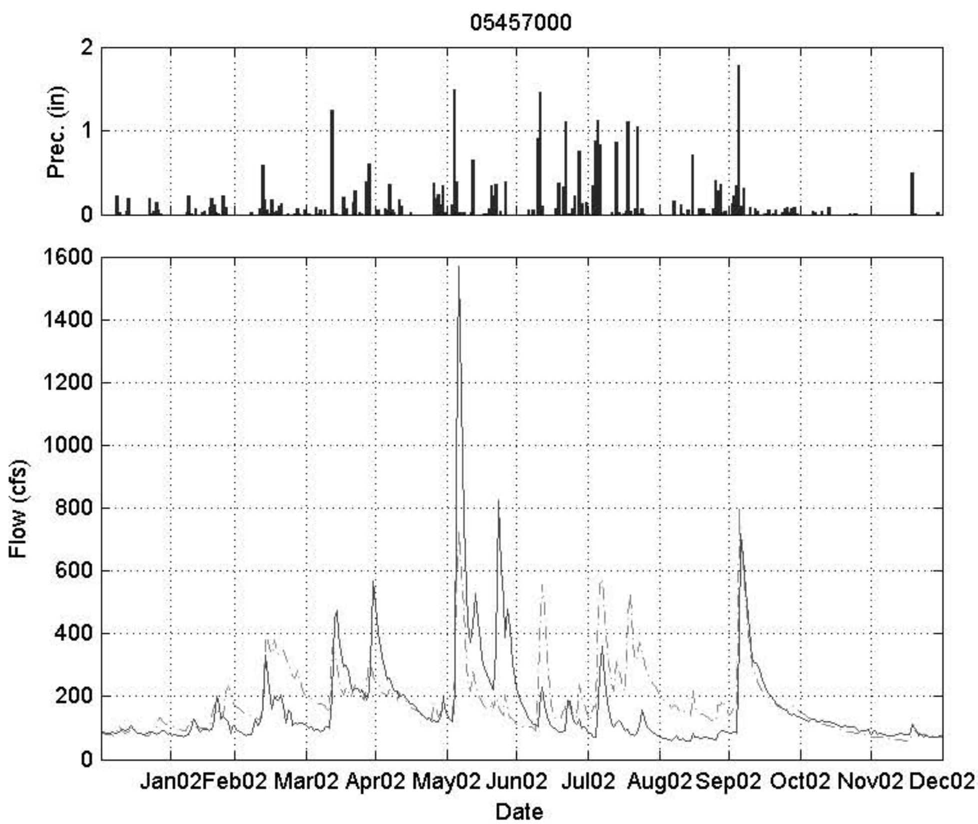
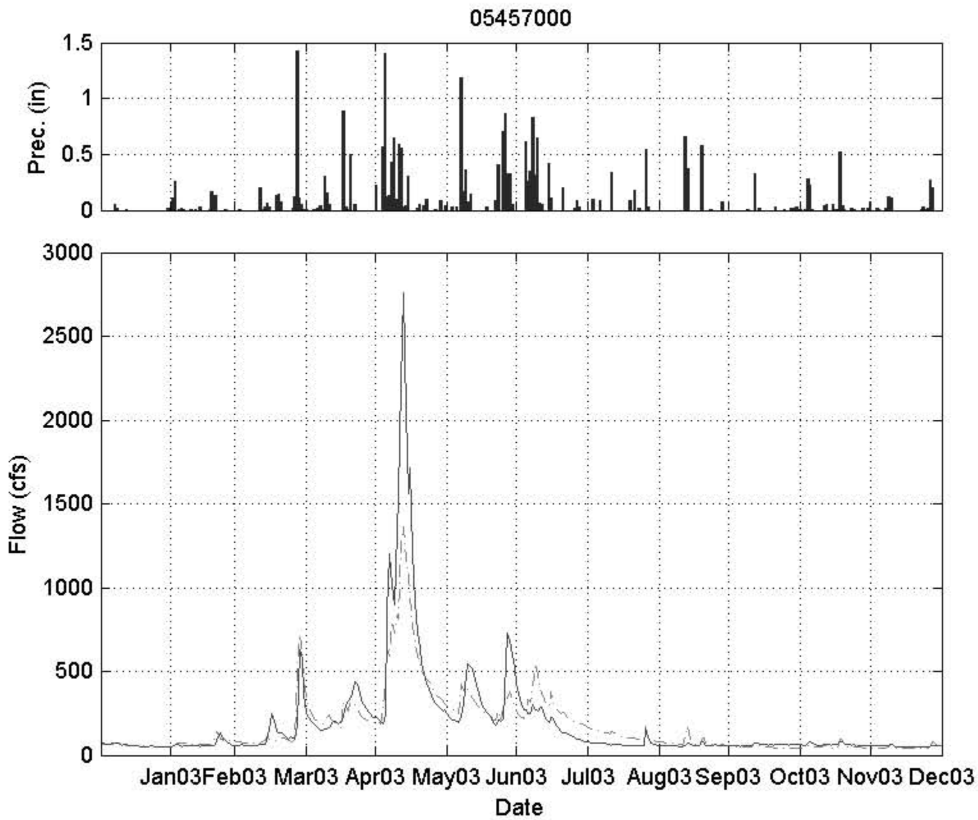
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
4000
3500
3000
2500
2000
1500
1000
500
0
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

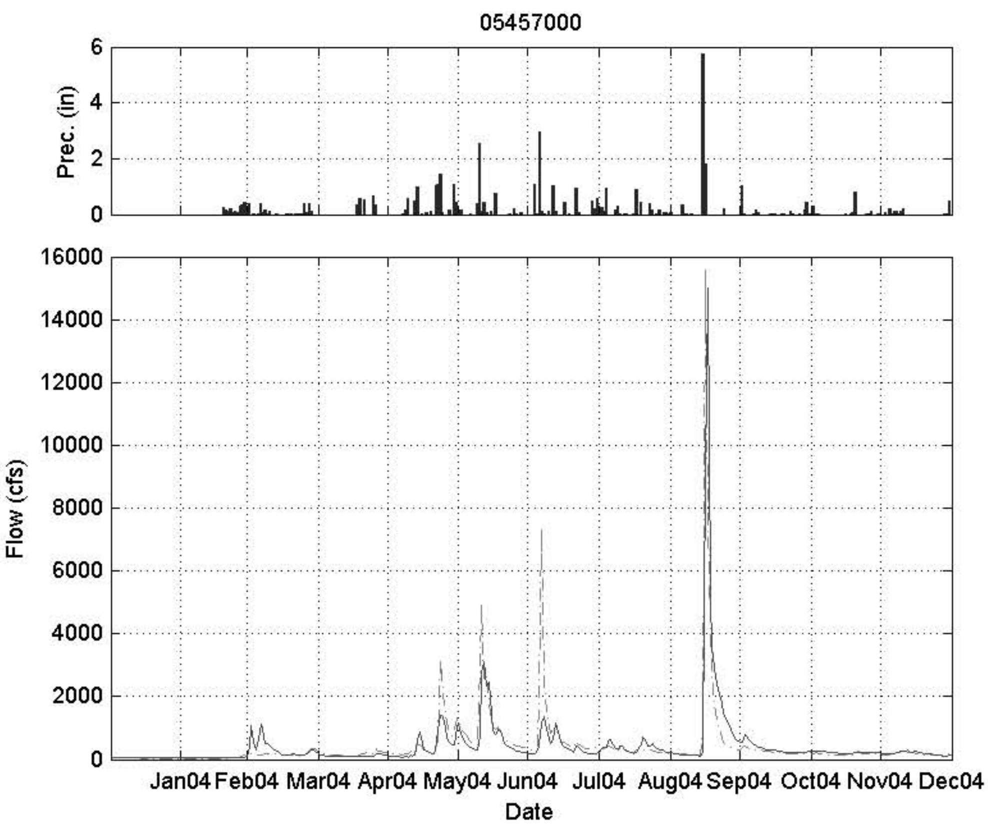

05457000
Prec. (in)
3
2
1
0
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

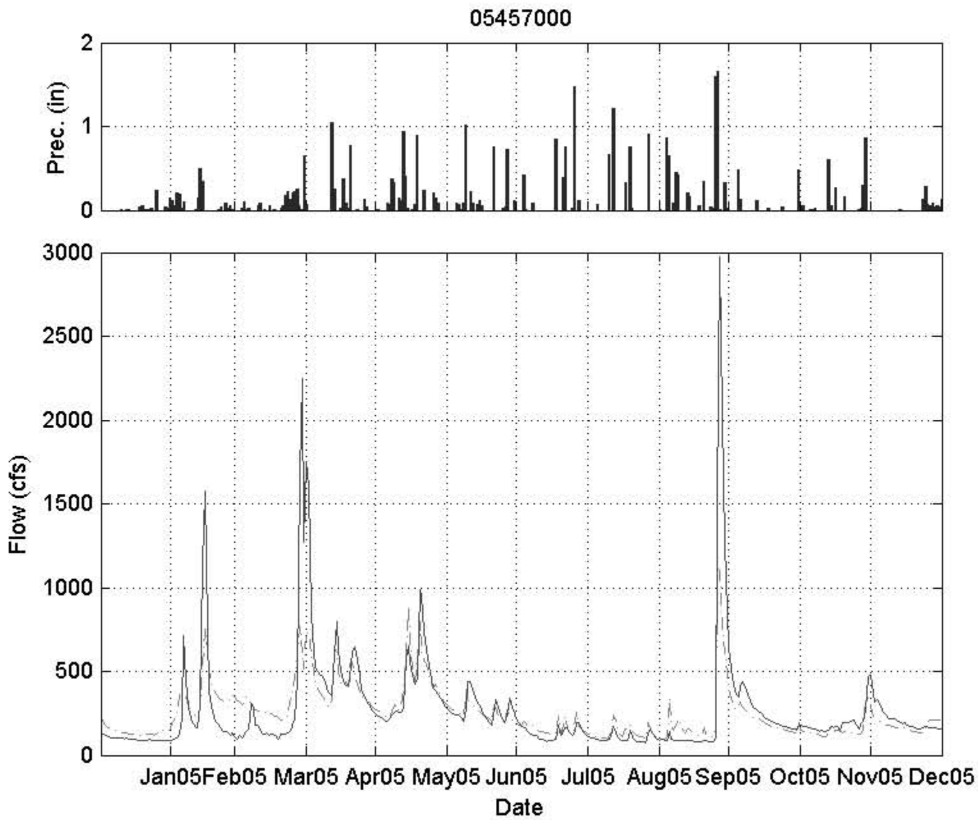

05457000
Prec. (in)
3
2
1
0
12000
10000
8000
6000
4000
2000
0
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

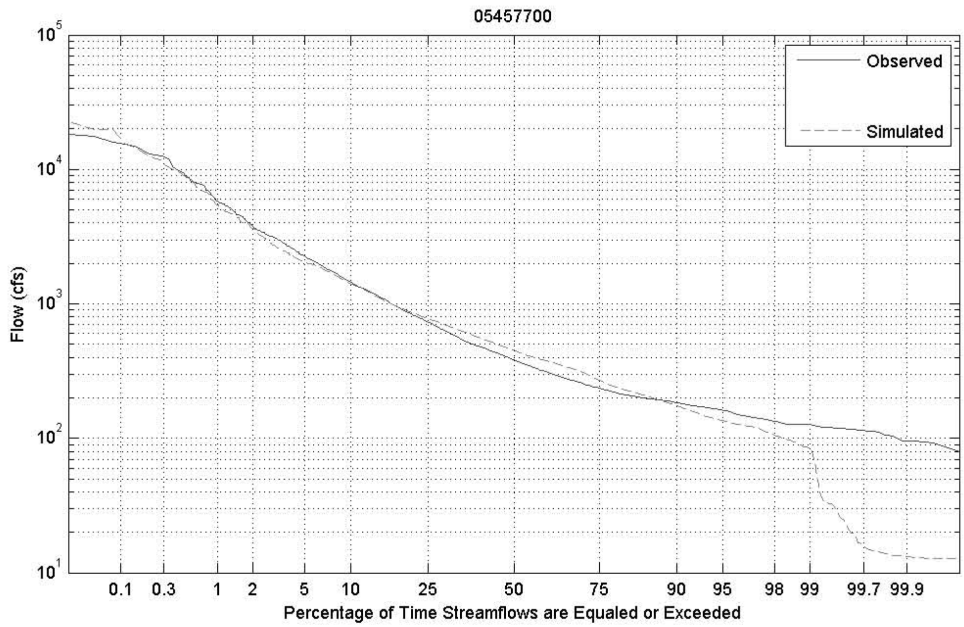

05457000
Prec. (in)
3
2
1
0
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

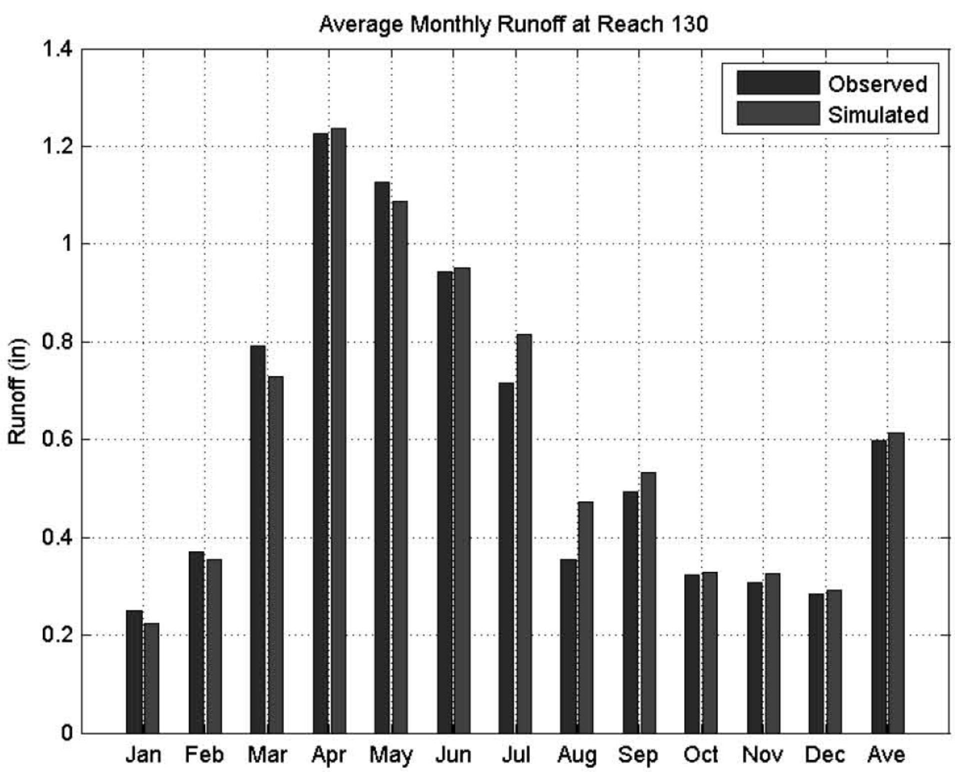

05457000
Prec. (in)
2
1
0
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

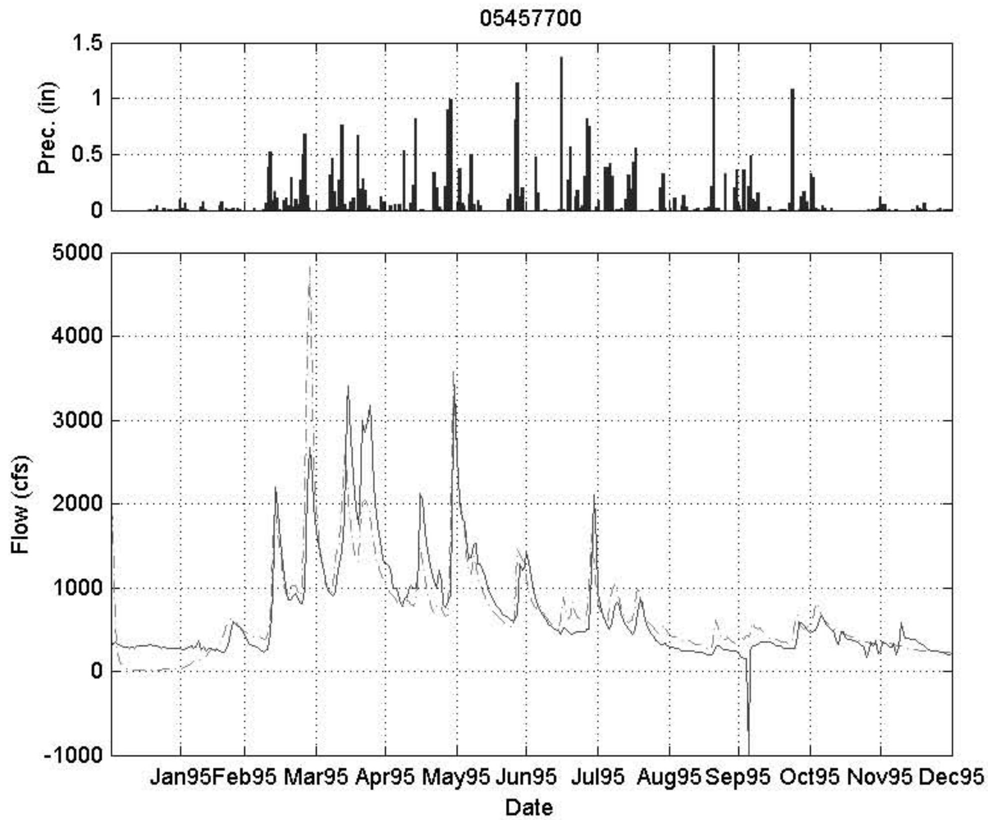

05457000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

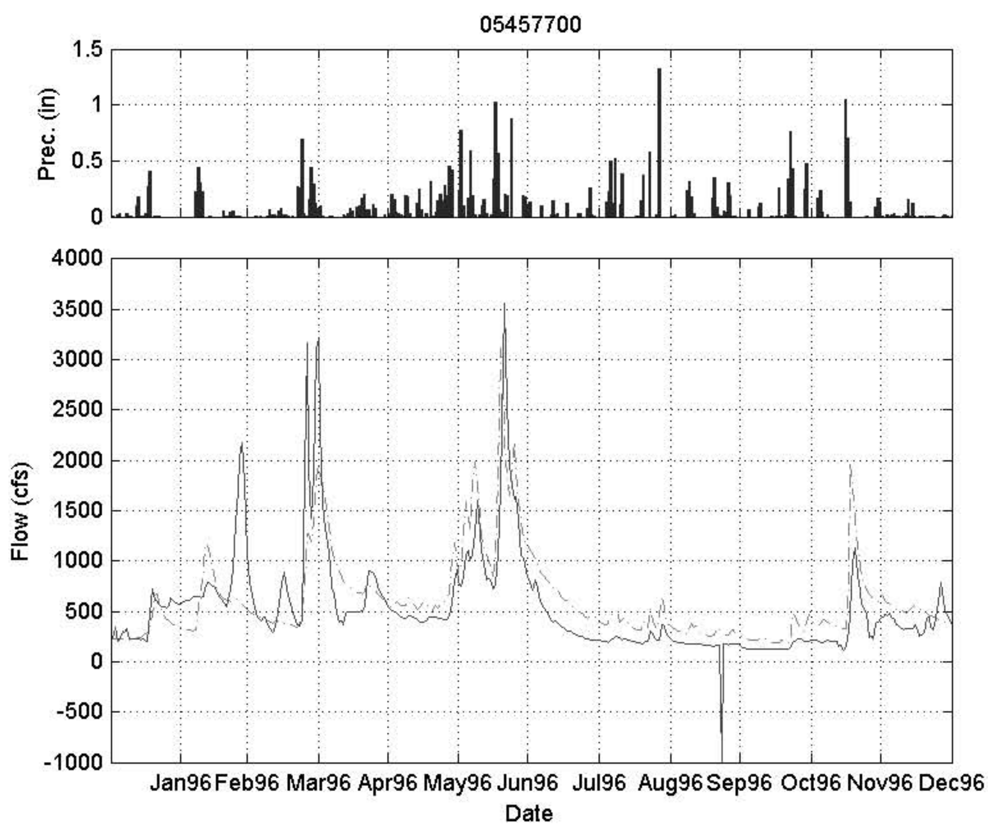

05457000
Prec. (in)
6
4
2
0
Flow (cfs)
16000
14000
12000
10000
8000
6000
4000
2000
0
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

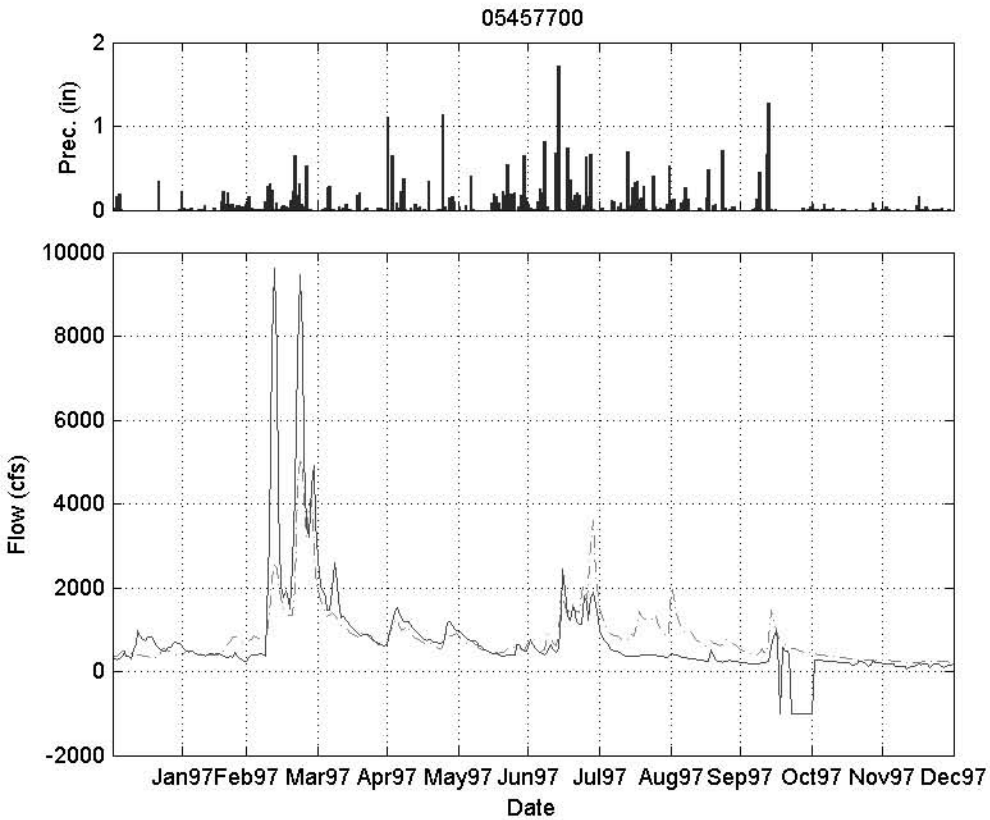

05457000
Prec. (in)
2
1
0
3000
2500
2000
1500
1000
500
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

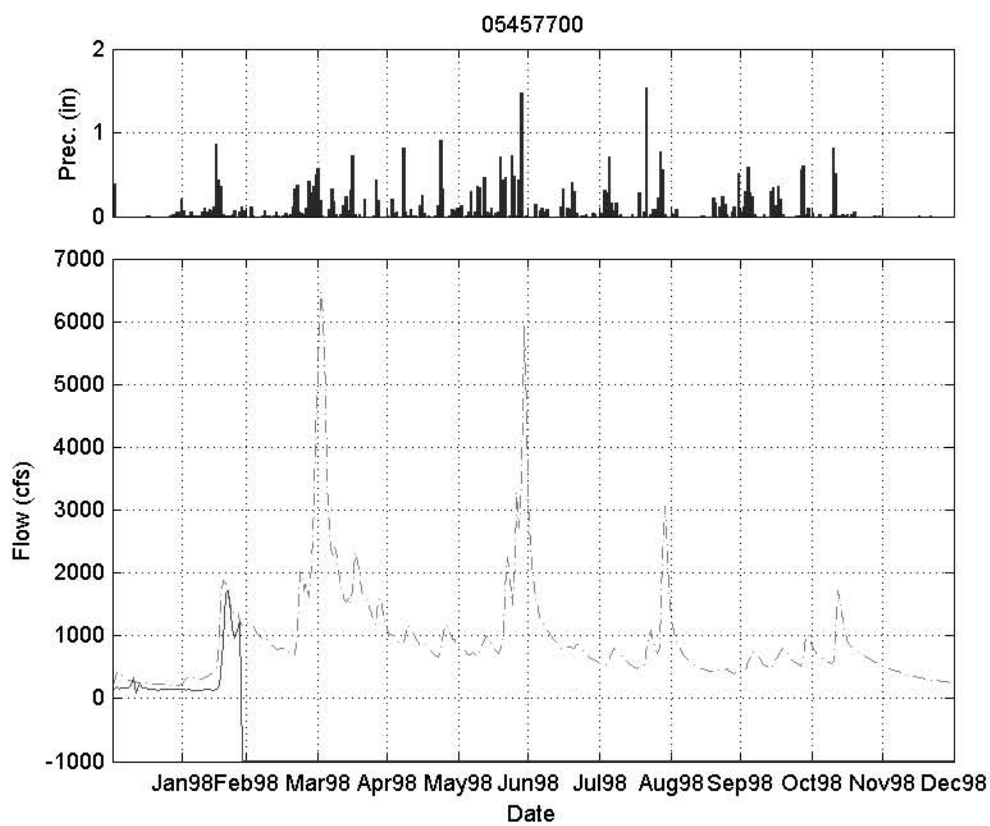

05457700
Observed
Simulated
Flow (cfs)
Percentage of Time Streamflows are Equaled or Exceeded
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9

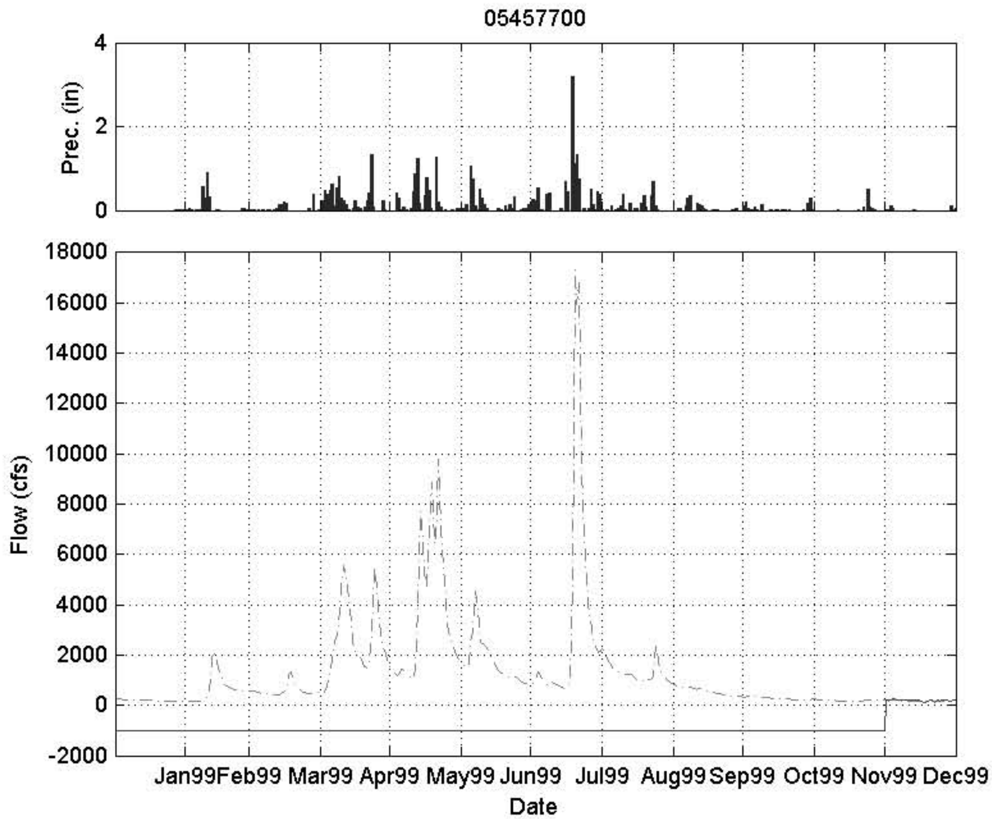

Average Monthly Runoff at Reach 130
Observed
Simulated
Runoff (in)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

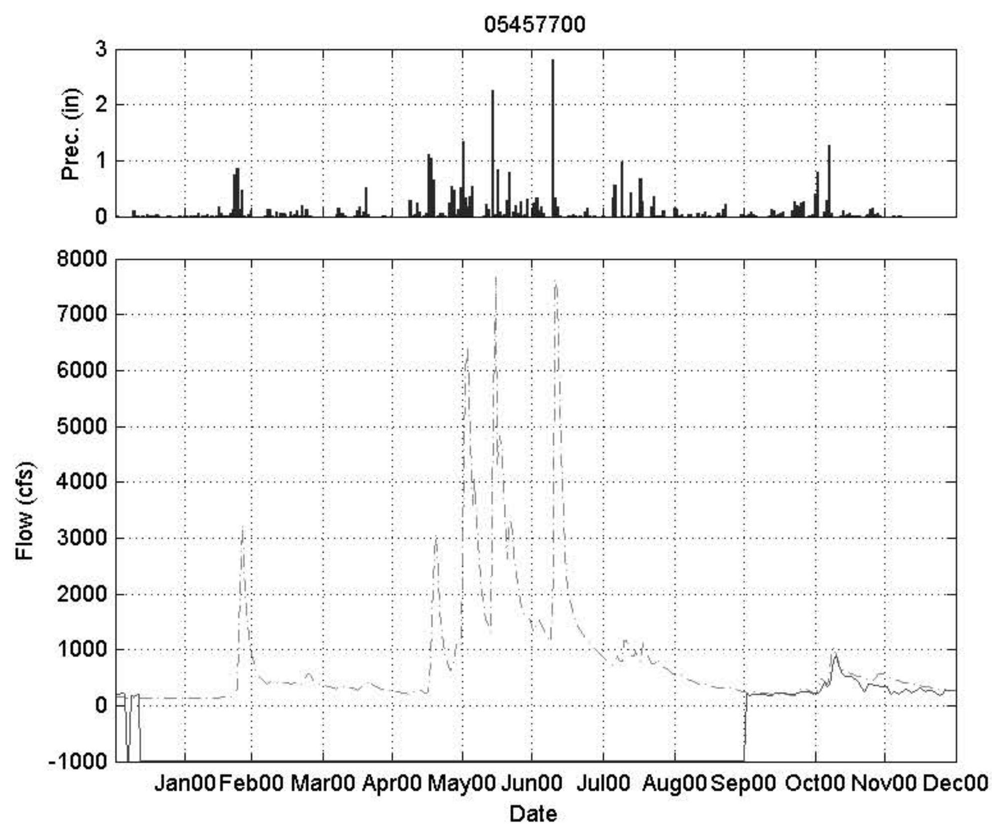

05457700
Prec. (in)
1.5
1
0.5
0
5000
4000
3000
2000
1000
0
-1000
Flow (cfs)
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

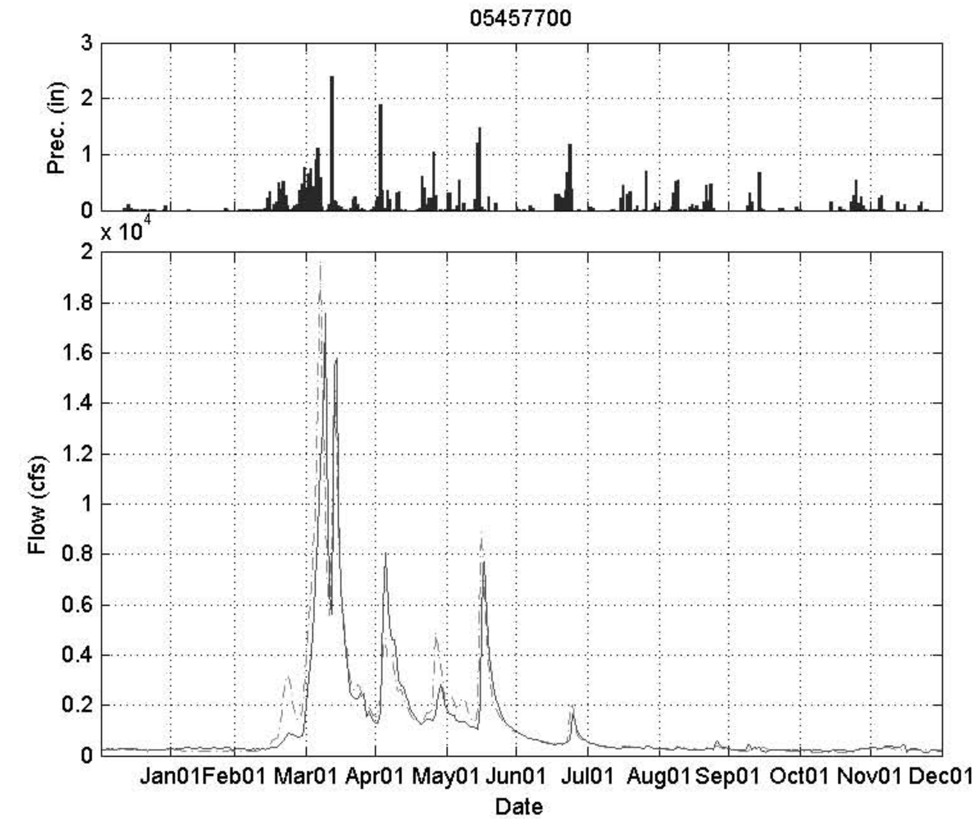

05457700
Prec. (in)
1.5
1
0.5
0
4000
3500
3000
2500
2000
1500
1000
500
0
-500
-1000
Flow (cfs)
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

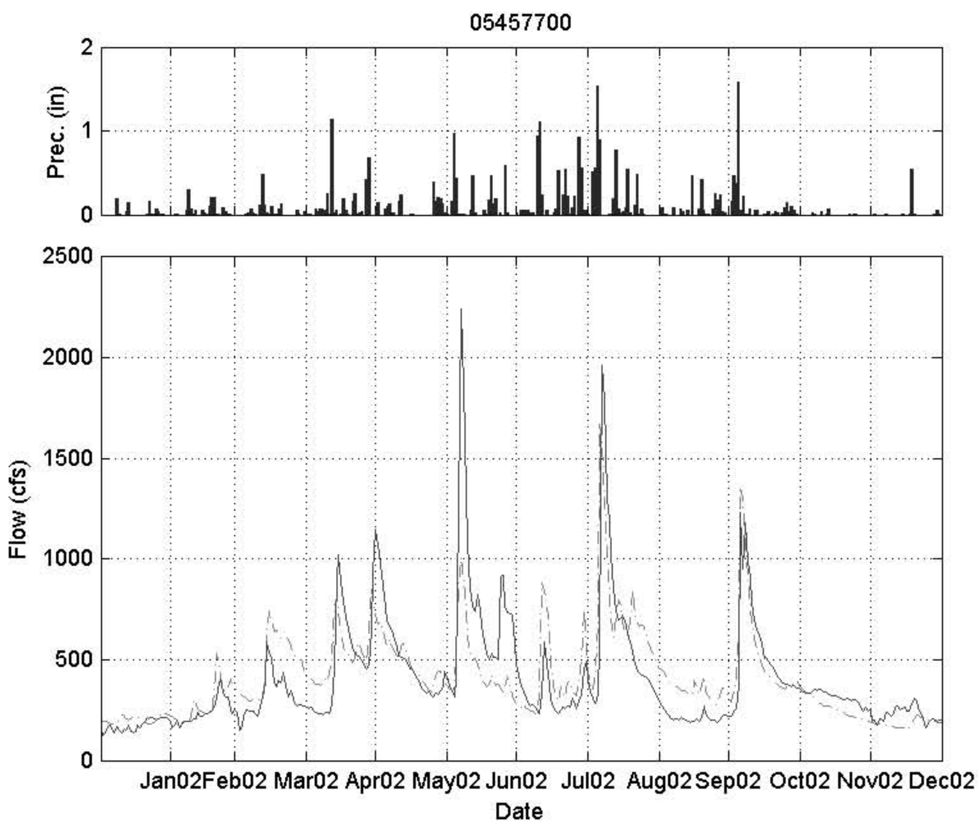

05457700
Prec. (in)
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

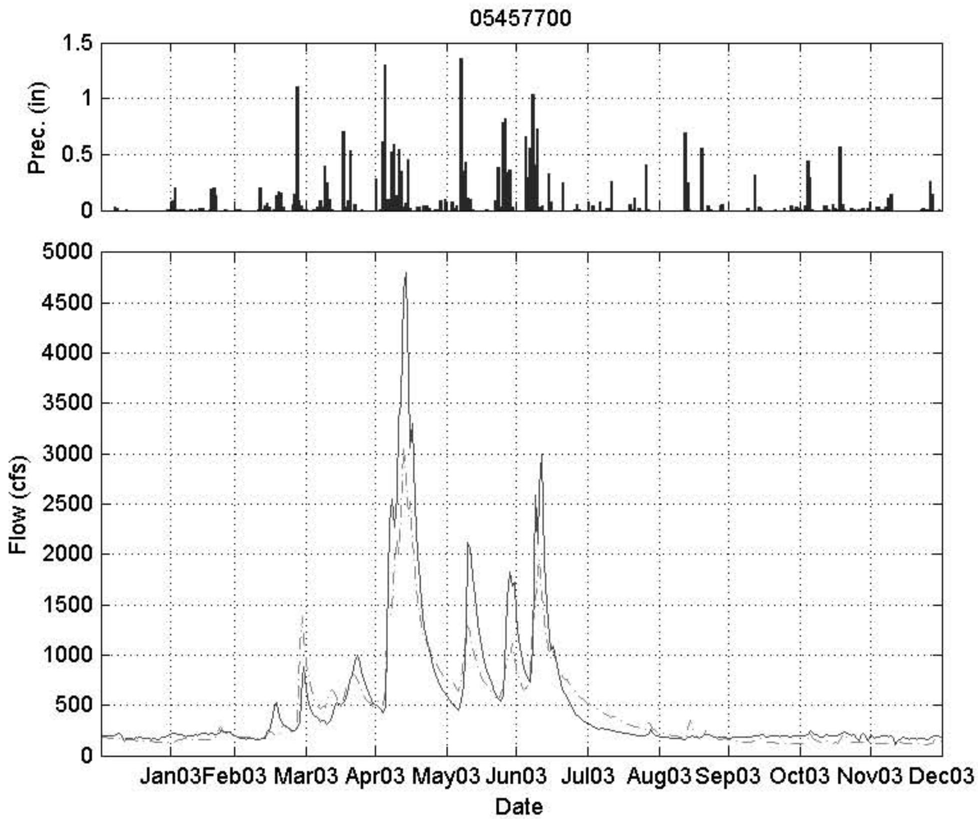

05457700
Prec. (in)
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

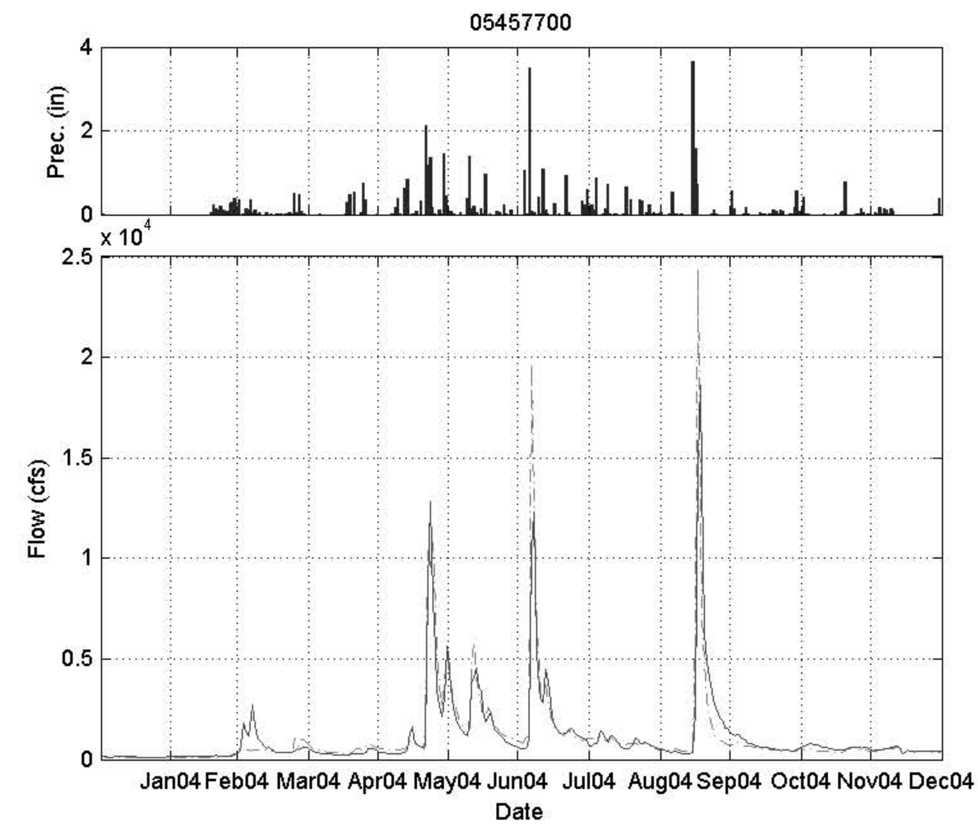

05457700
Prec. (in)
4
2
0
Flow (cfs)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

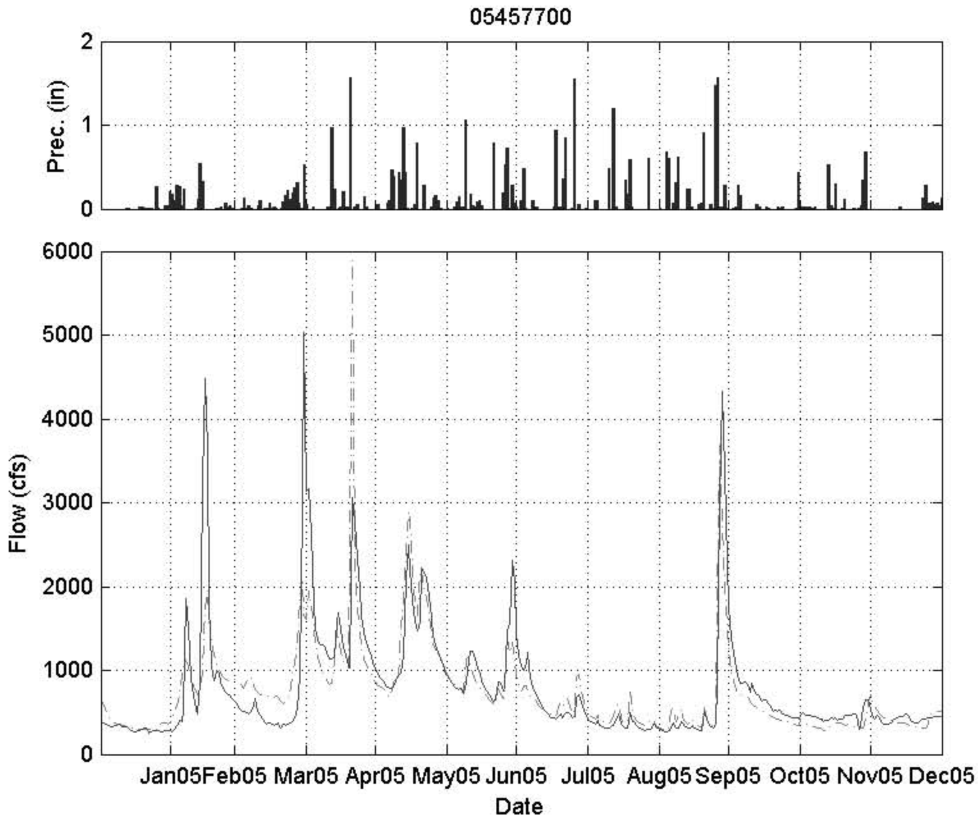

05457700
Prec. (in)
3
2
1
0
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

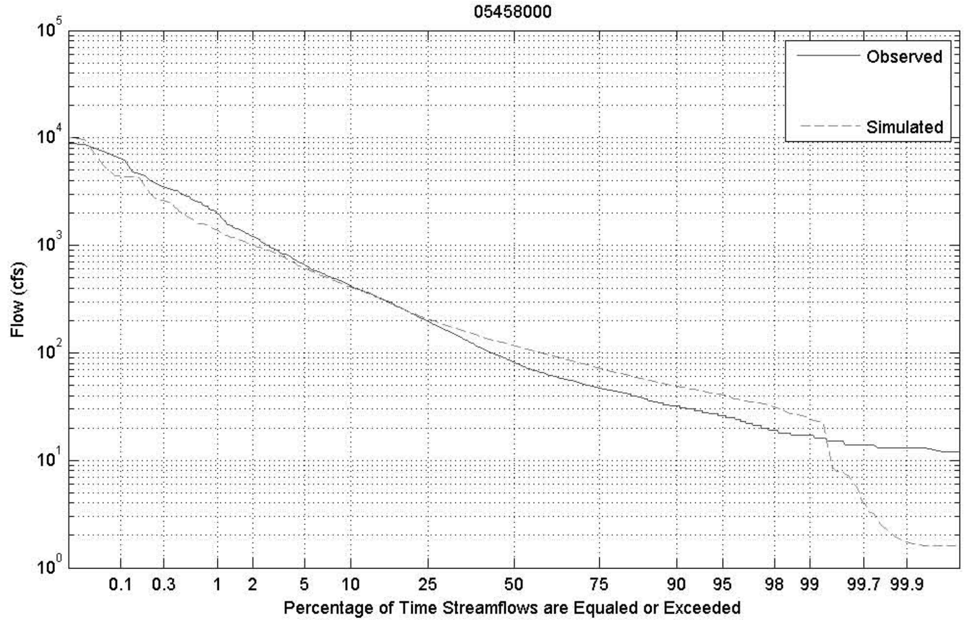

05457700
Prec. (in)
x 10^4
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

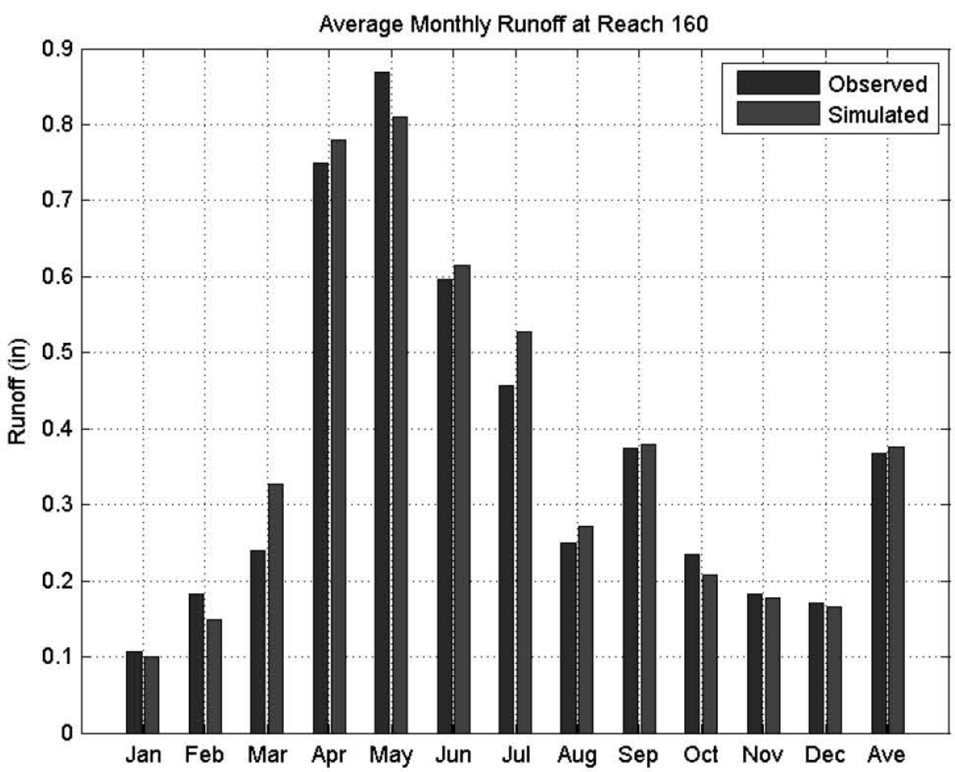

05457700
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

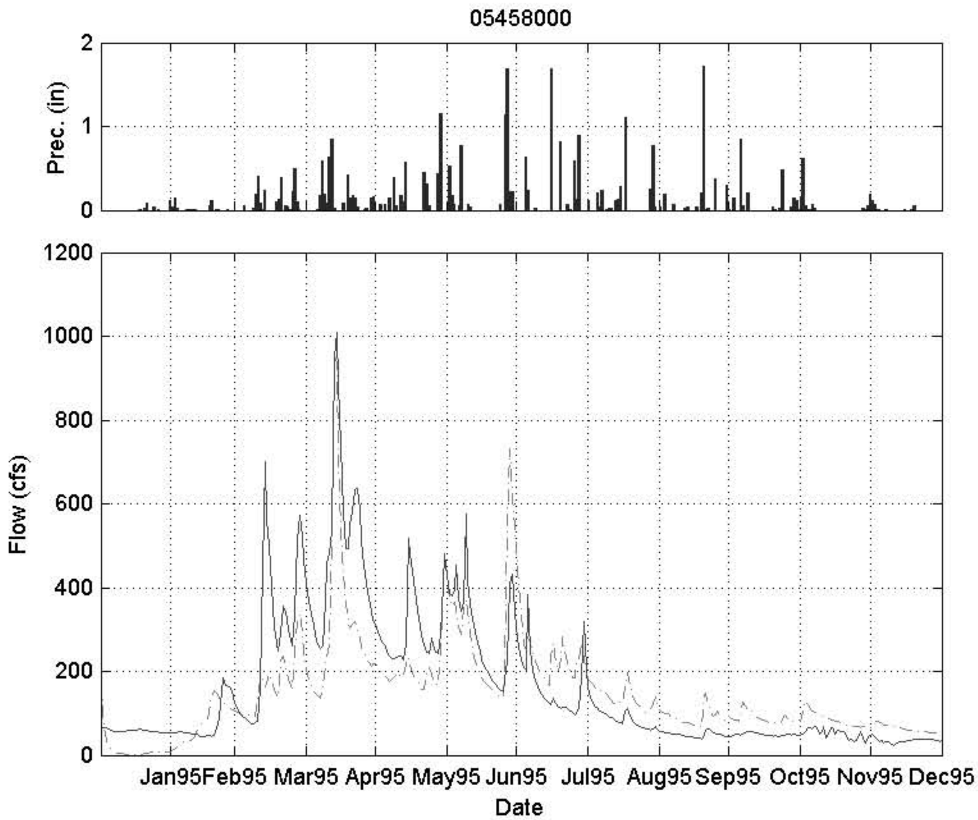

05457700
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

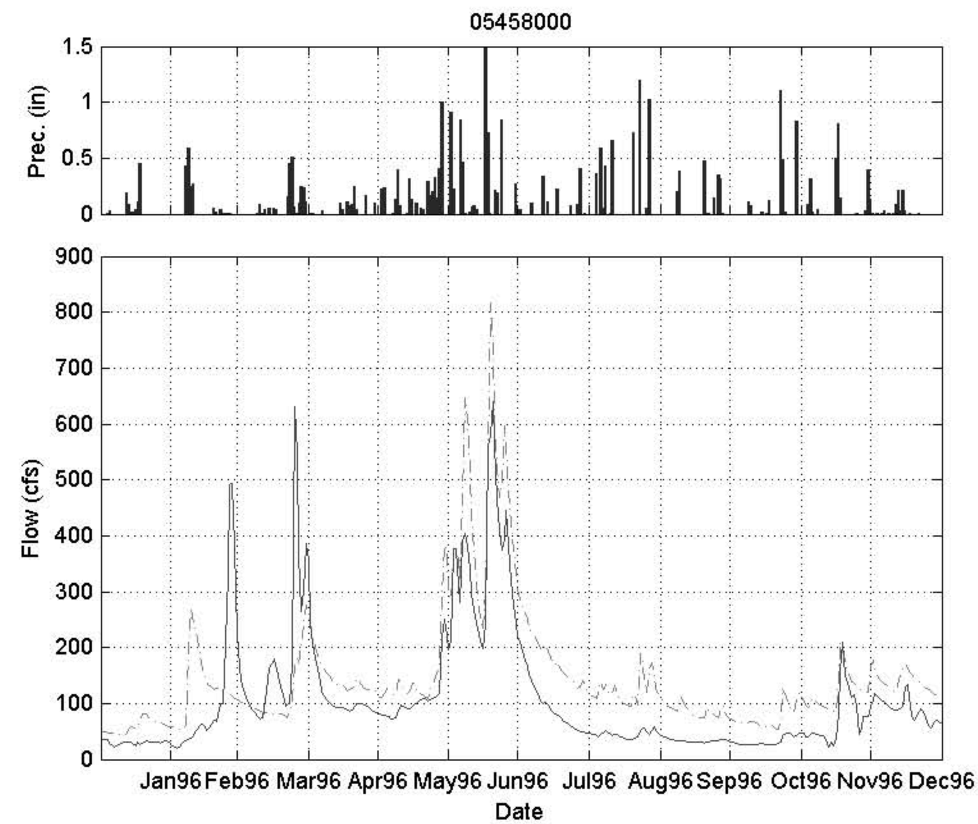

05457700
Prec. (in)
4
2
0
x 10^4
Flow (cfs)
2.5
2
1.5
1
0.5
0
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

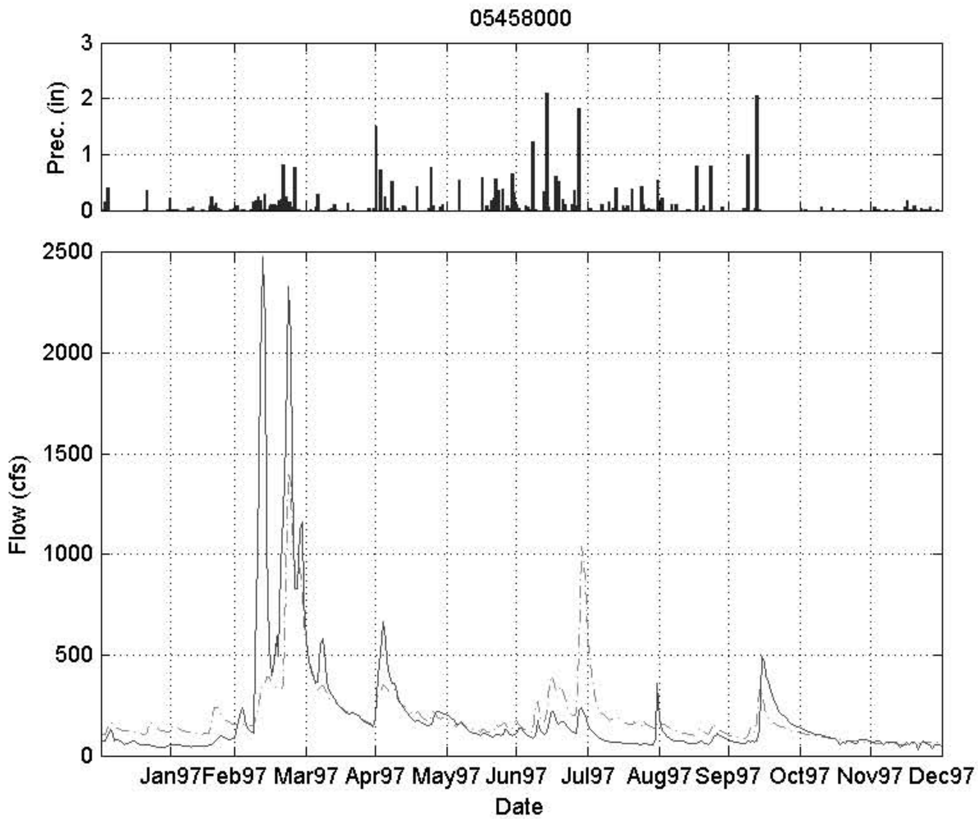

05457700
Prec. (in)
2
1
0
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

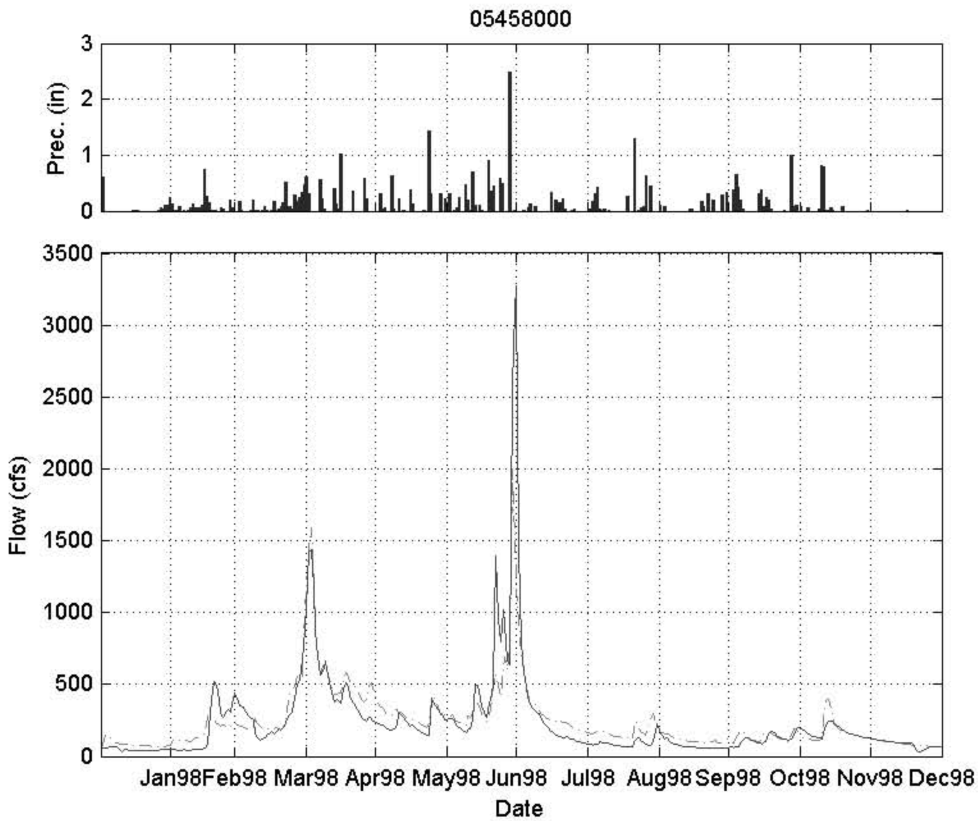

05458000
Observed
Simulated
Flow (cfs)
Percentage of Time Streamflows are Equaled or Exceeded
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9

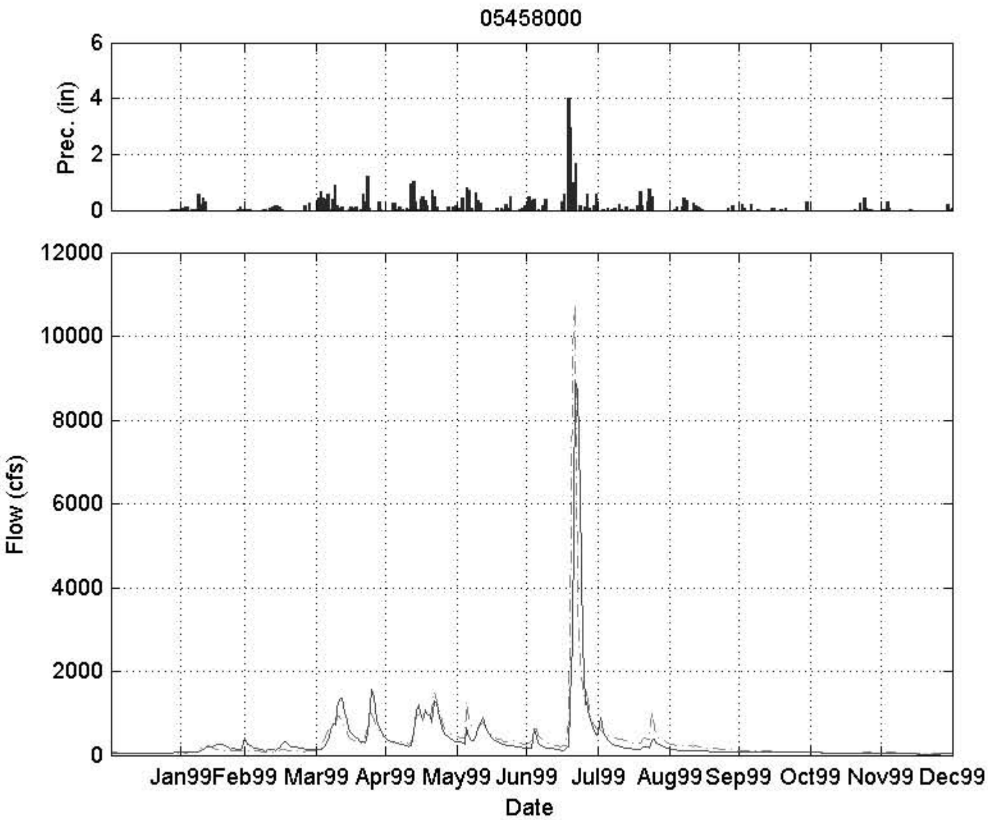

Average Monthly Runoff at Reach 160
Observed
Simulated
Runoff (in)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

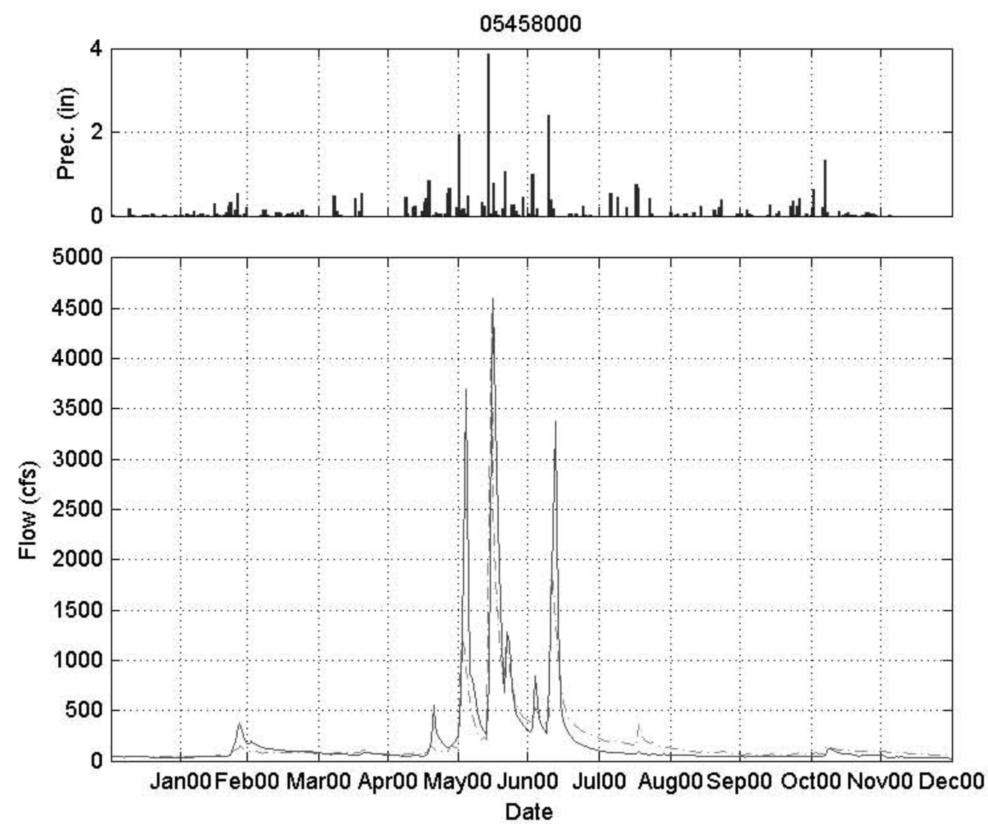

05458000
Prec. (in)
2
1
0
Flow (cfs)
1200
1000
800
600
400
200
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

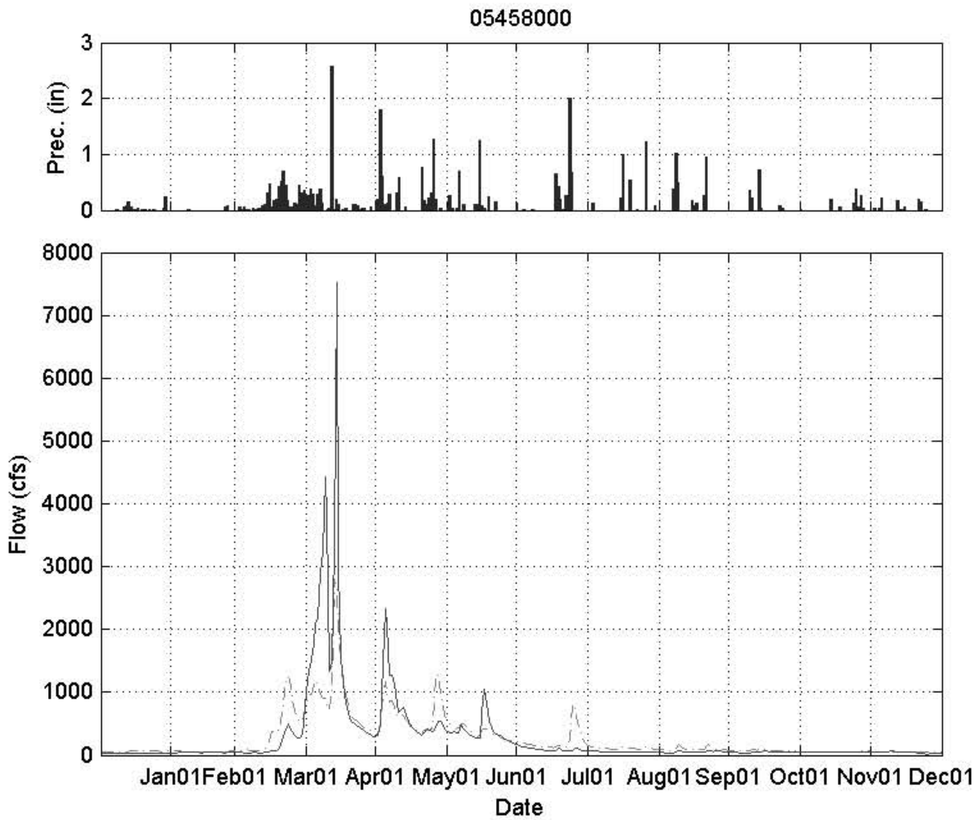

05458000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
900
800
700
600
500
400
300
200
100
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

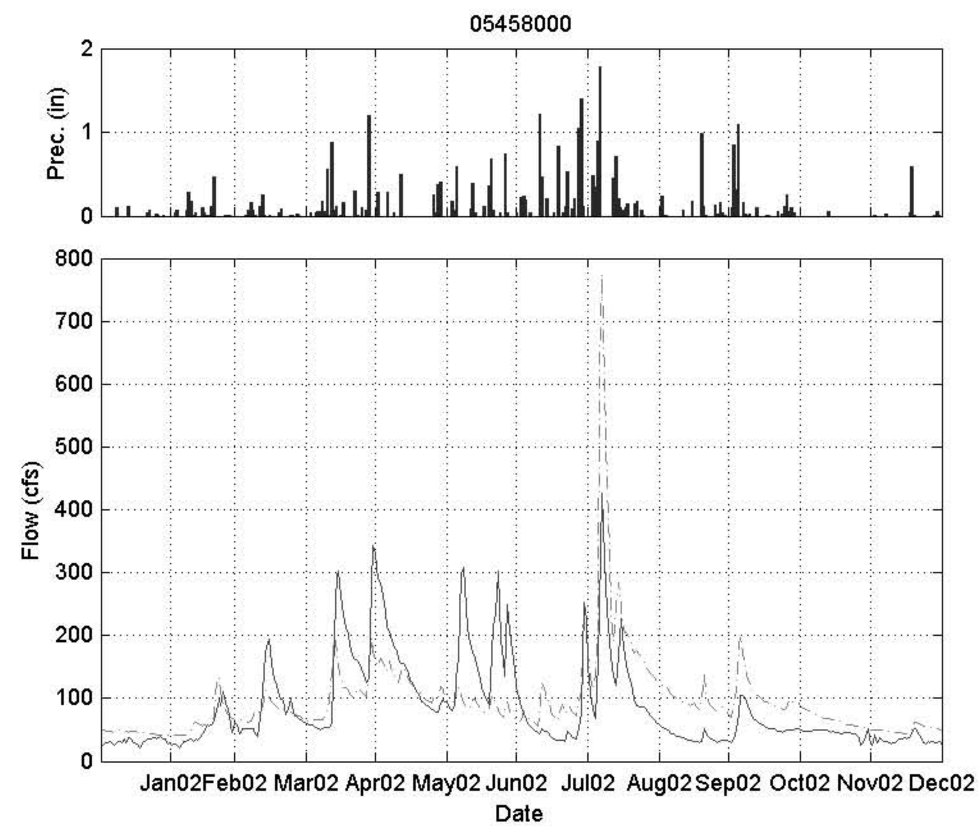

05458000
Prec. (in)
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

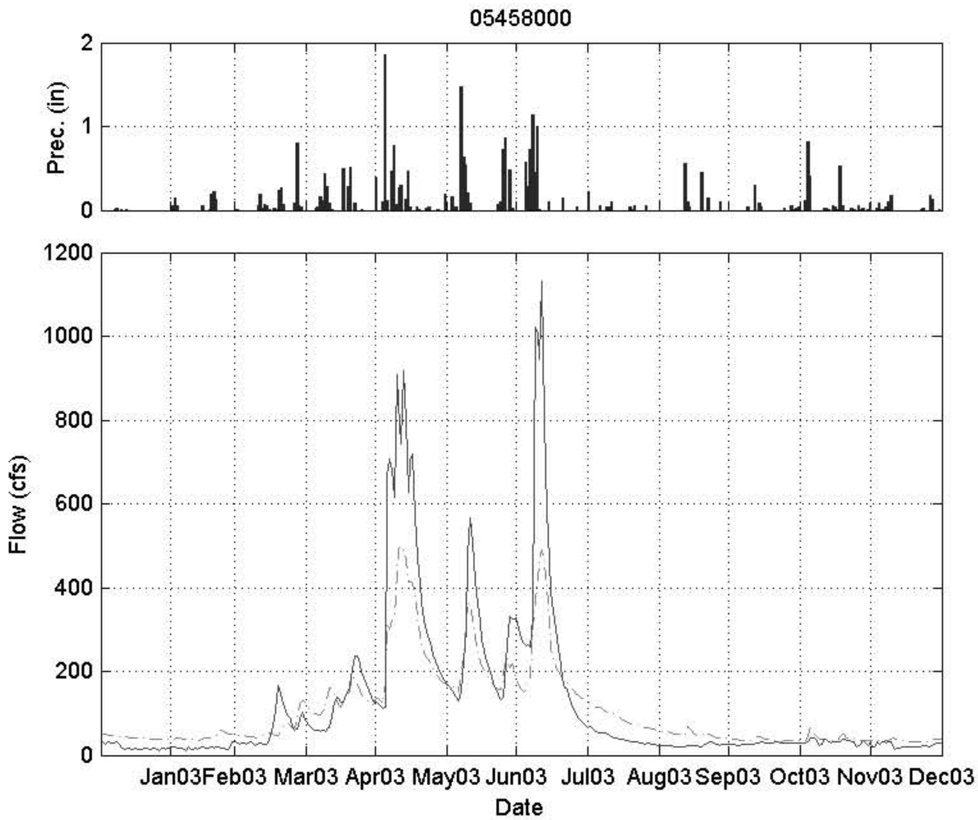

05458000
Prec. (in)
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

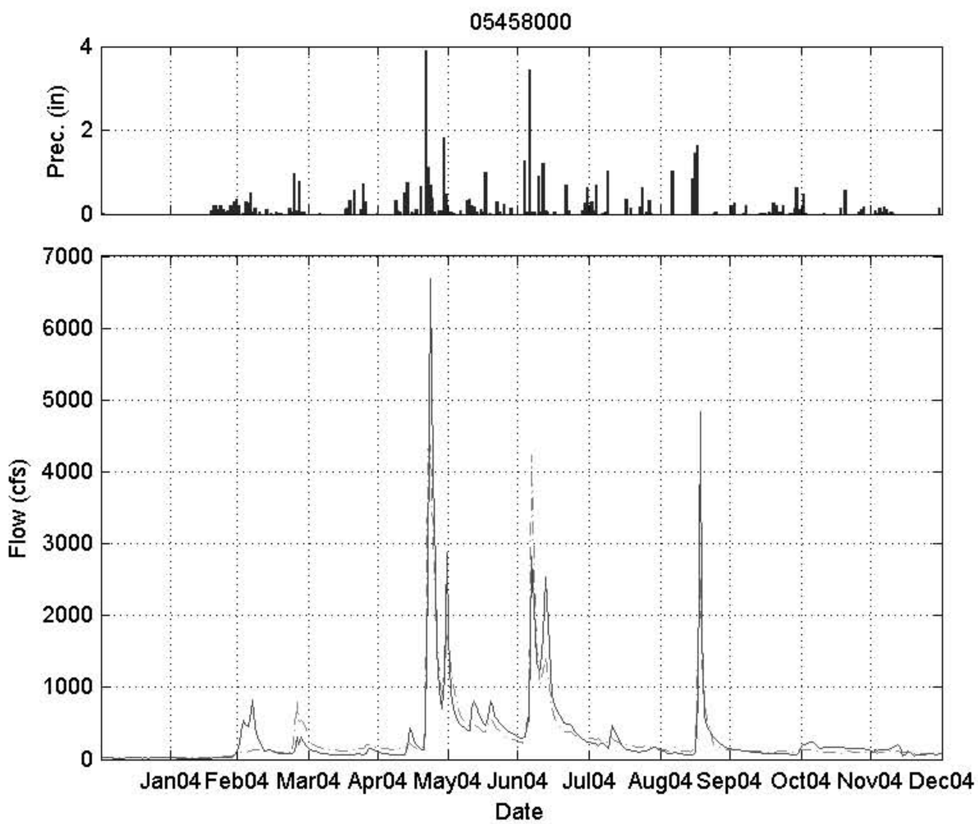

05458000
Prec. (in)
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

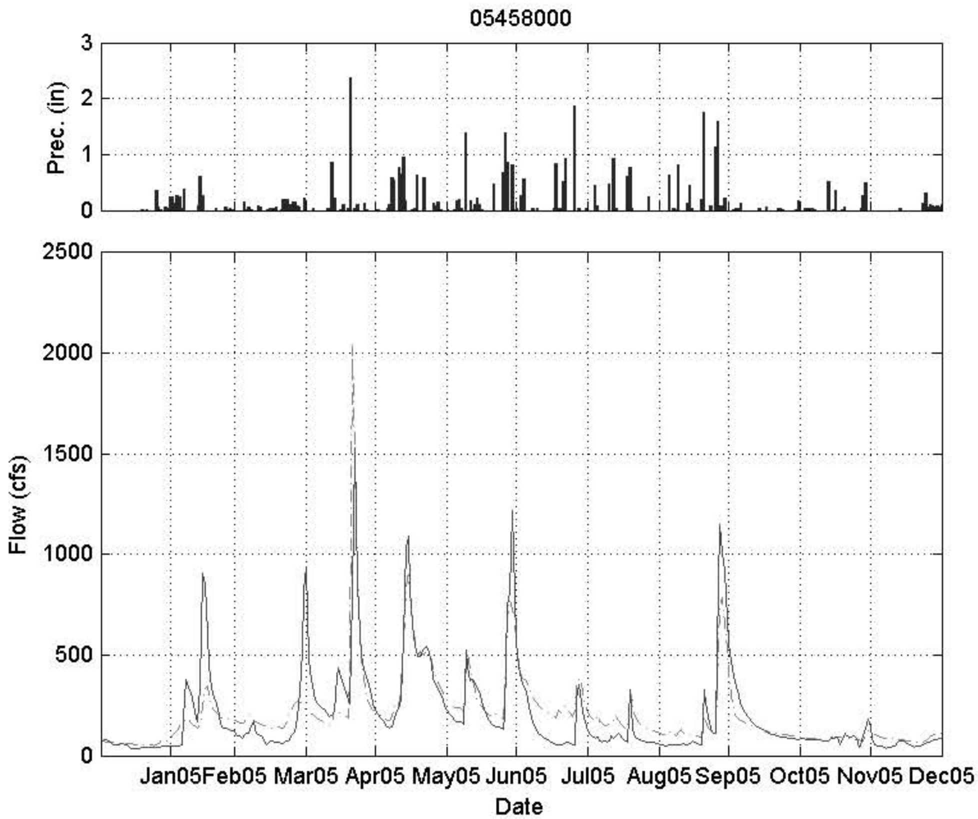

05458000
Prec. (in)
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

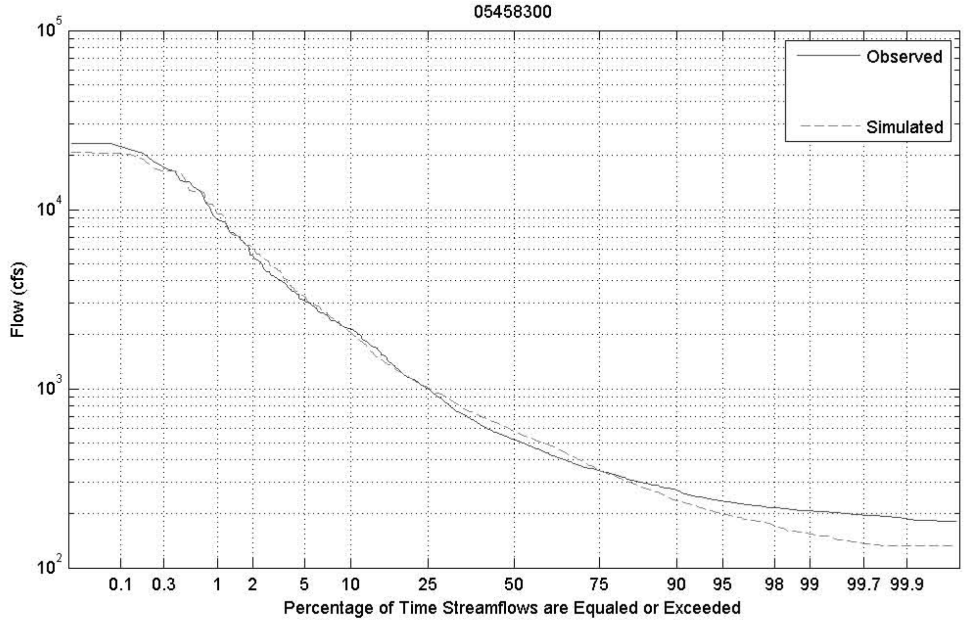

05458000
Prec. (in)
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

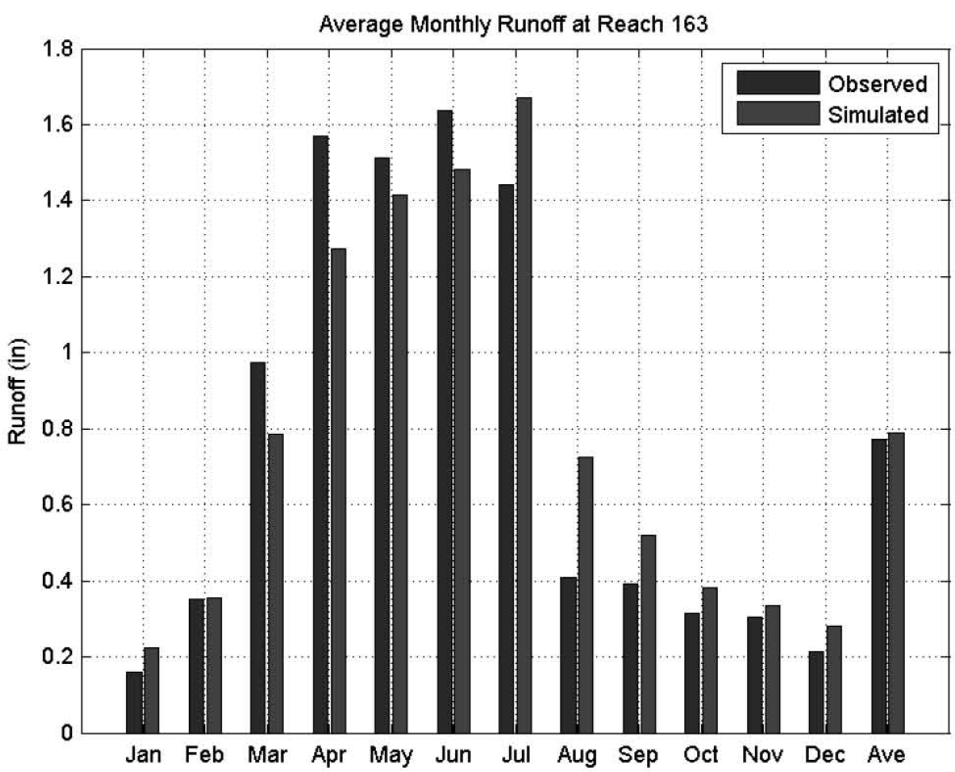

05458000
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

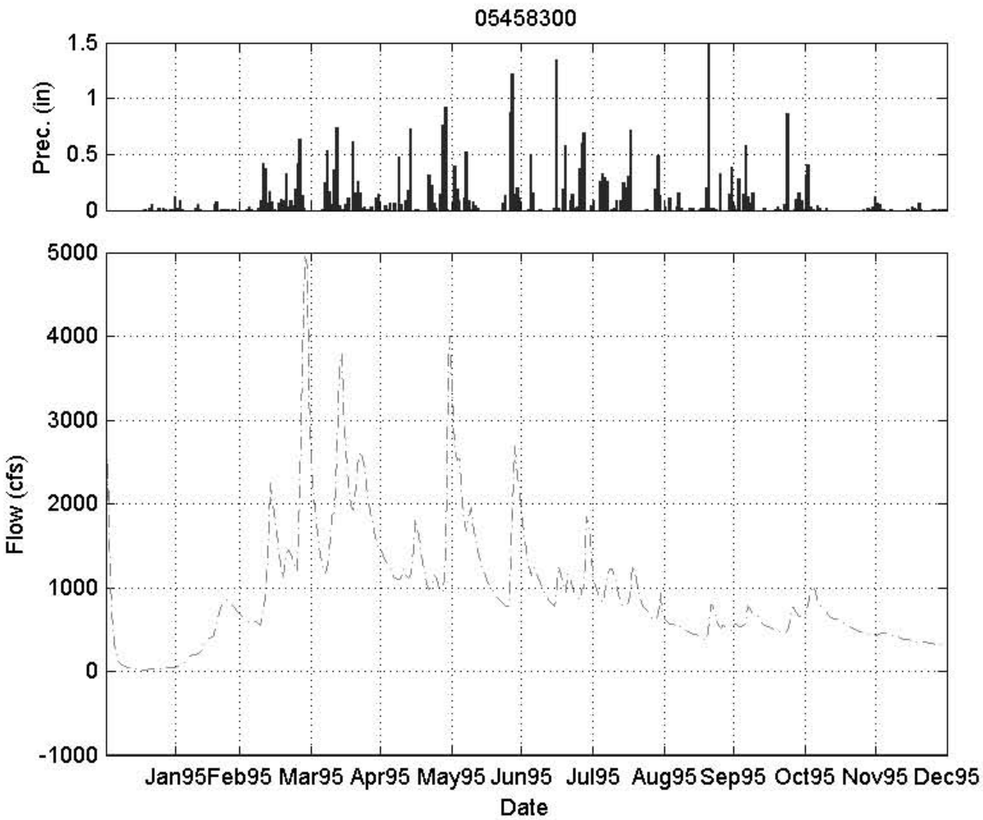

05458000
Prec. (in)
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

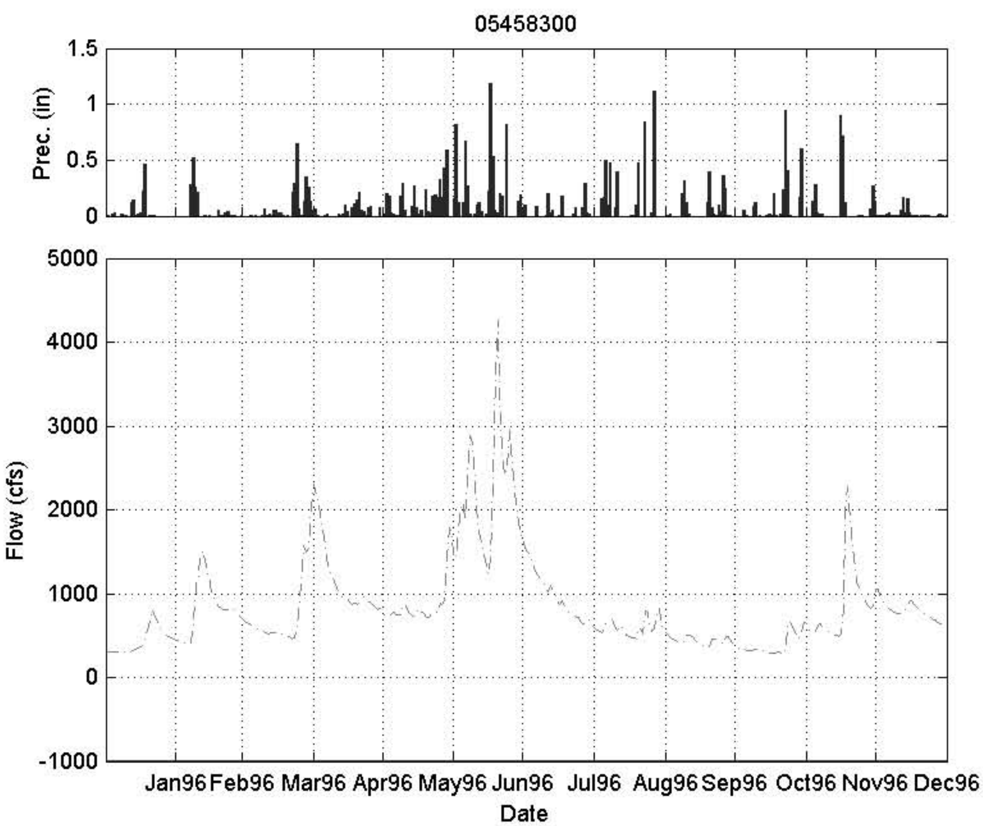

05458000
Prec. (in)
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

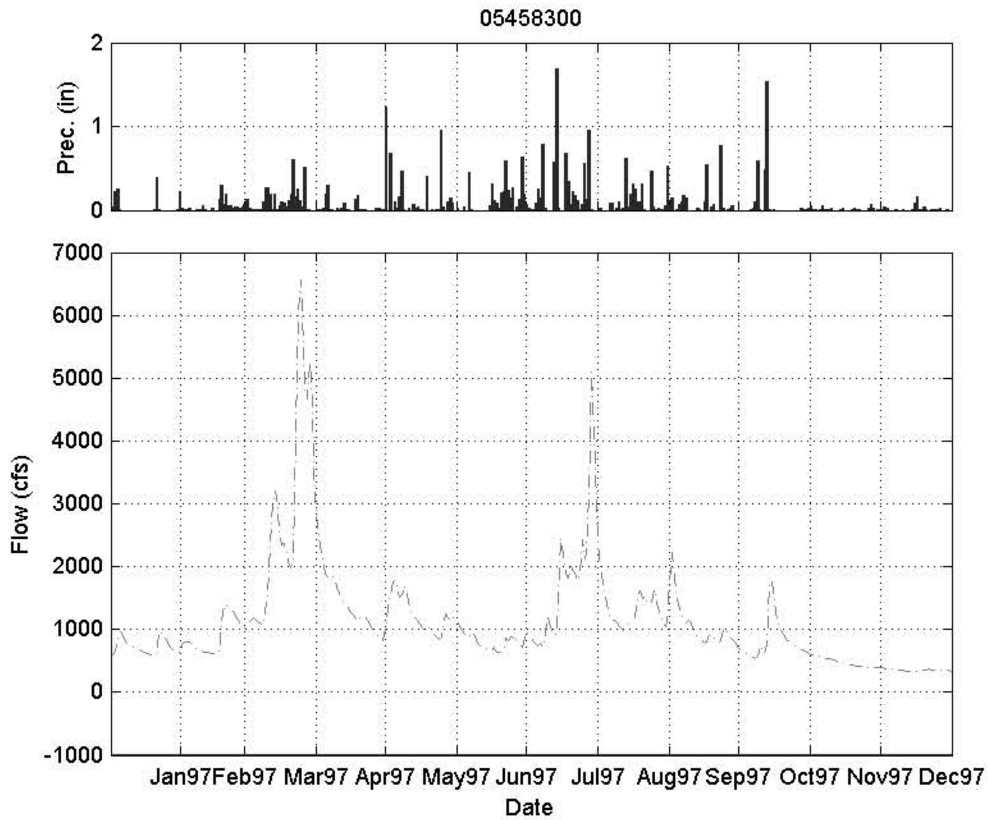

05458000
Prec. (in)
3
2
1
0
2500
2000
1500
1000
500
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

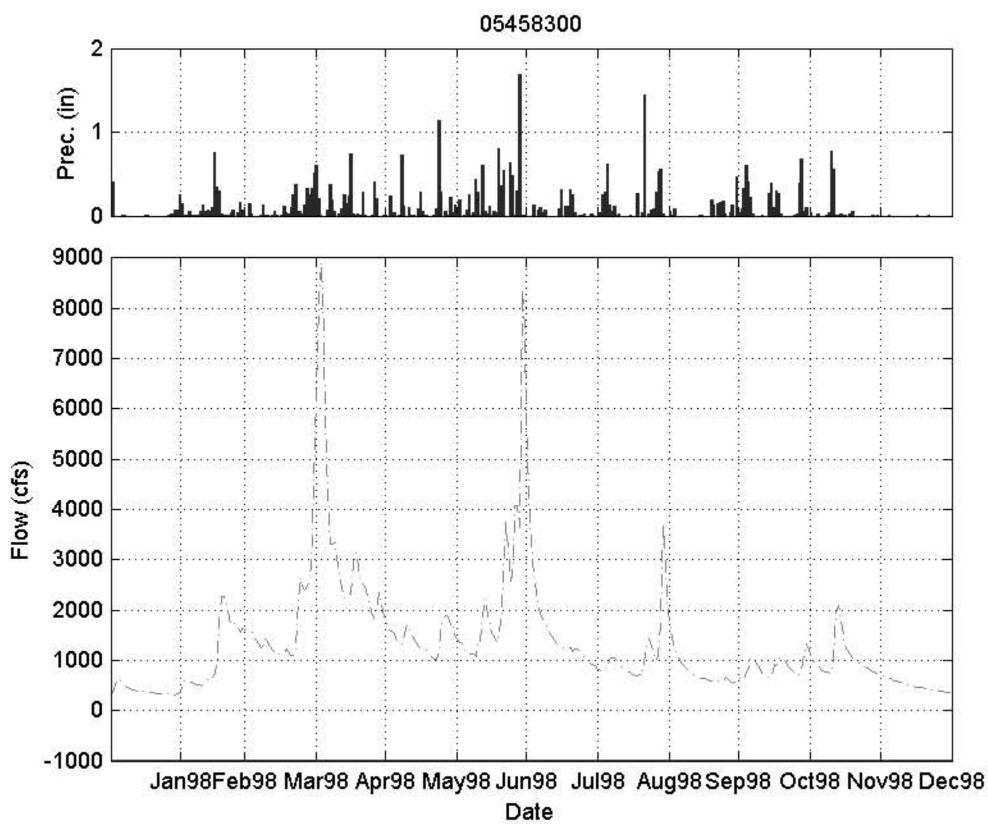

05458300
Observed
Simulated
Flow (cfs)
10^5
10^4
10^3
10^2
0.1
0.3
1
2
5
10
25
50
75
90
95
98
99
99.7
99.9
Percentage of Time Streamflows are Equaled or Exceeded

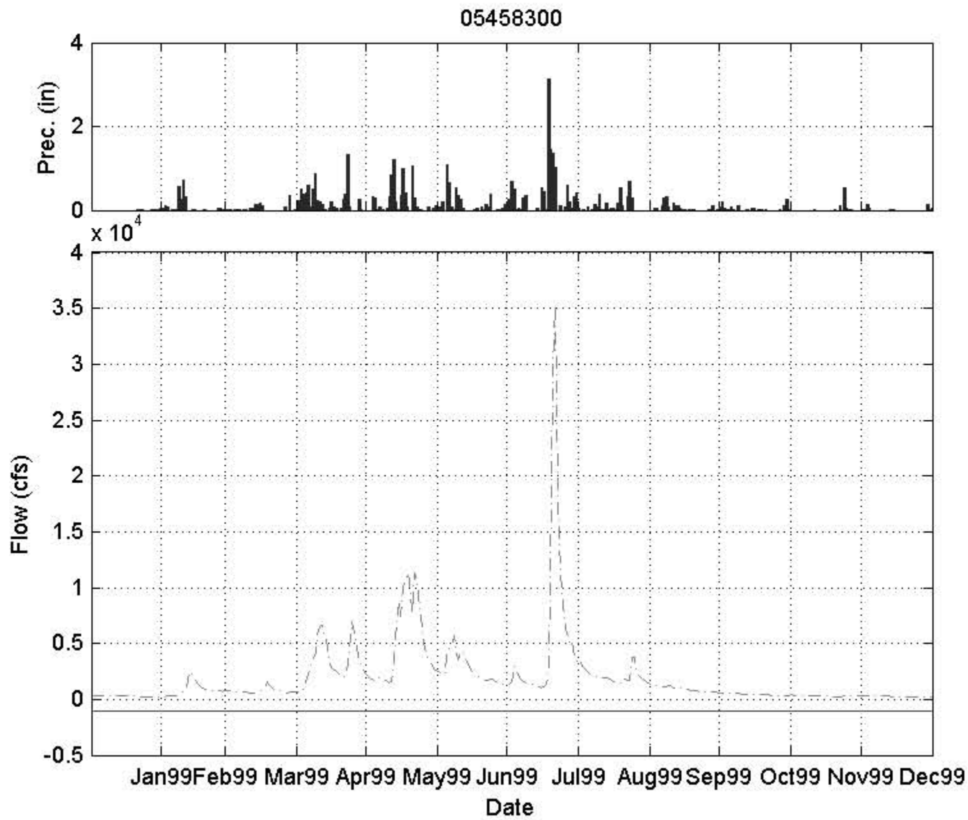

Average Monthly Runoff at Reach 163
Observed
Simulated
Runoff (in)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ave

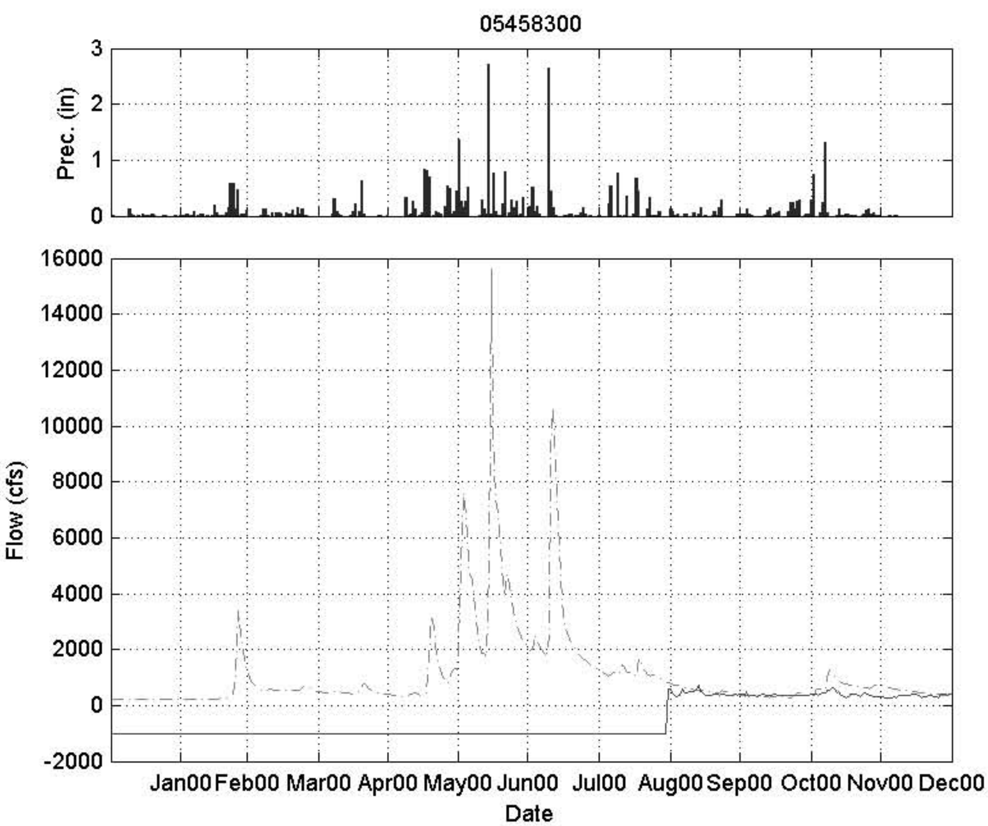

05458300
Prec. (in)
Flow (cfs)
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

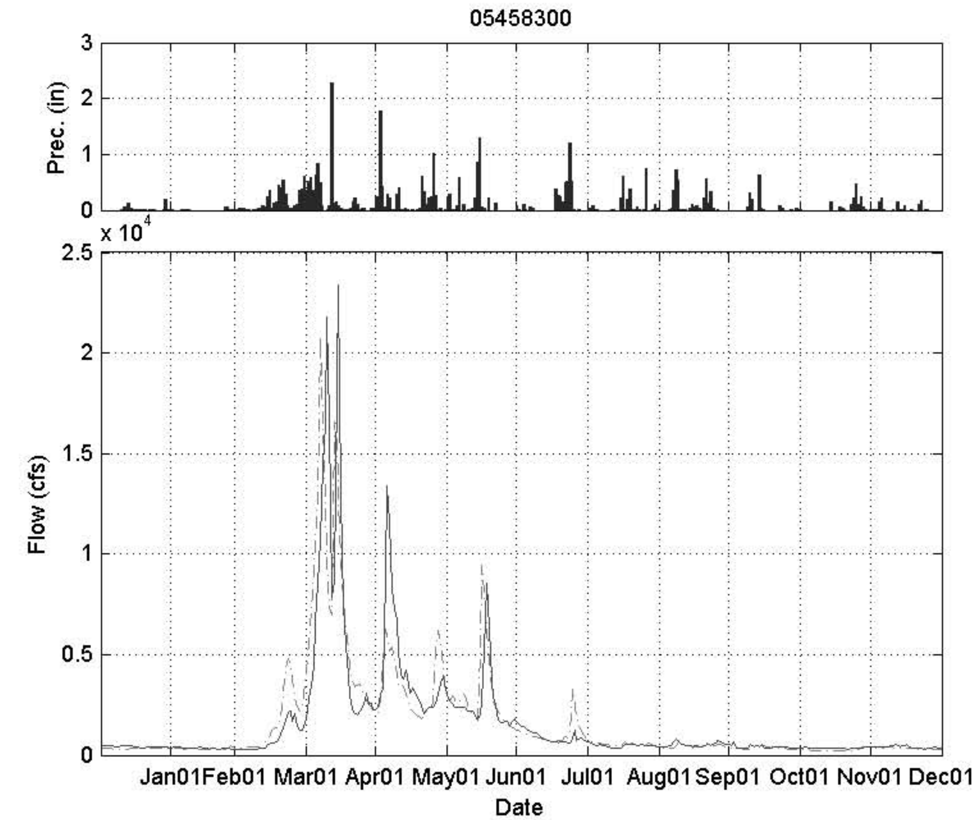

05458300
Prec. (in)
Flow (cfs)
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

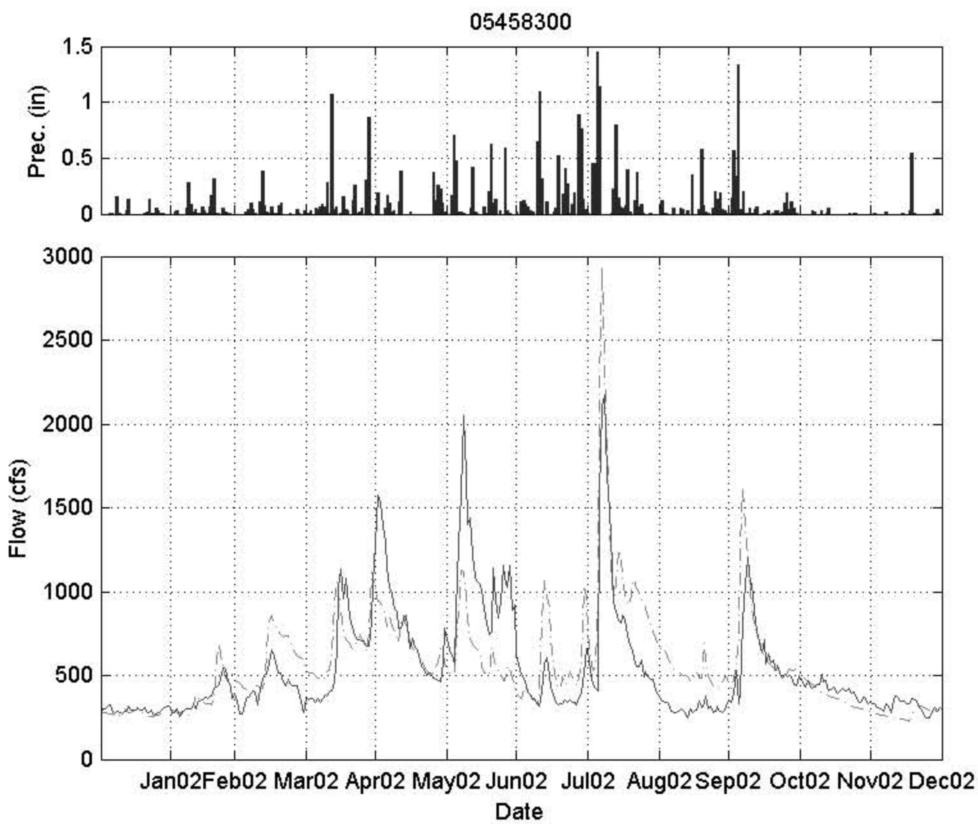

05458300
Prec. (in)
2
1
0
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
-1000
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

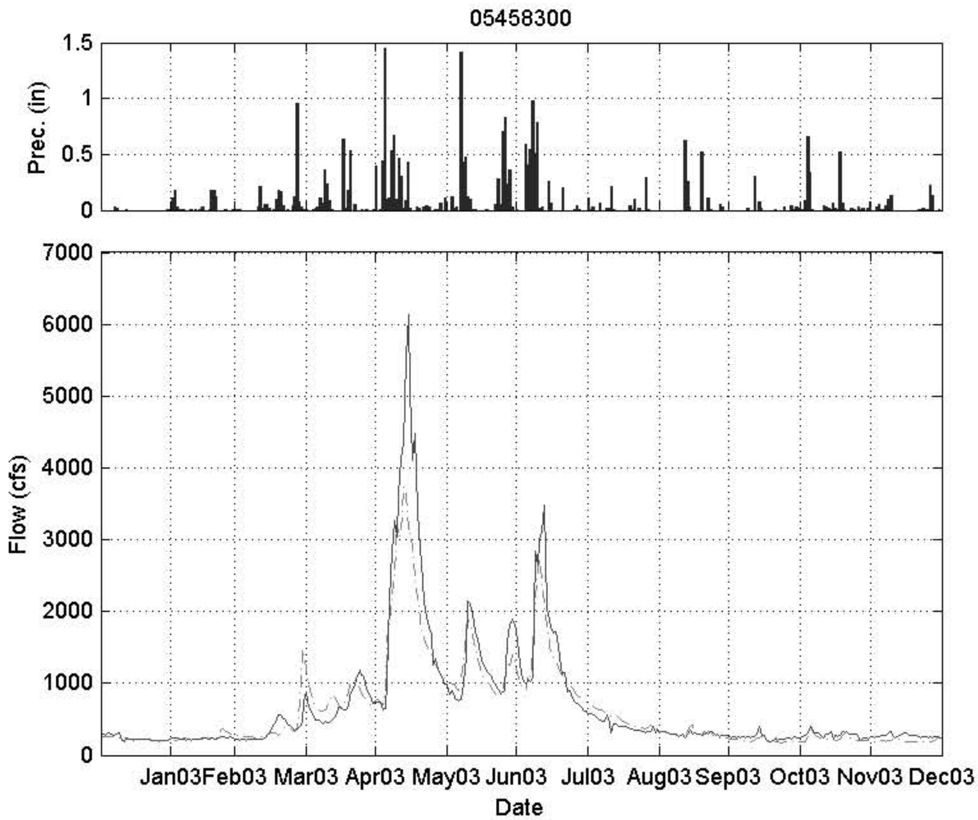

05458300
Prec. (in)
2
1
0
Flow (cfs)
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
-1000
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

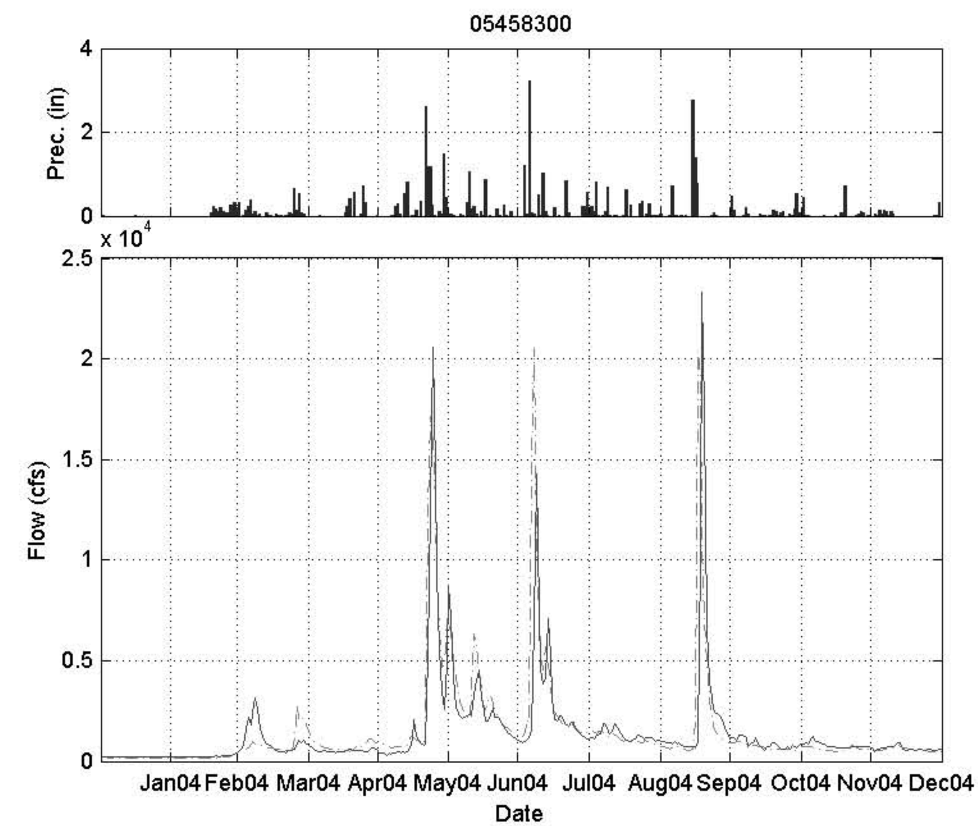

05458300
Prec. (in)
4
2
0
x 10^4
Flow (cfs)
4
3.5
3
2.5
2
1.5
1
0.5
0
-0.5
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

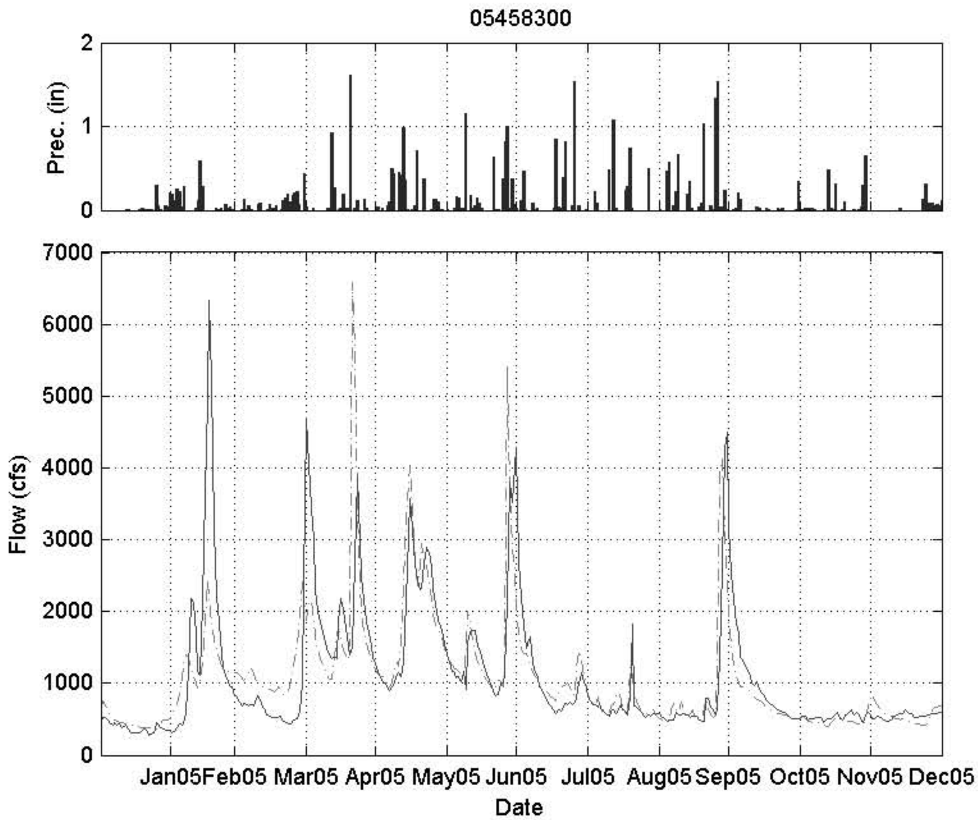

05458300
Prec. (in)
3
2
1
0
Flow (cfs)
16000
14000
12000
10000
8000
6000
4000
2000
0
-2000
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

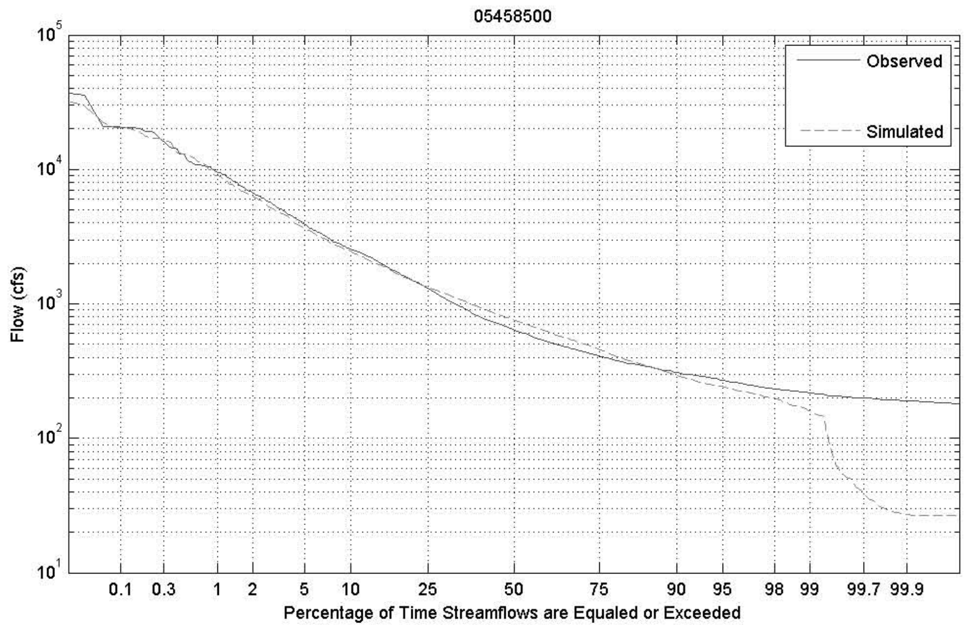

05458300
Prec. (in)
x 10^4
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

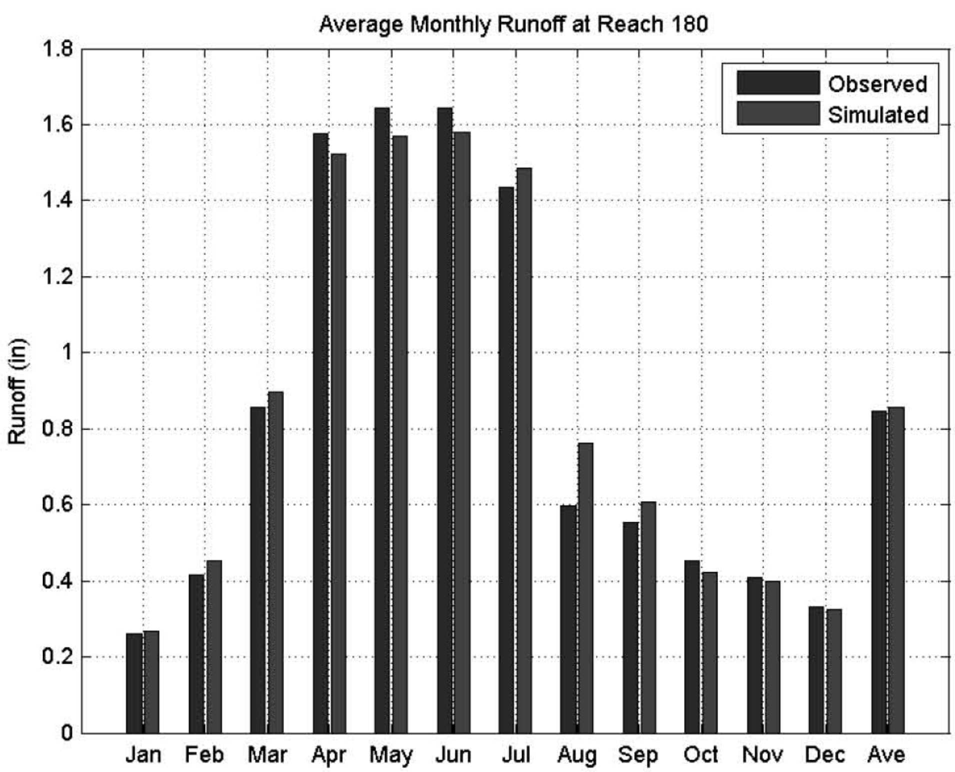

05458300
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

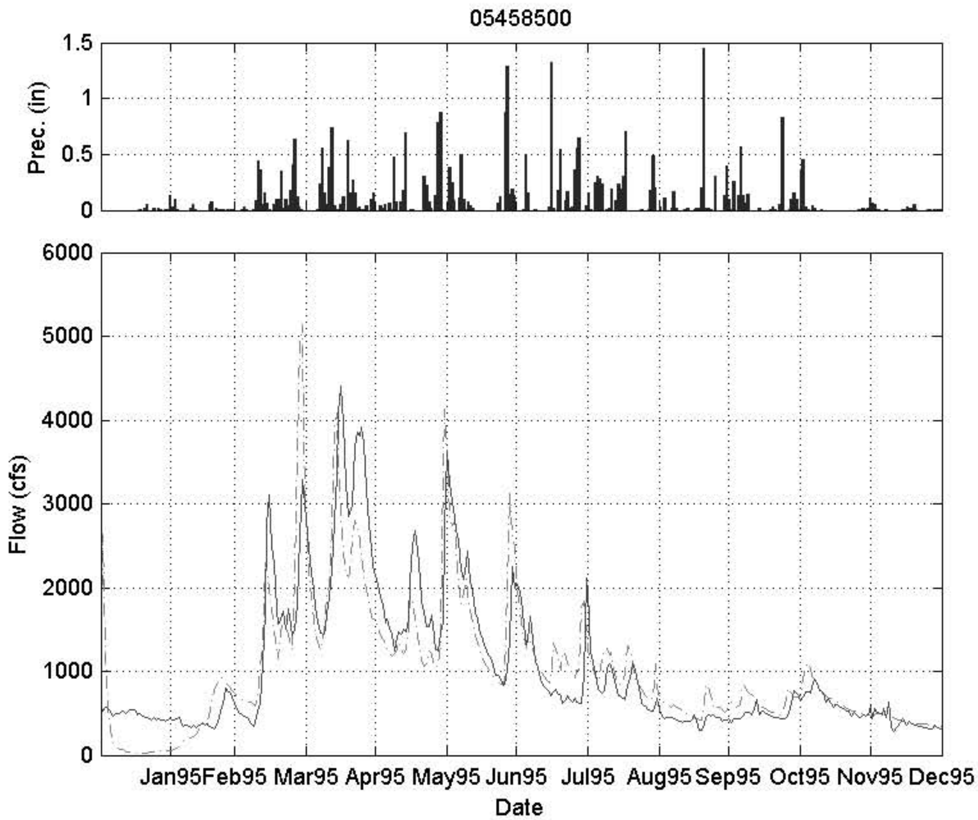

05458300
Prec. (in)
1.5
1
0.5
0
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

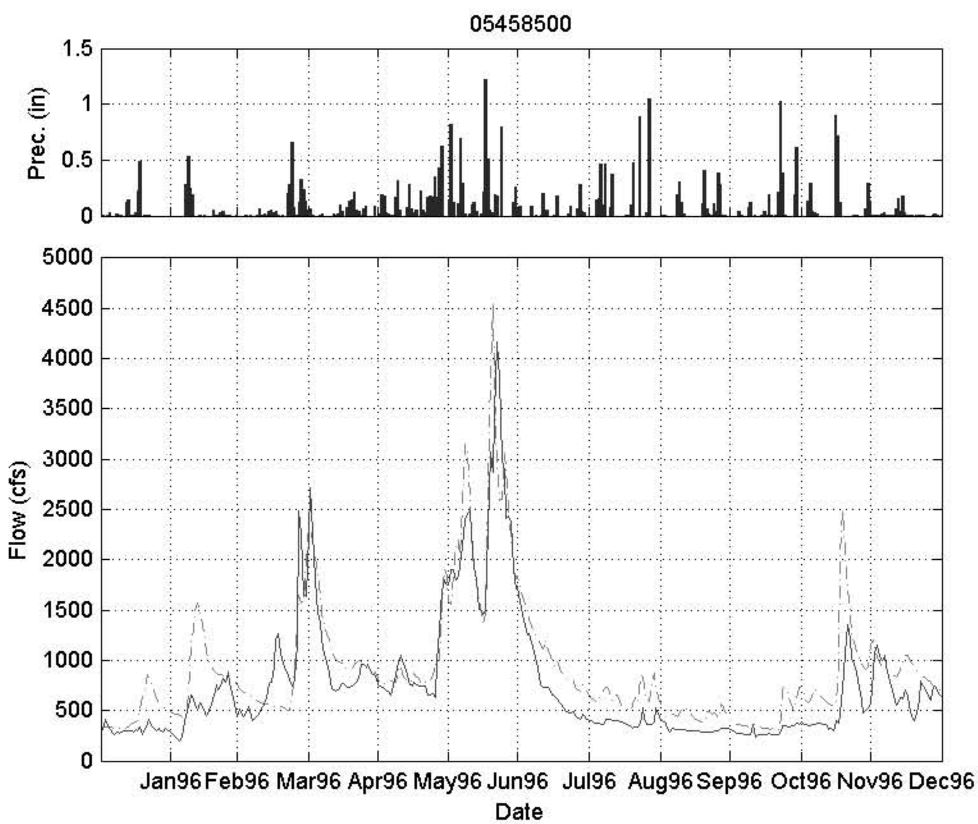

05458300
Prec. (in)
4
2
0
x 10^4
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

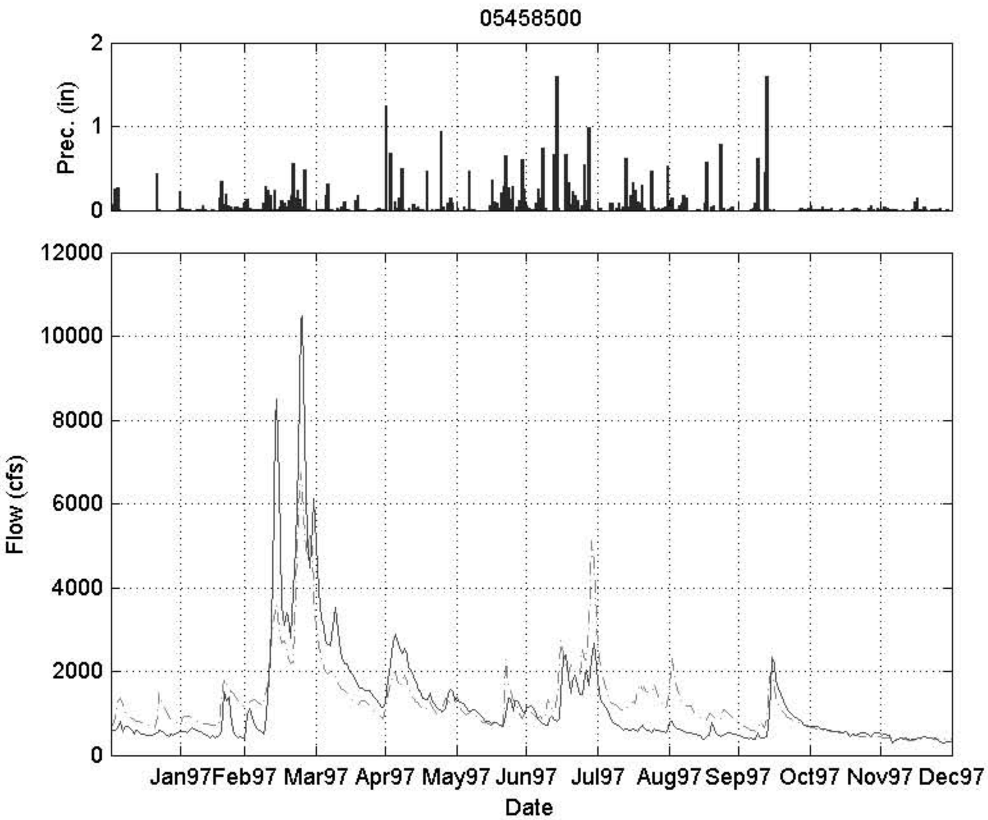

05458300
Prec. (in)
2
1
0
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

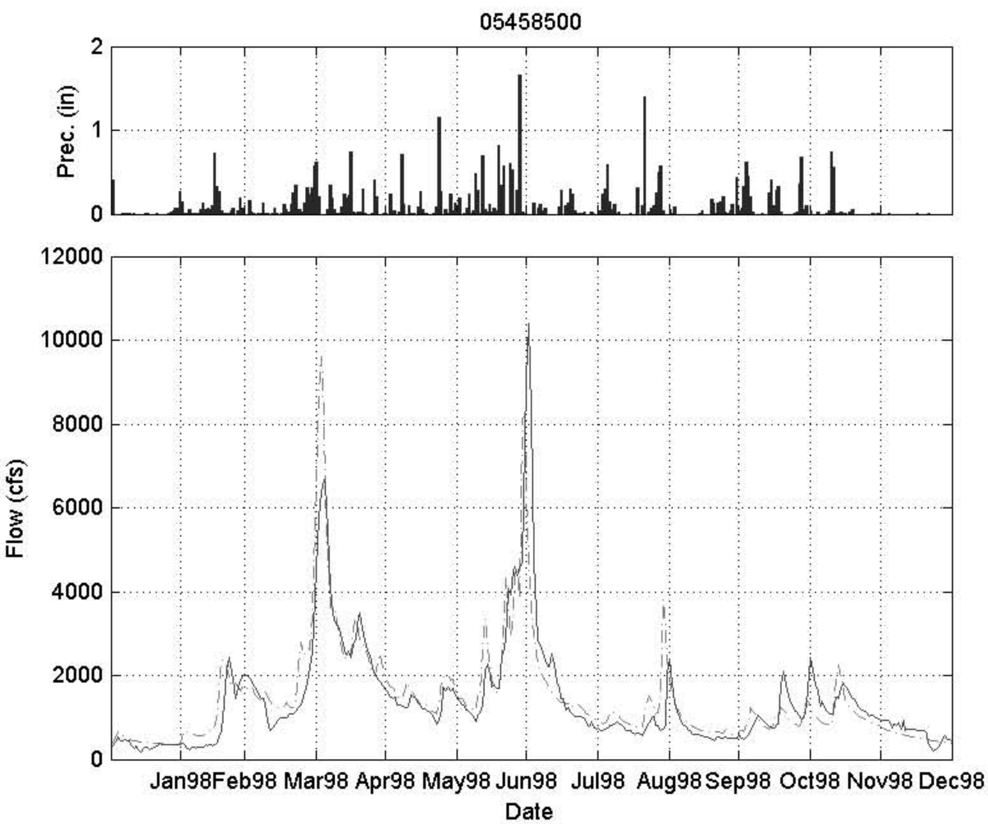

05458500
Observed
Simulated
Flow (cfs)
10^5
10^4
10^3
10^2
10^1
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

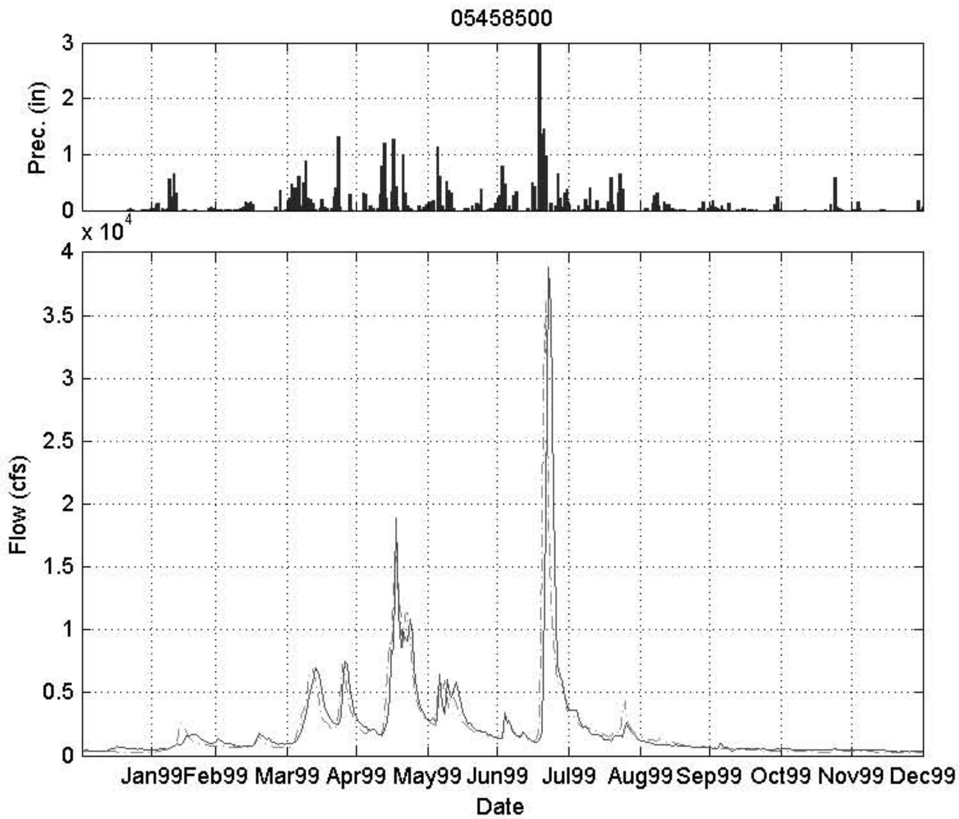

Average Monthly Runoff at Reach 180
Observed
Simulated
Runoff (in)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

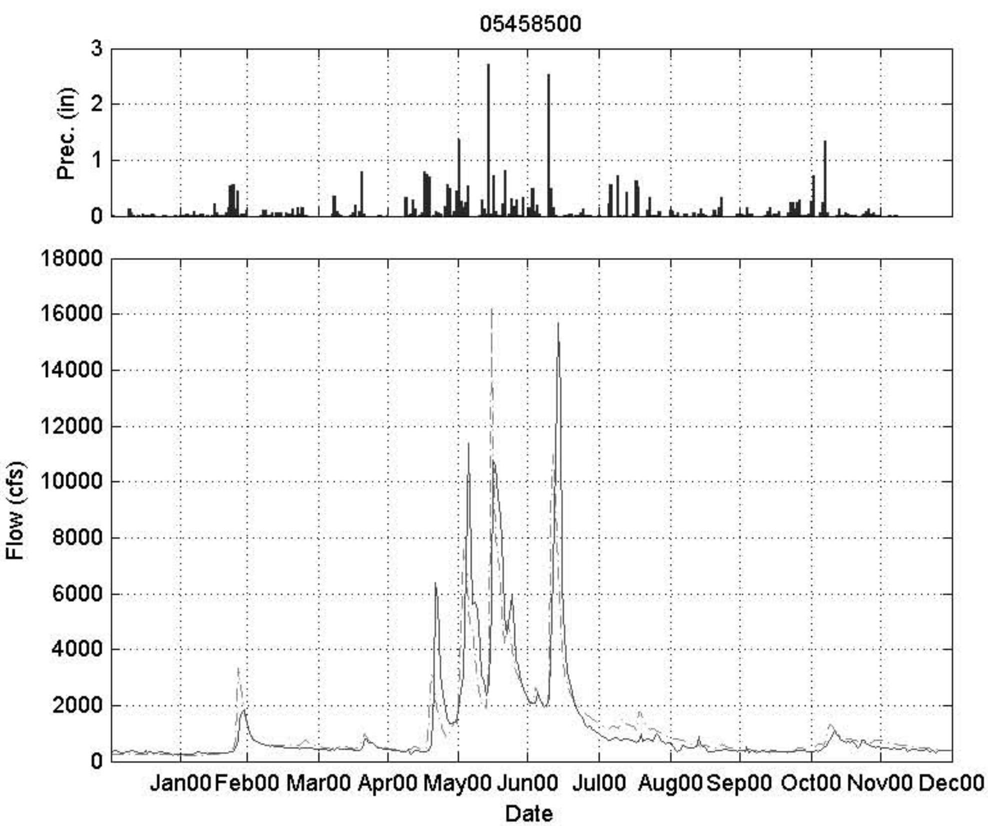

05458500
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
6000
5000
4000
3000
2000
1000
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

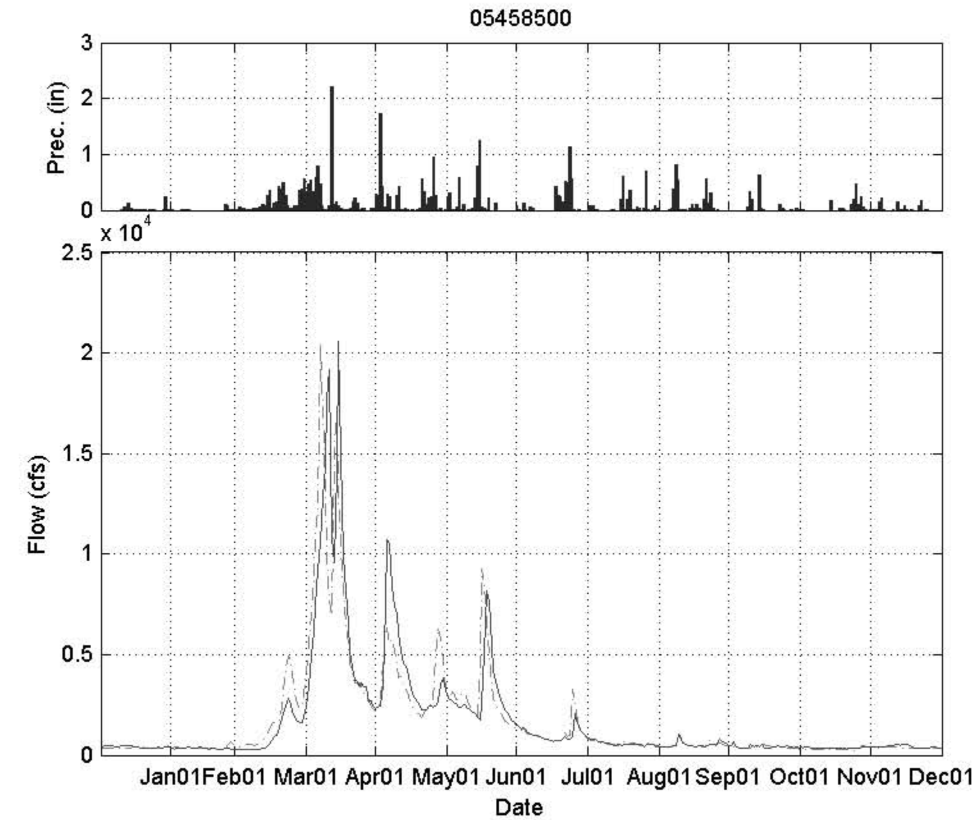

05458500
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

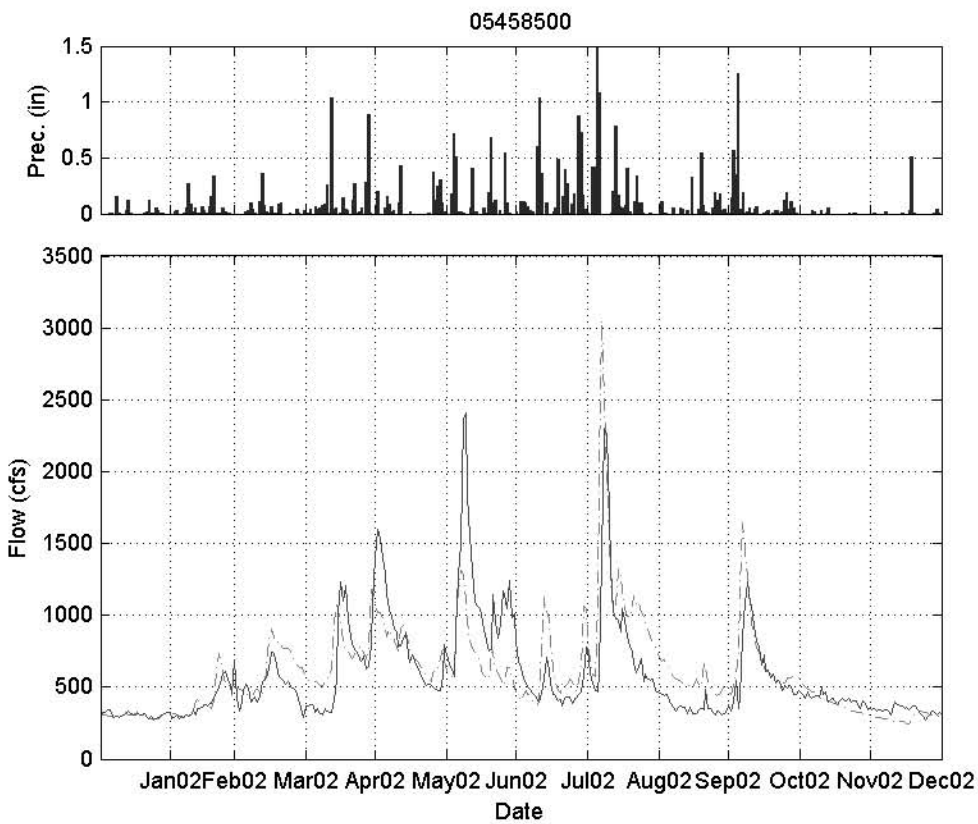

05458500
Prec. (in)
2
1
0
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

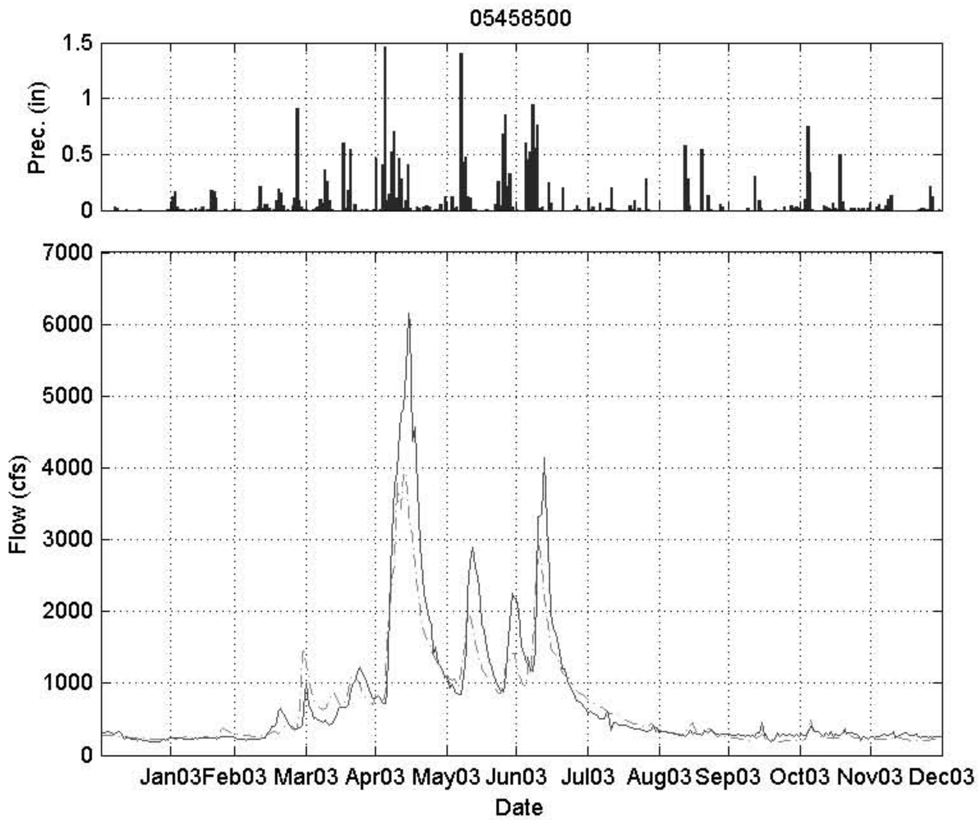

05458500
Prec. (in)
2
1
0
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

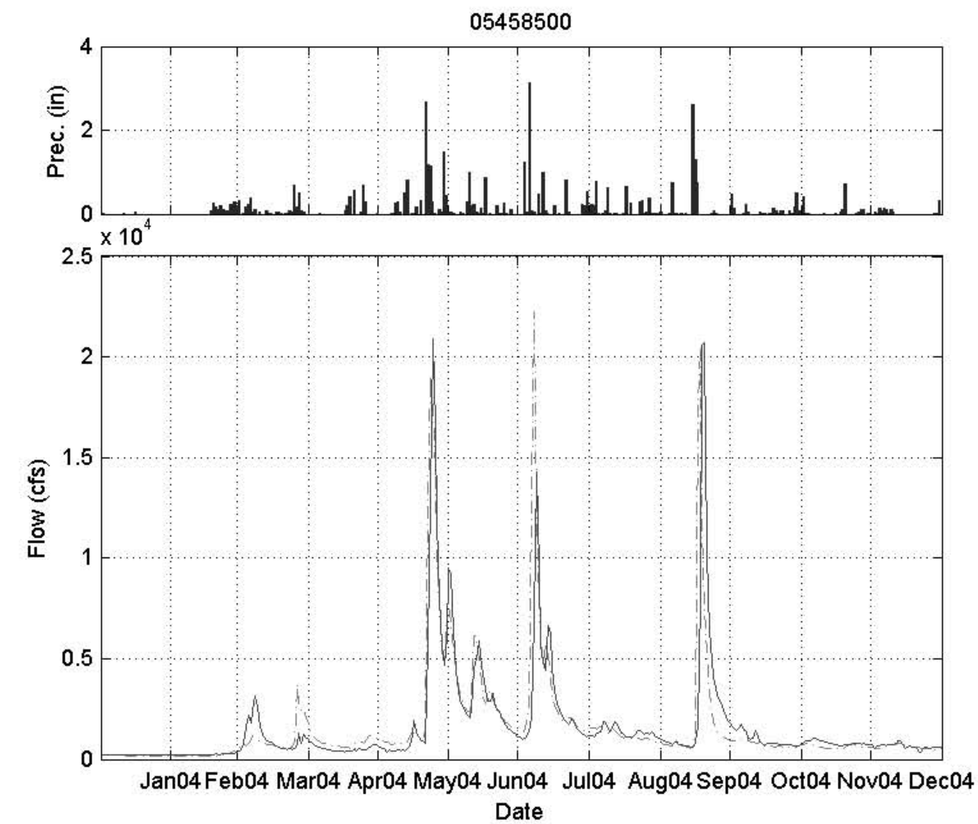

05458500
Prec. (in)
Flow (cfs)
x 10^4
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

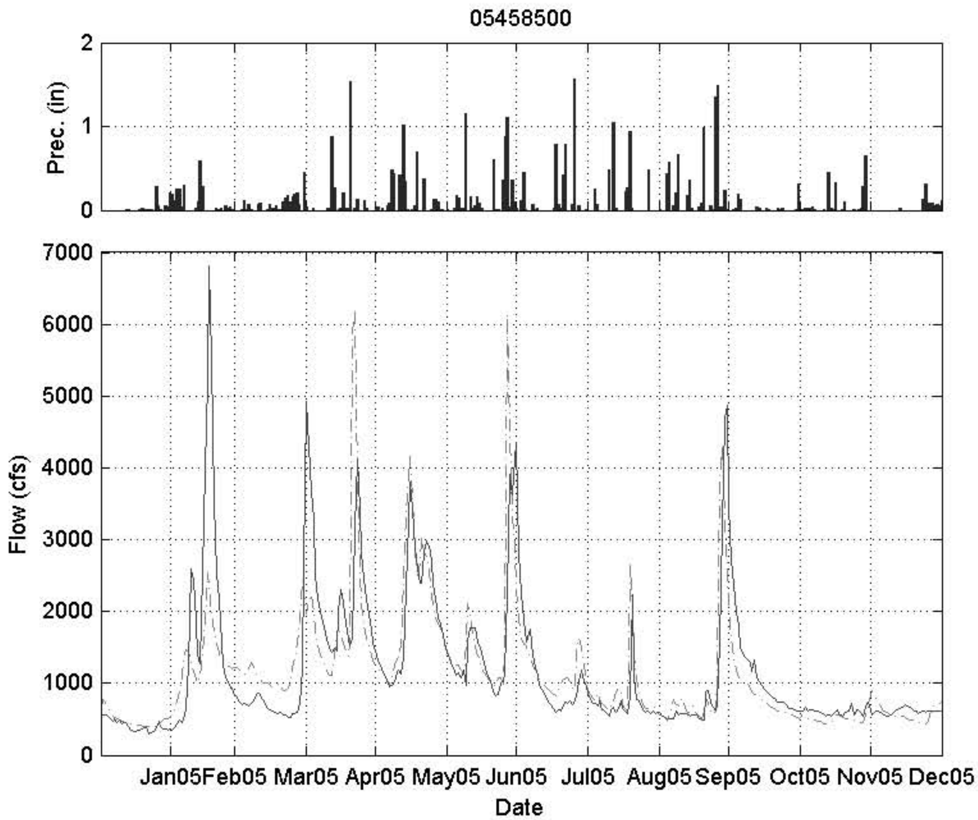

05458500
Prec. (in)
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

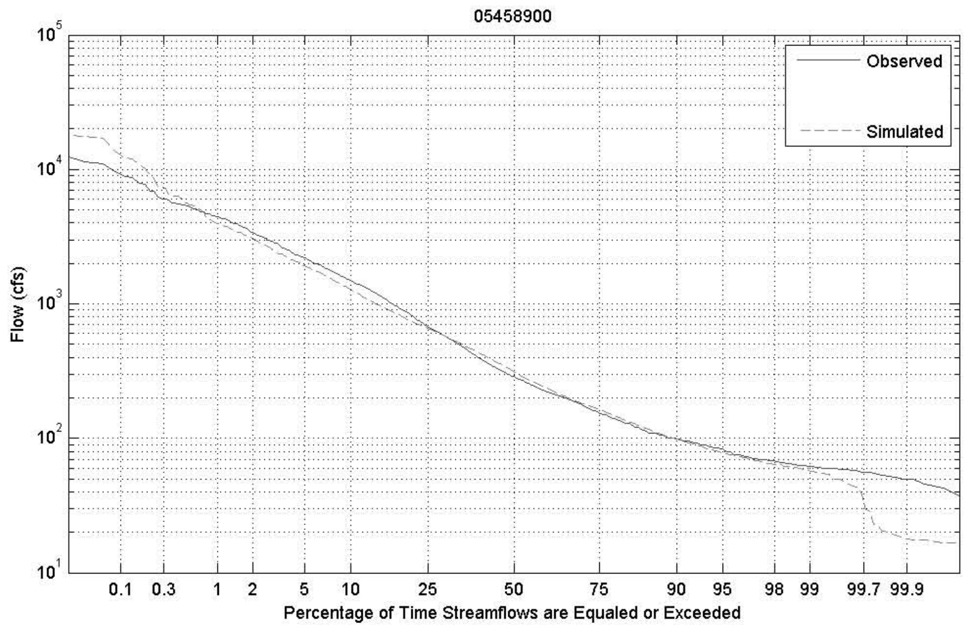

05458500
Prec. (in)
x 10^4
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

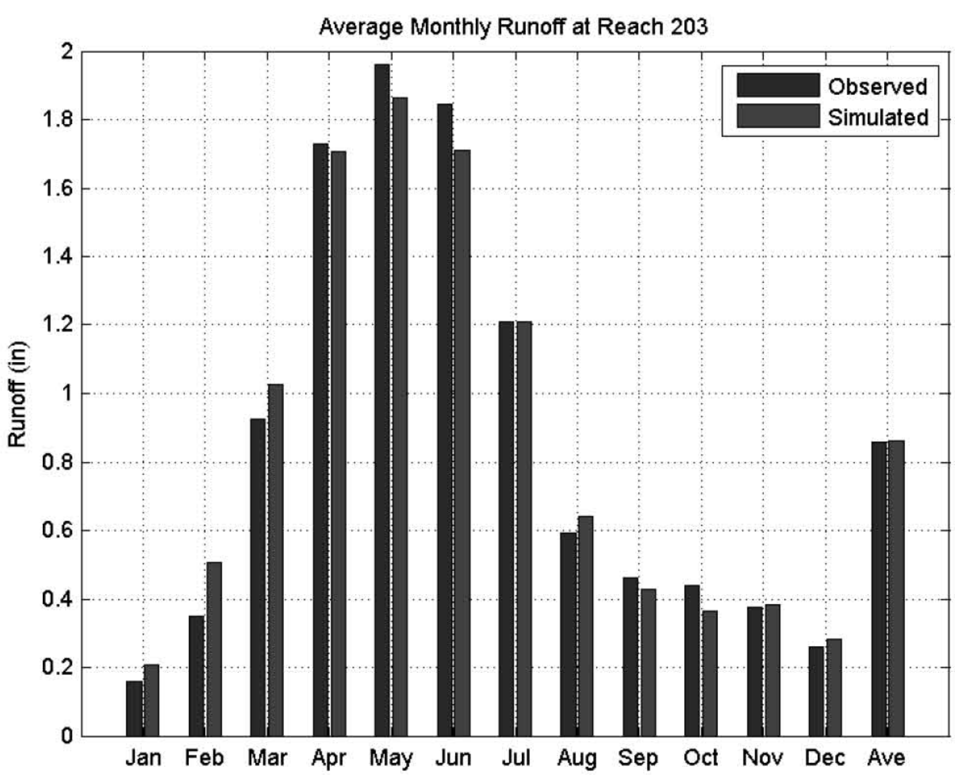

05458500
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

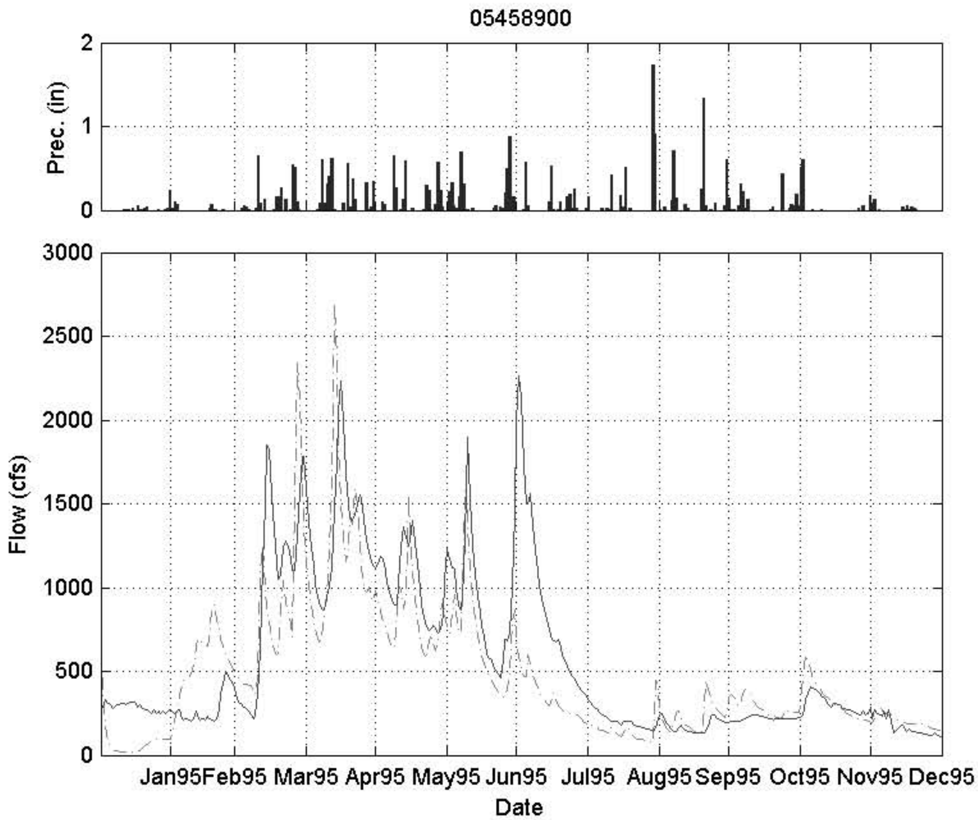

05458500
Prec. (in)
1.5
1
0.5
0
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

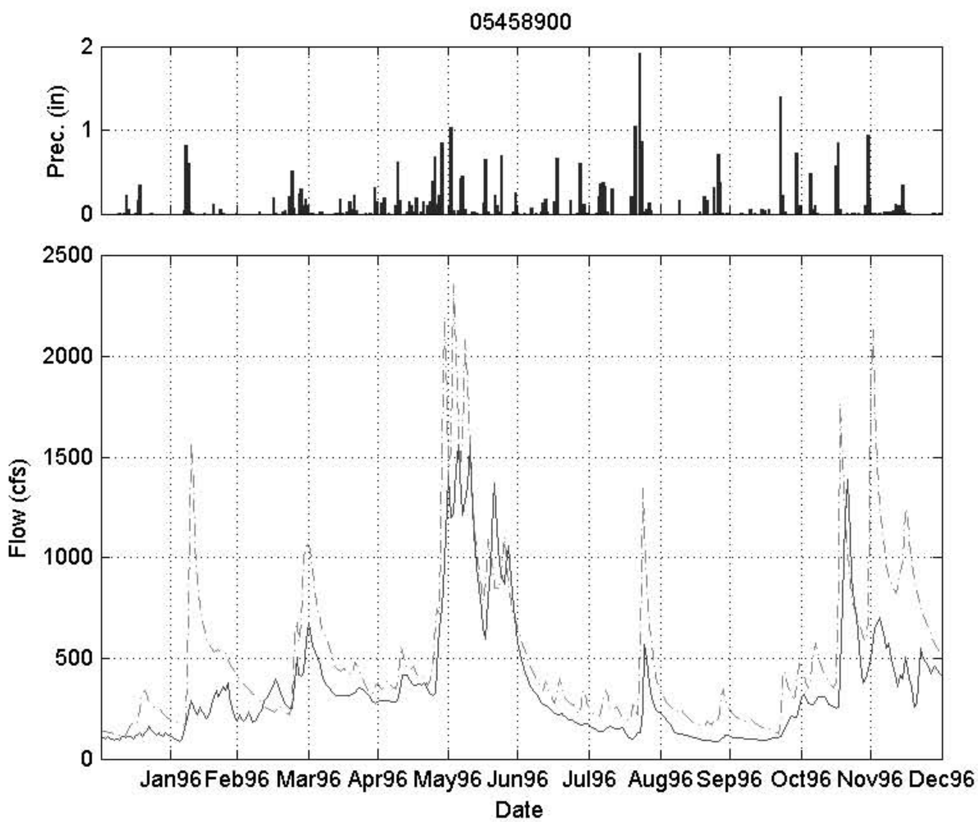

05458500
Prec. (in)
4
2
0
x 10^4
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

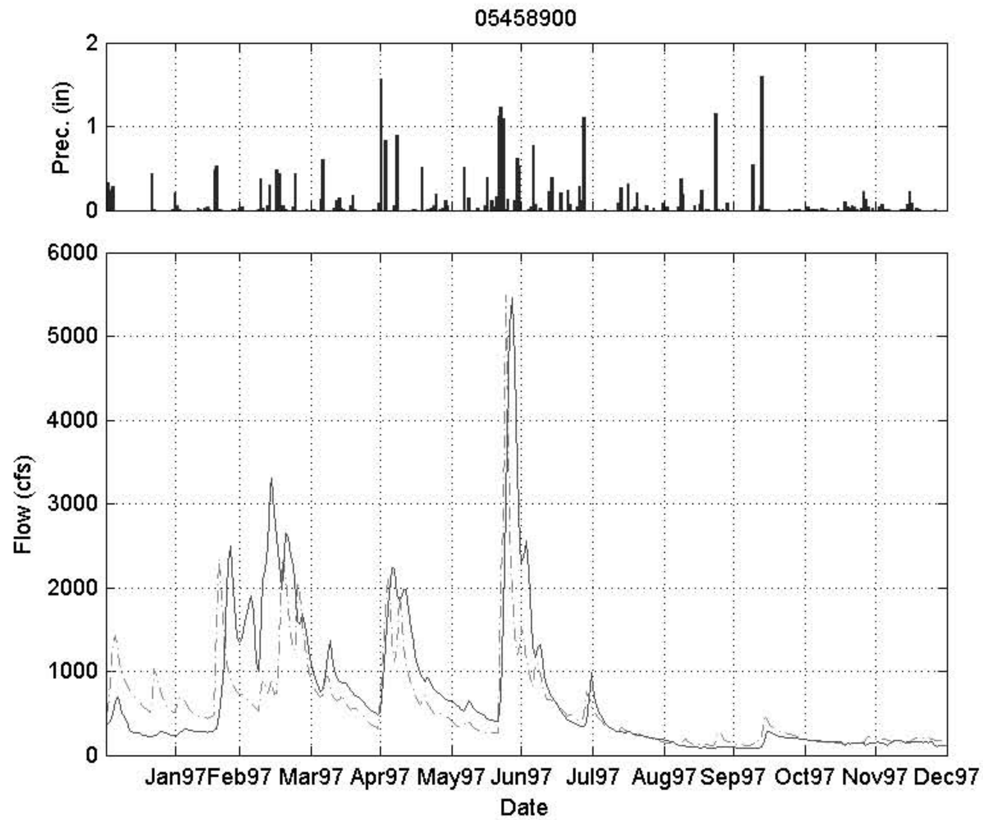

05458500
Prec. (in)
2
1
0
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

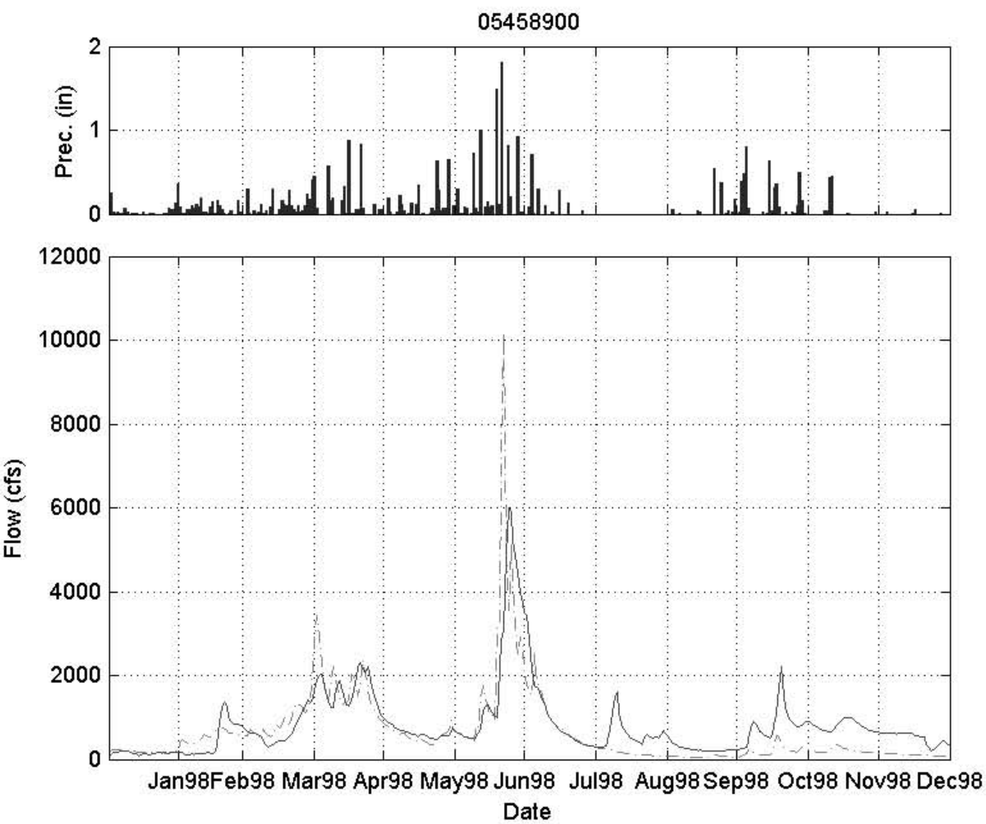

05458900
Observed
Simulated
Flow (cfs)
Percentage of Time Streamflows are Equaled or Exceeded

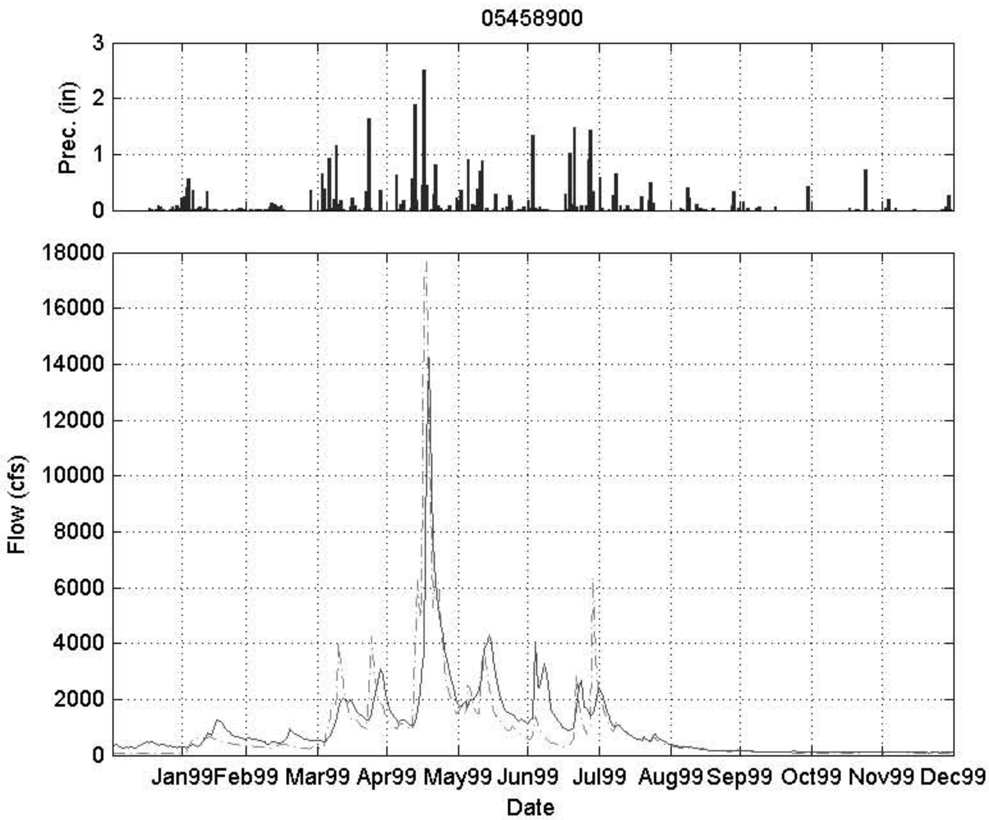

Average Monthly Runoff at Reach 203
Observed
Simulated
Runoff (in)
Jan
Feb
Mar
Apr
May
Jun
Jul
Aug
Sep
Oct
Nov
Dec
Ave

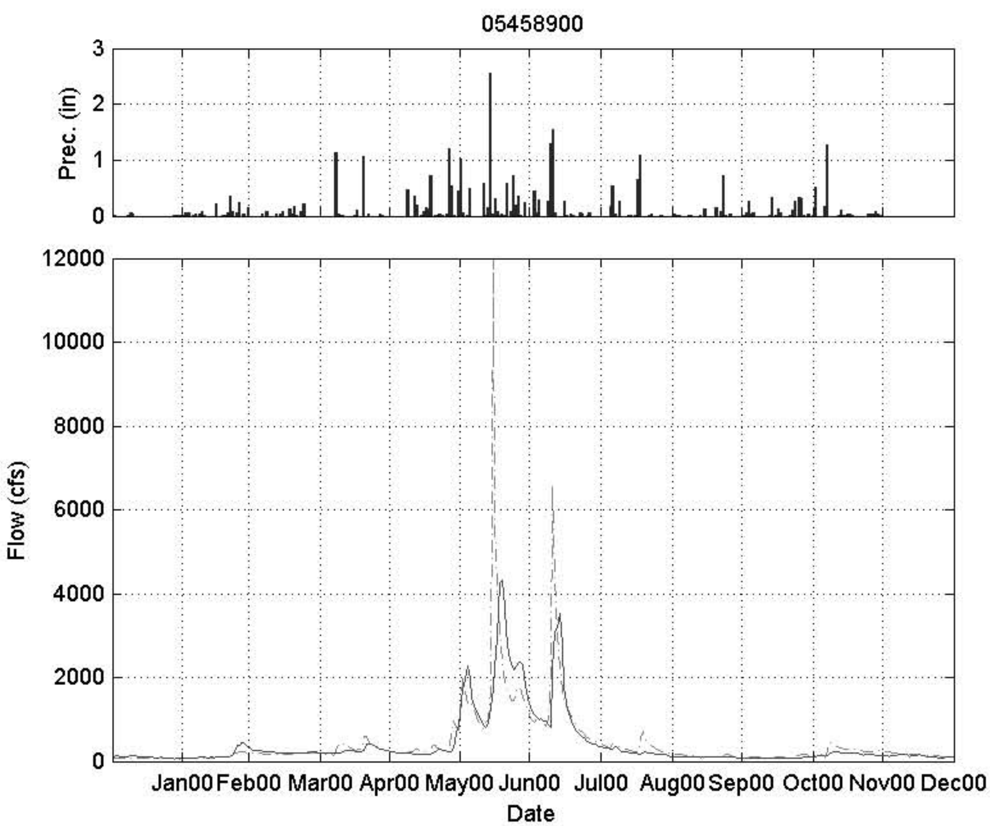

05458900
Prec. (in)
2
1
0
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

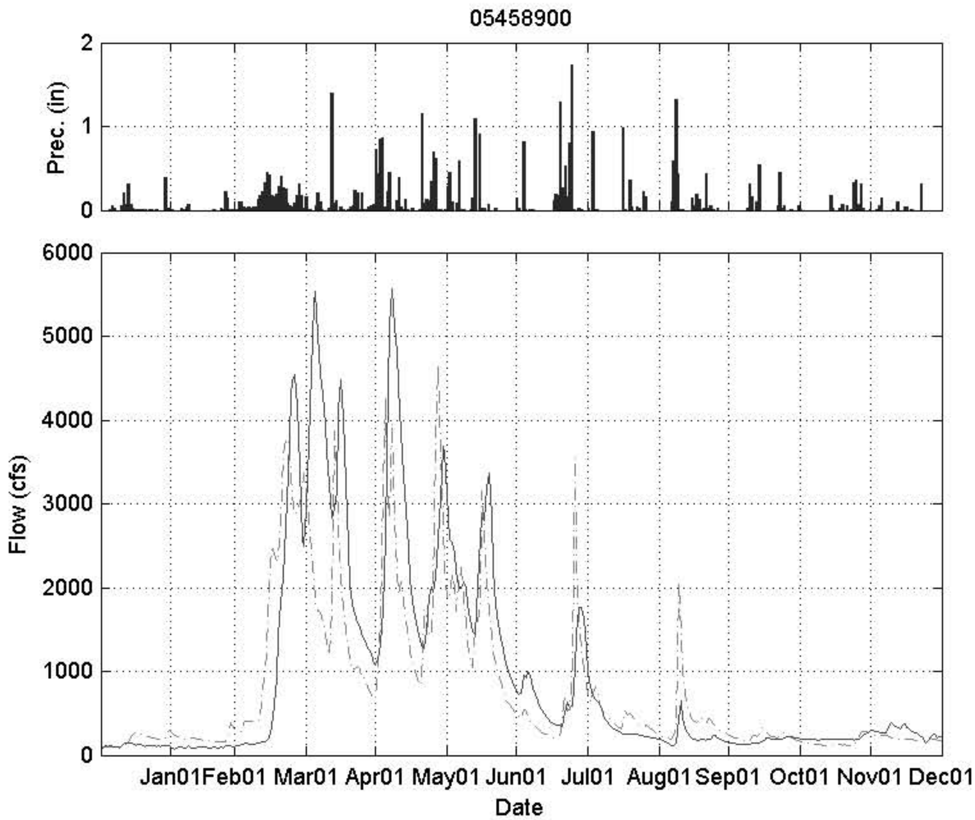

05458900
Prec. (in)
2
1
0
Flow (cfs)
2500
2000
1500
1000
500
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

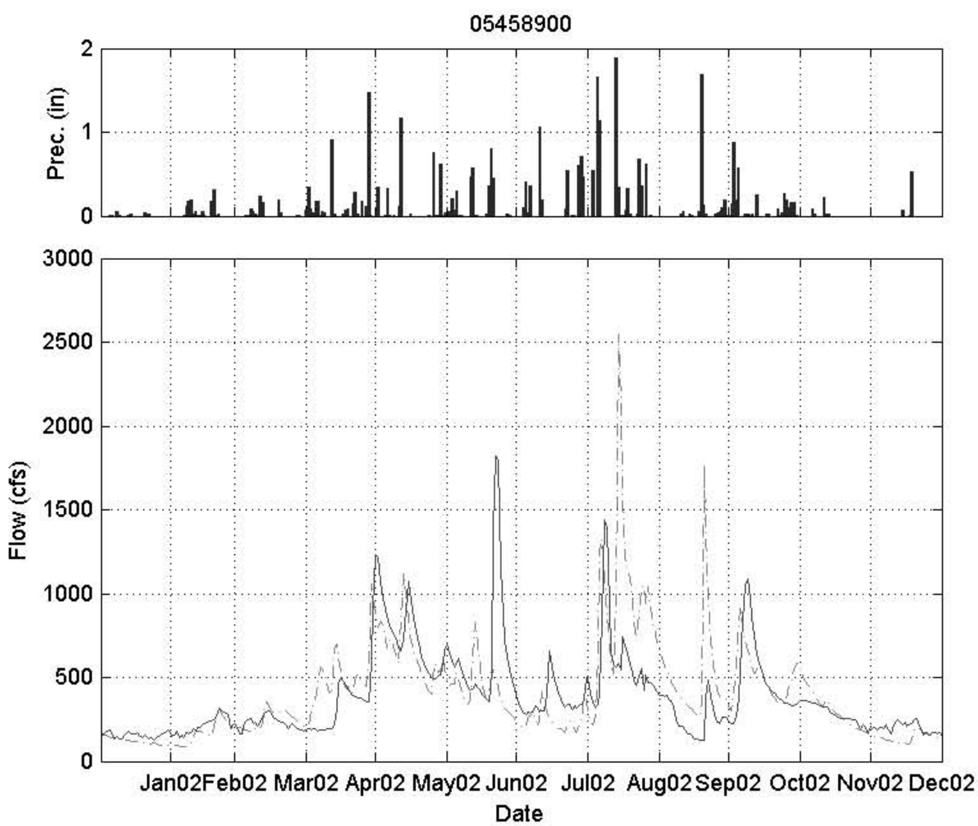

05458900
Prec. (in)
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

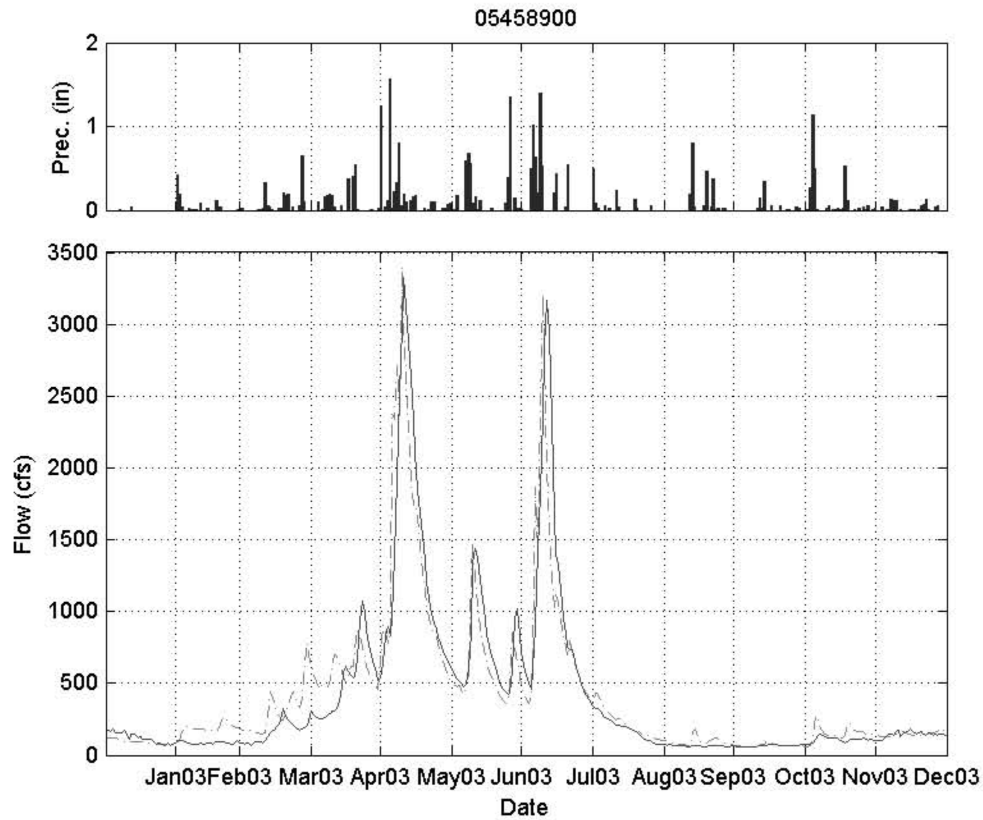

05458900
Prec. (in)
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

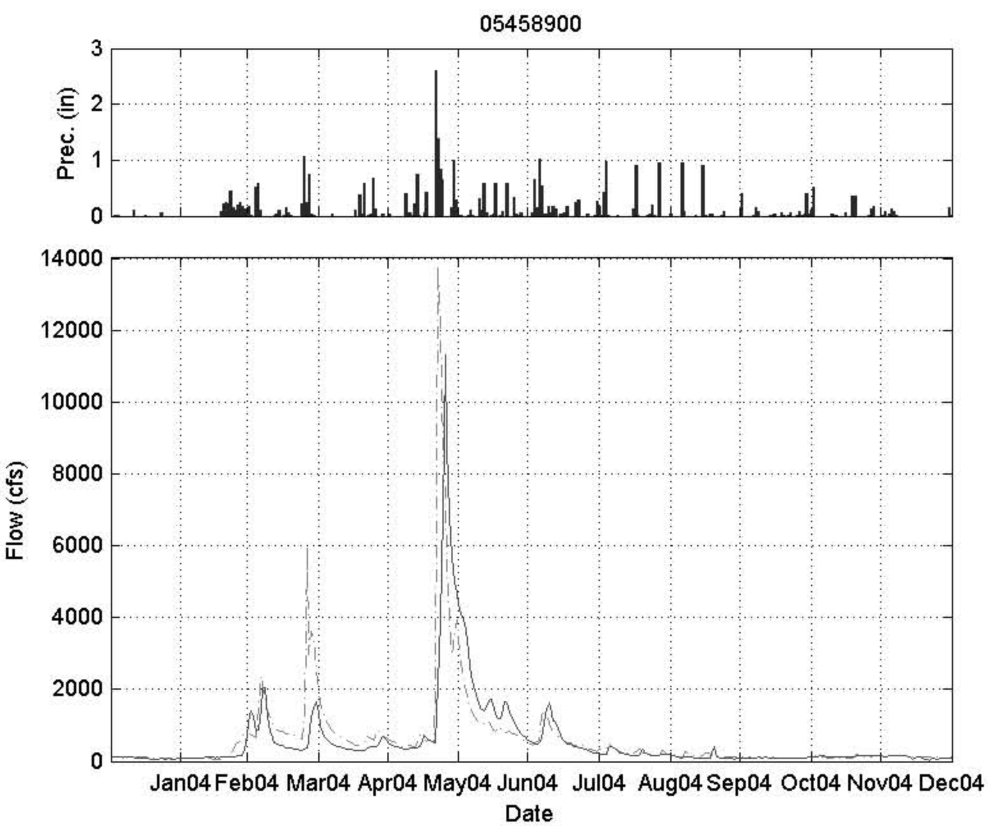

05458900
Prec. (in)
3
2
1
0
Flow (cfs)
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

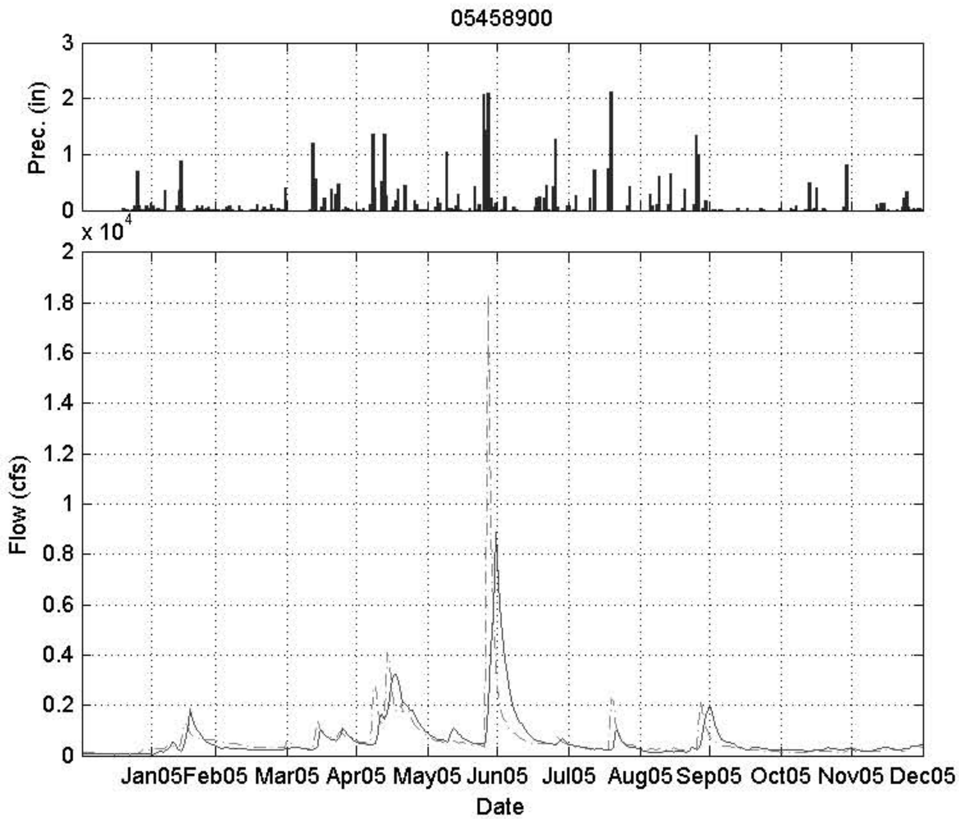

05458900
Prec. (in)
3
2
1
0
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

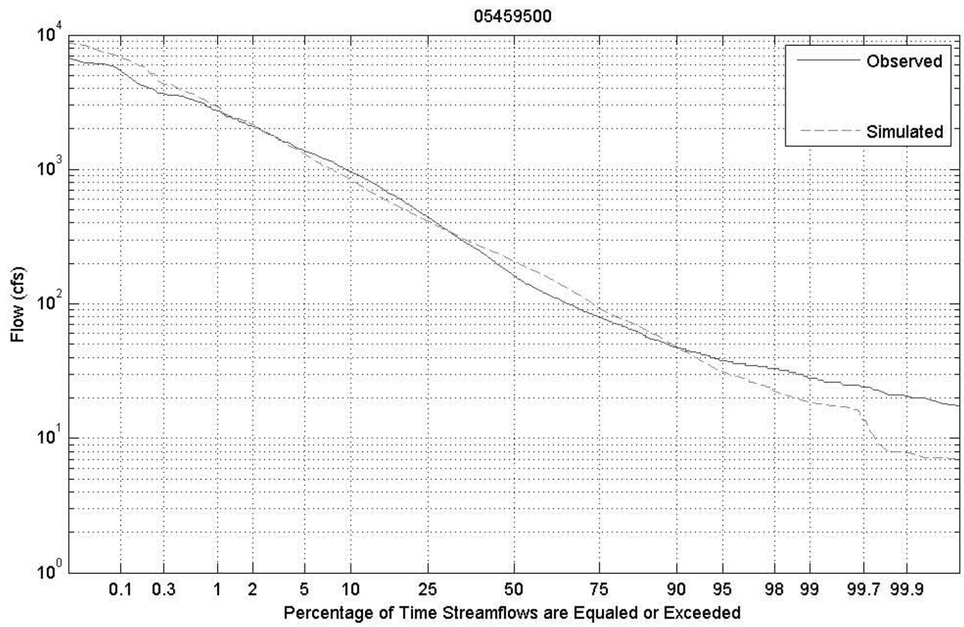

05458900
Prec. (in)
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

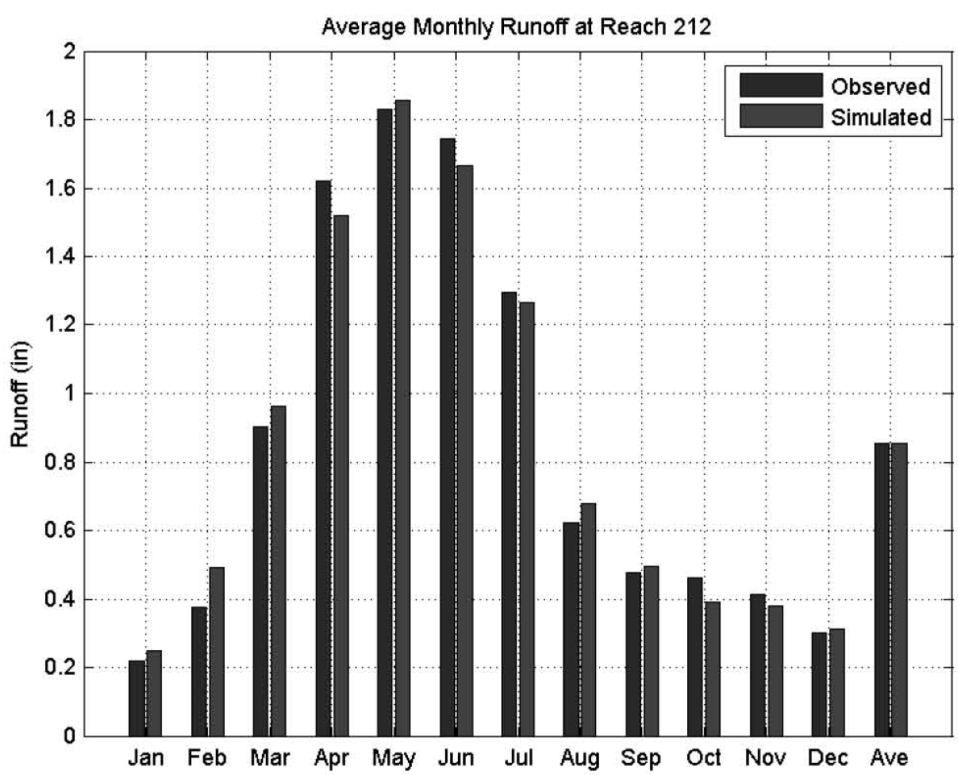

05458900
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

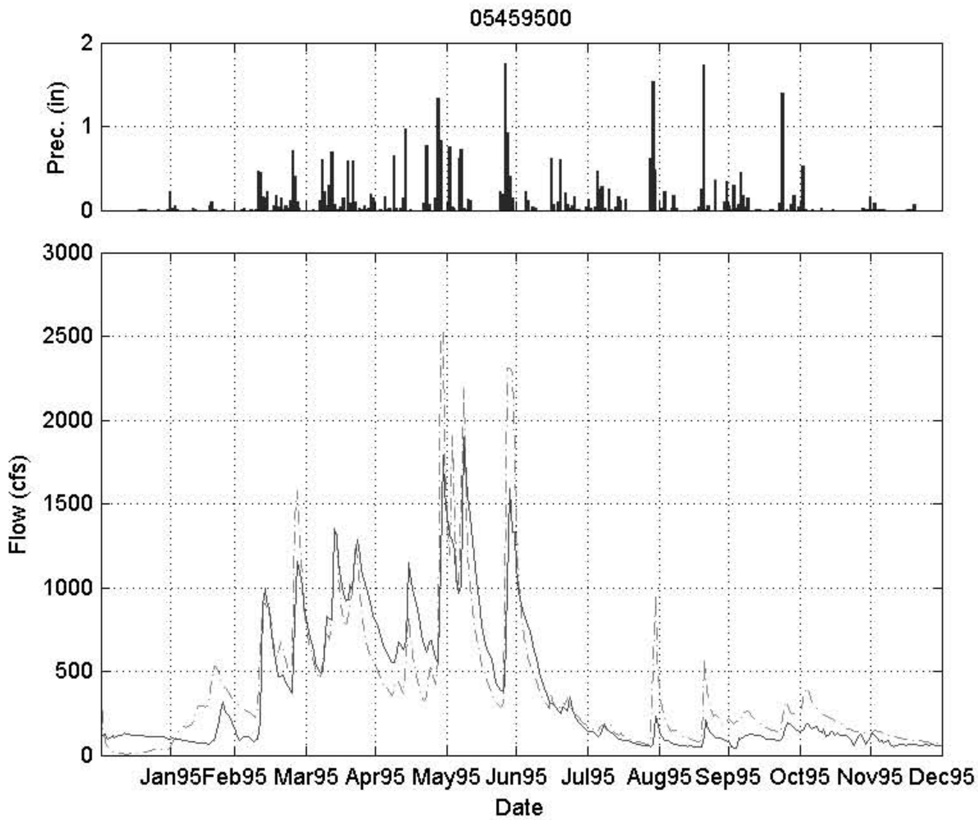

05458900
Prec. (in)
0
1
2
Flow (cfs)
0
500
1000
1500
2000
2500
3000
3500
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

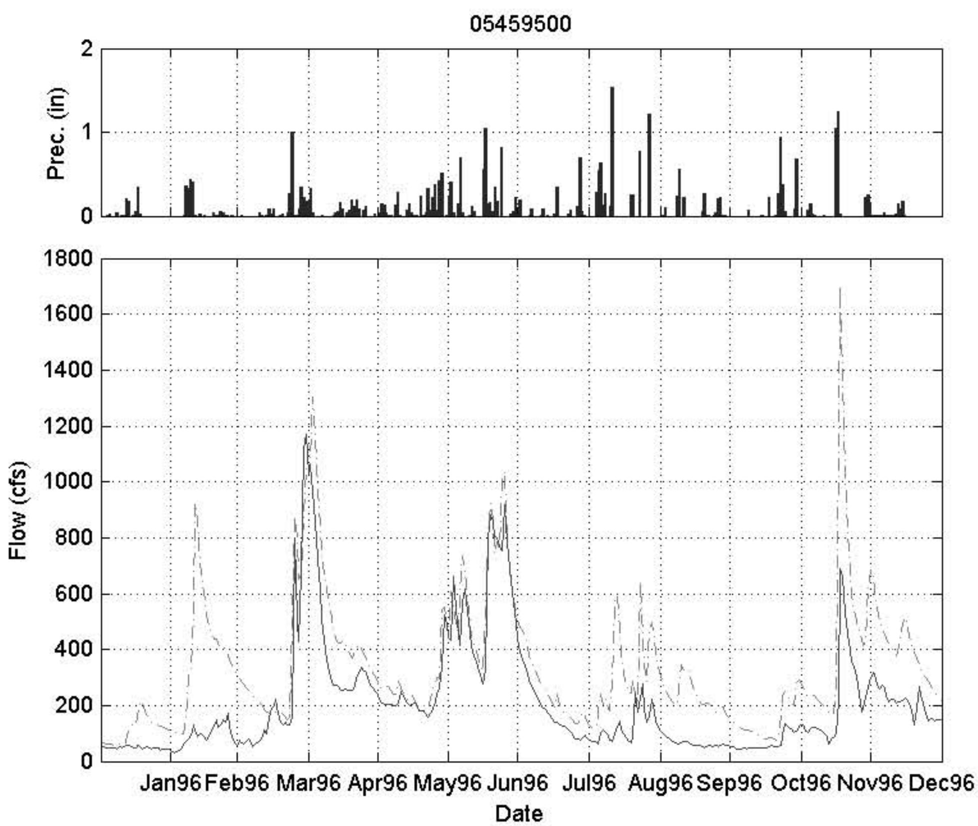

05458900
Prec. (in)
0
1
2
3
Flow (cfs)
0
2000
4000
6000
8000
10000
12000
14000
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

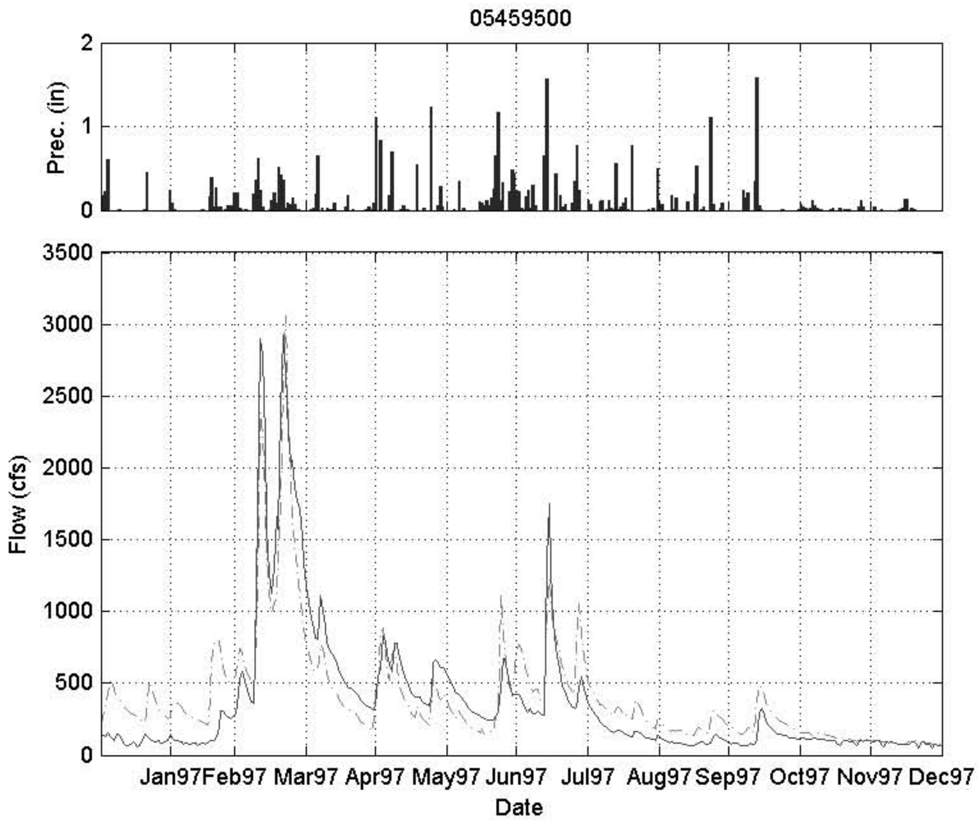

05458900
Prec. (in)
Flow (cfs)
x 10^4
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

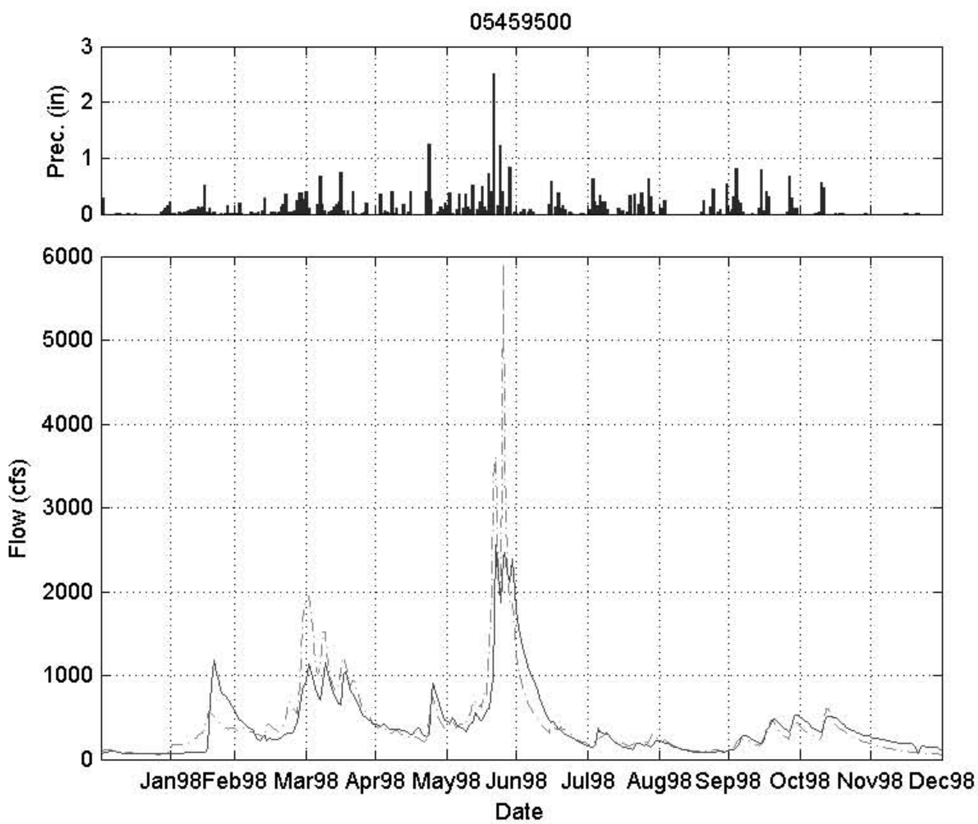

05459500
Observed
Simulated
Flow (cfs)
10^4
10^3
10^2
10^1
10^0
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

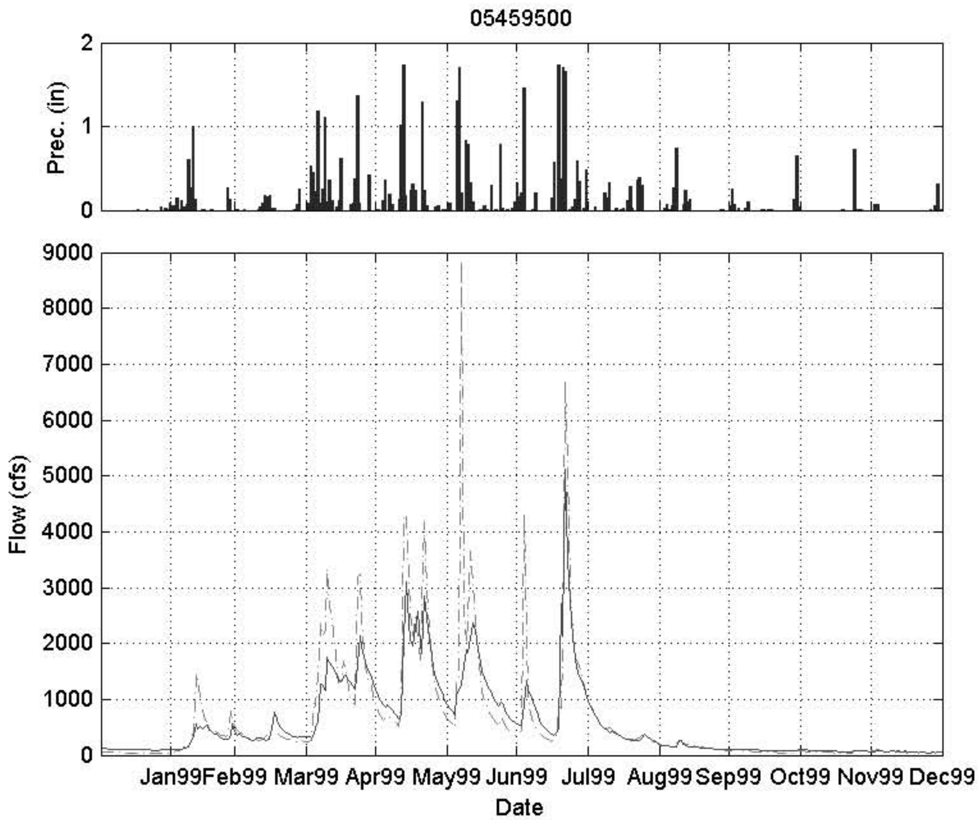

Average Monthly Runoff at Reach 212
Observed
Simulated
Runoff (in)
0 0.2 0.4 0.6 0.8 1 1.2 1.4 1.6 1.8 2
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

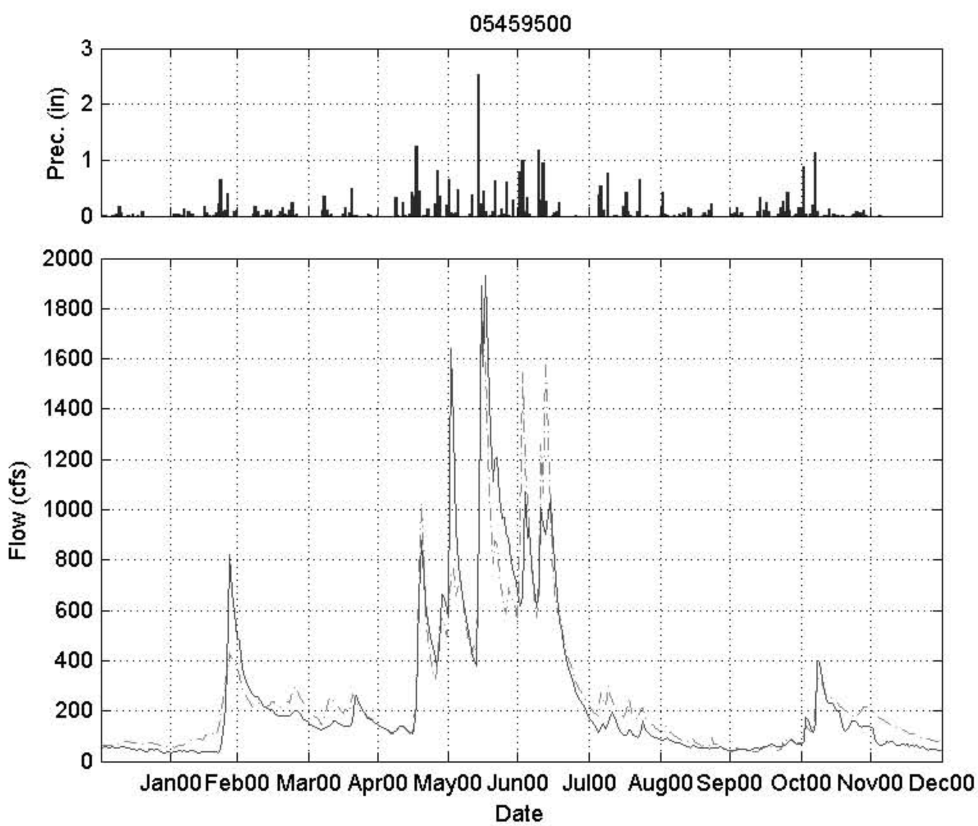

05459500
Prec. (in)
Flow (cfs)
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

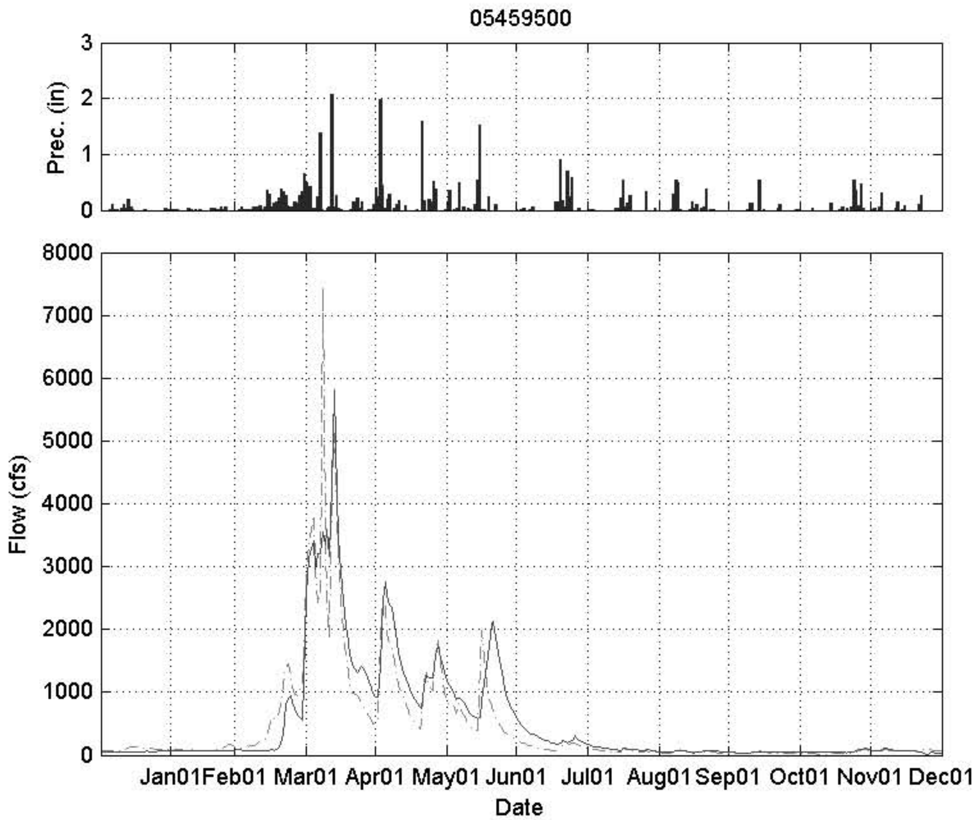

05459500
Prec. (in)
Flow (cfs)
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

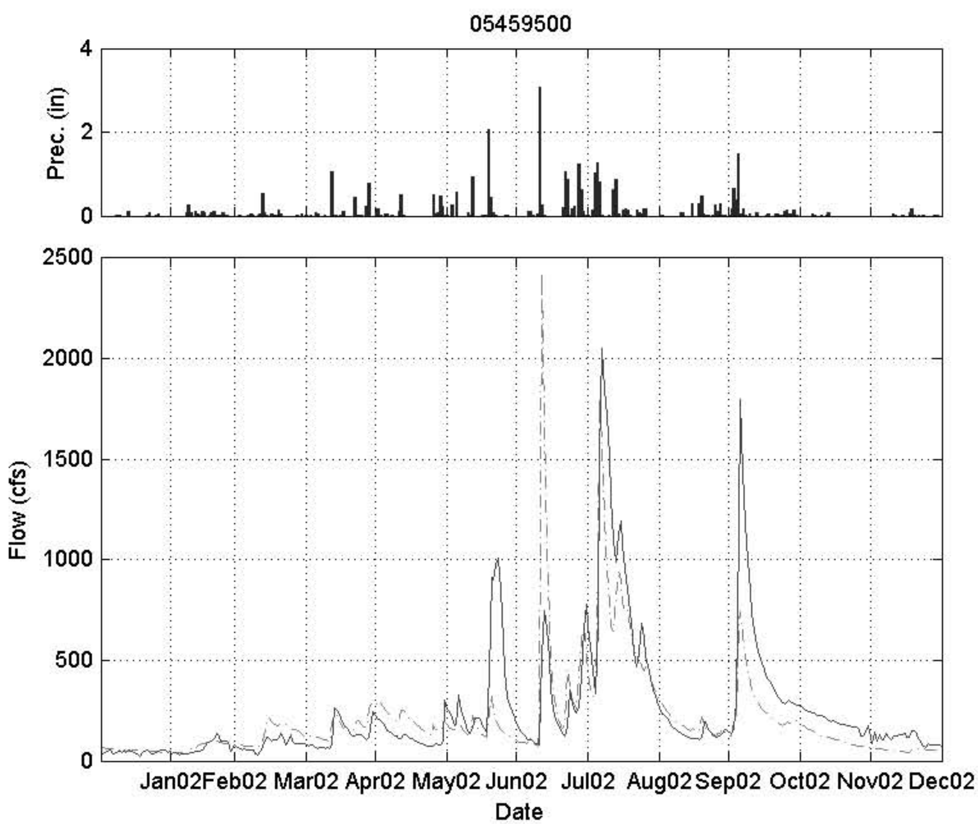

05459500
Prec. (in)
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

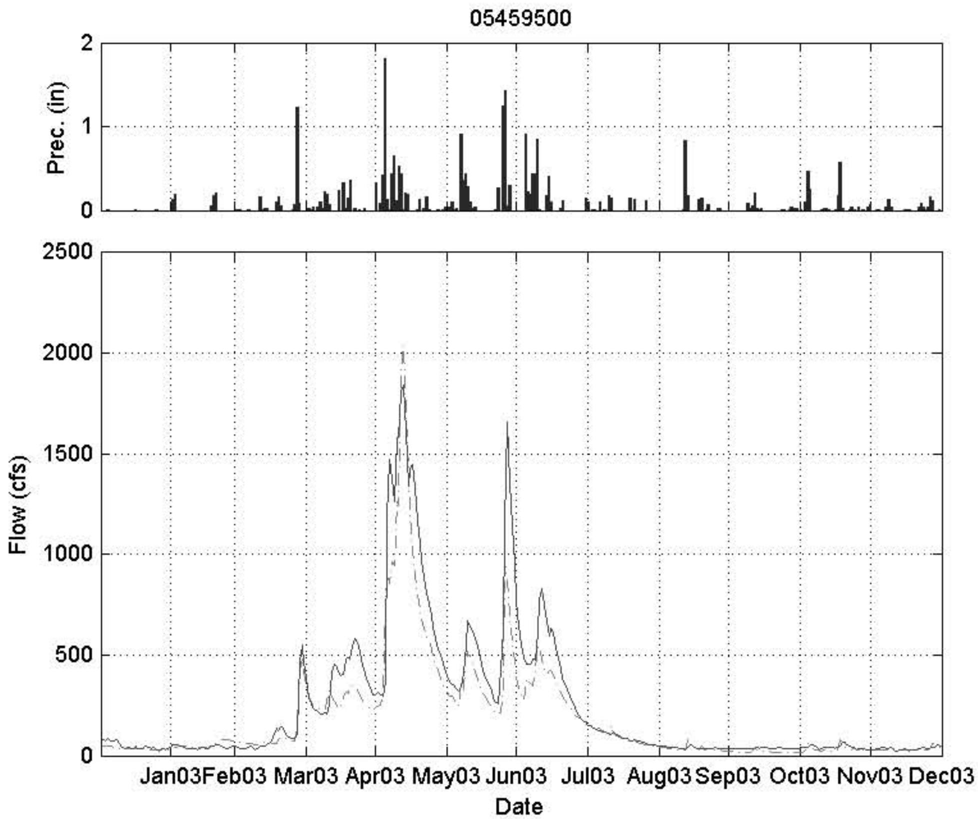

05459500
Prec. (in)
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

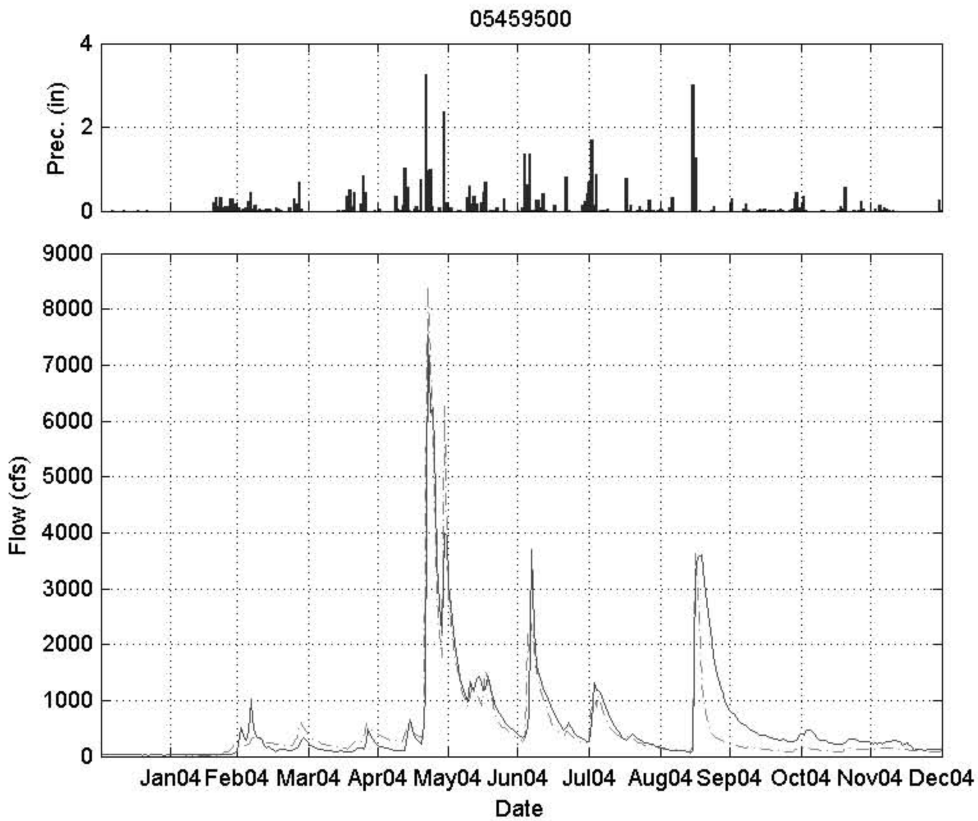

05459500
Prec. (in)
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

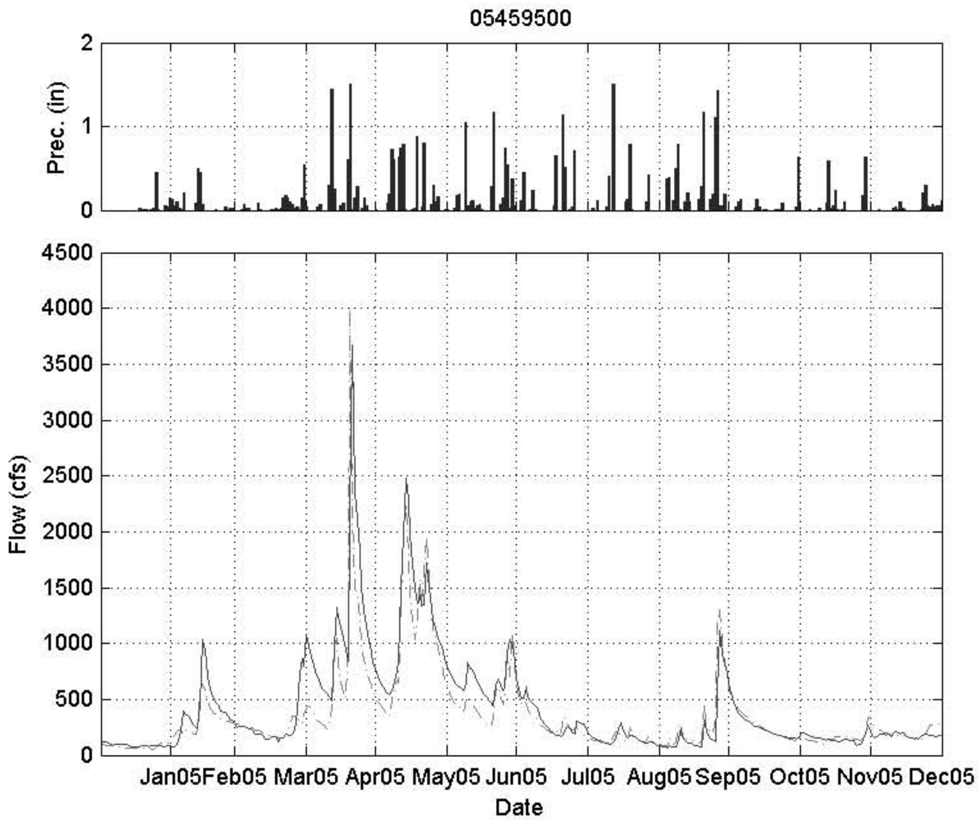

05459500
Prec. (in)
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

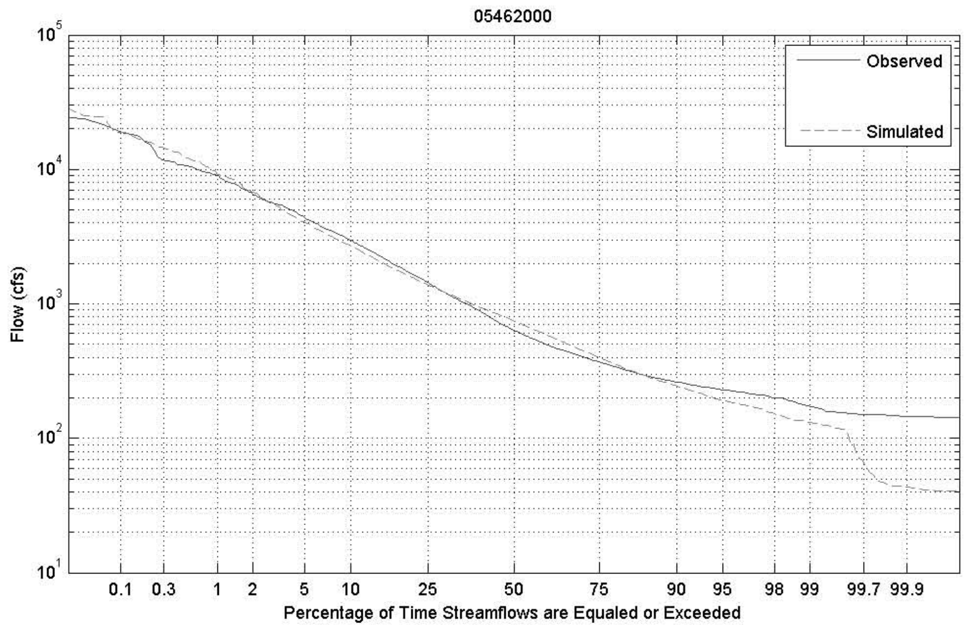

05459500
Prec. (in)
3
2
1
0
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

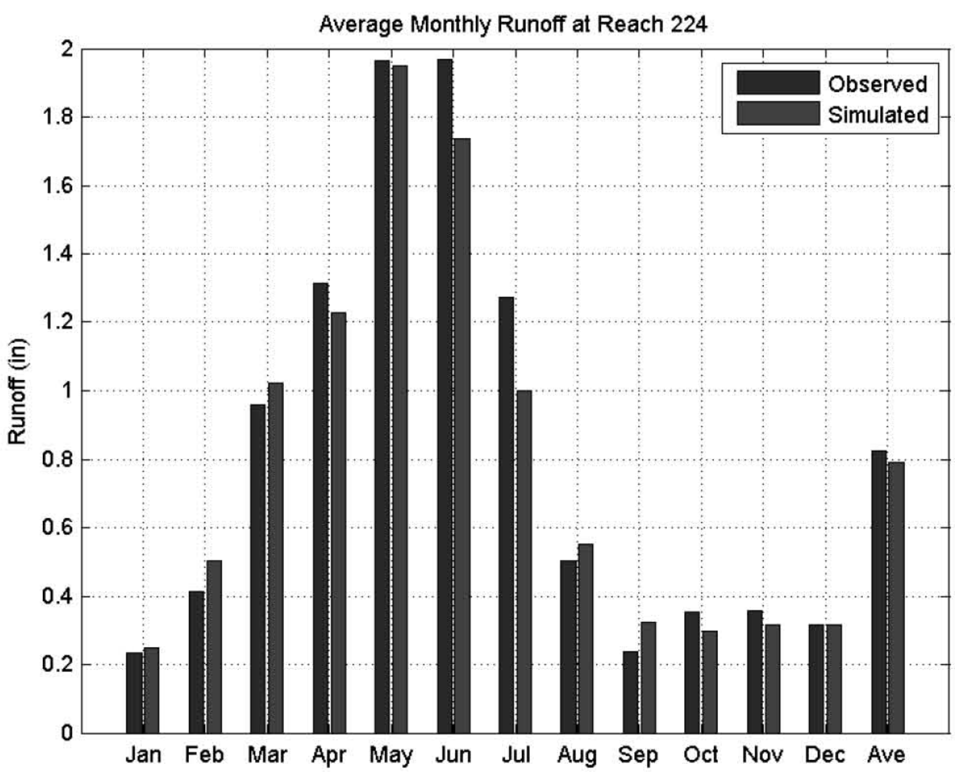

05459500
Prec. (in)
4
2
0
Flow (cfs)
2500
2000
1500
1000
500
0
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

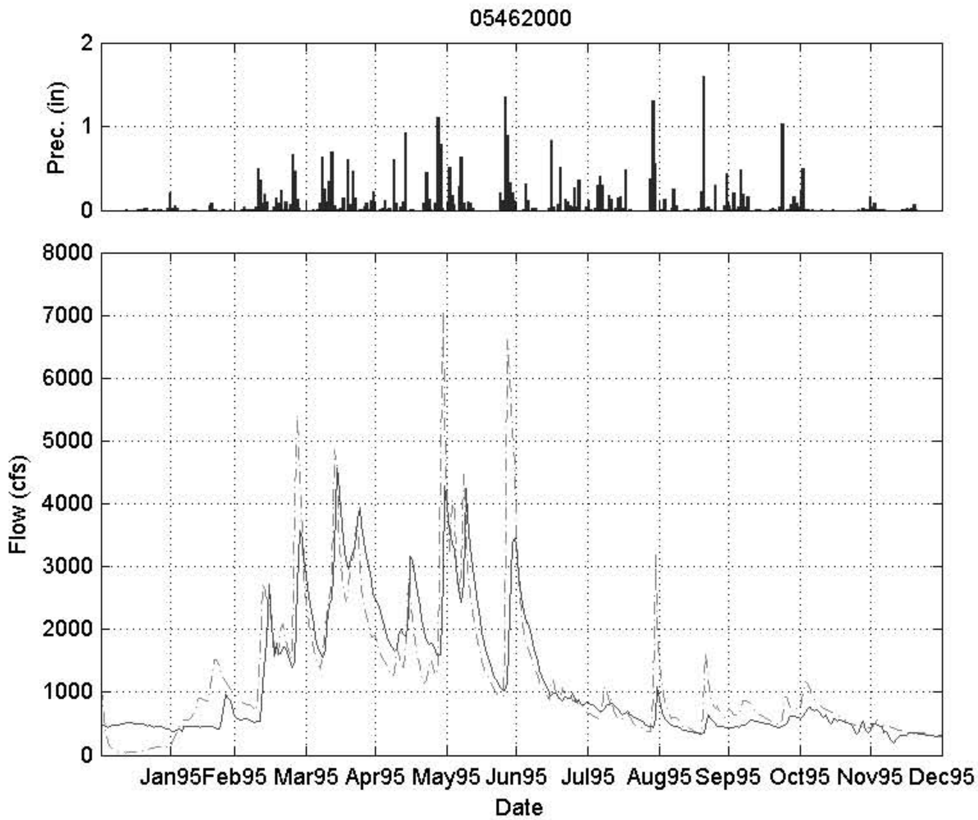

05459500
Prec. (in)
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

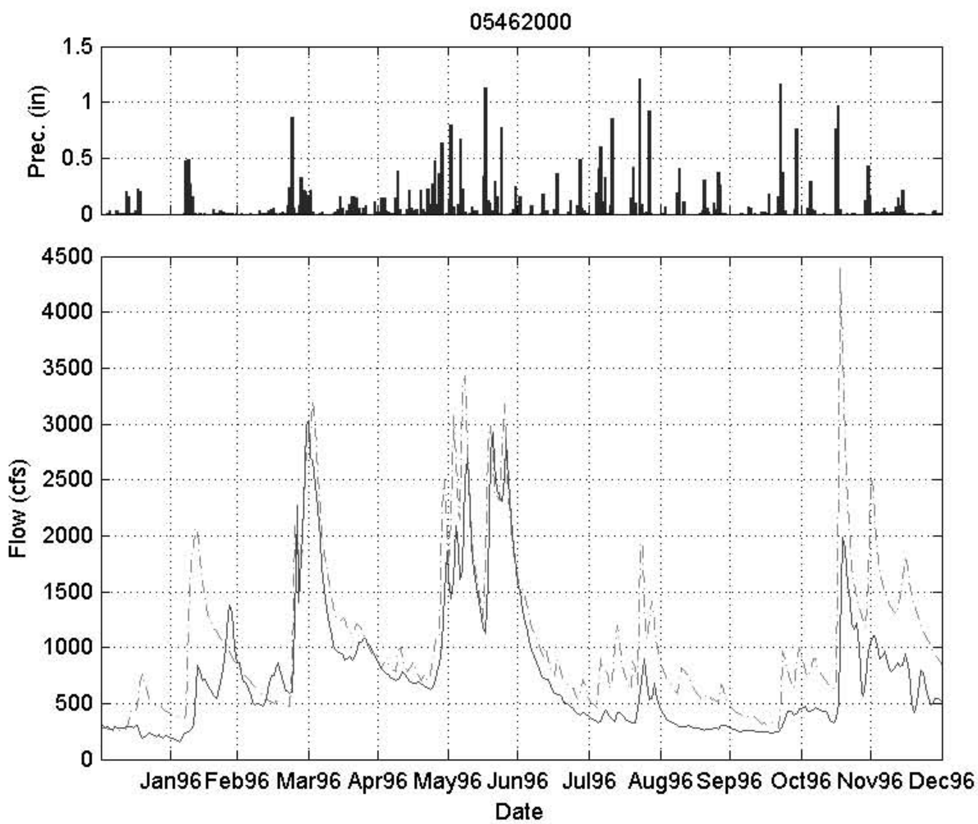

05459500
Prec. (in)
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

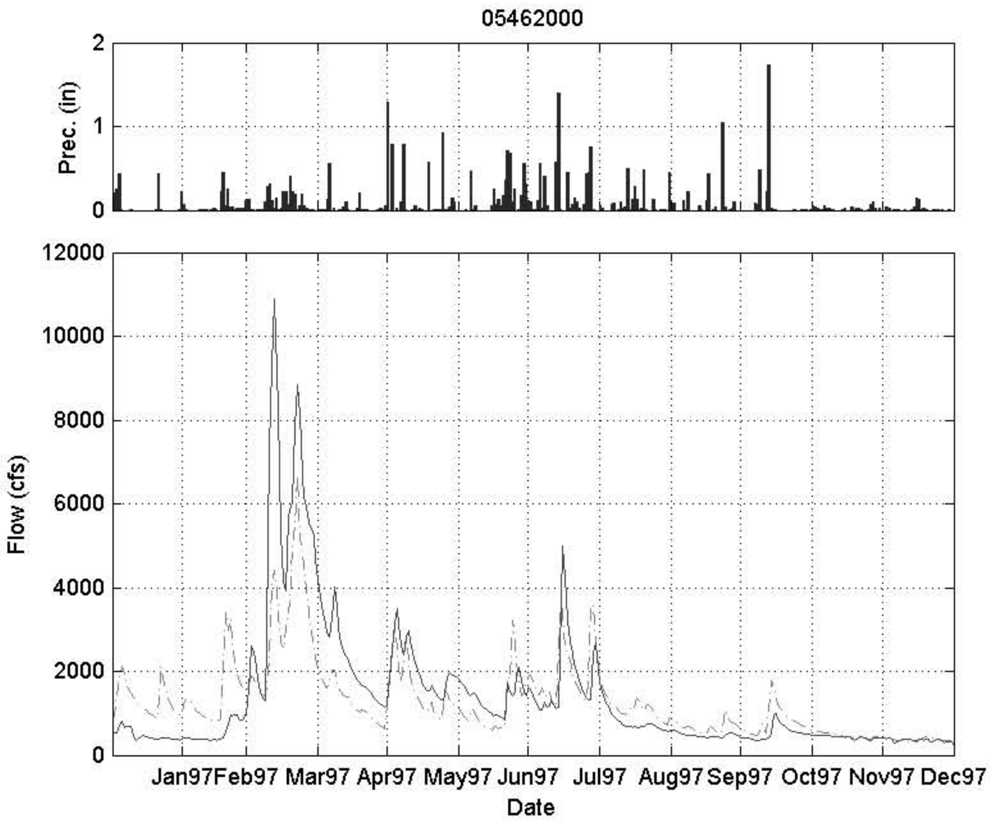

05459500
Prec. (in)
2
1
0
Flow (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

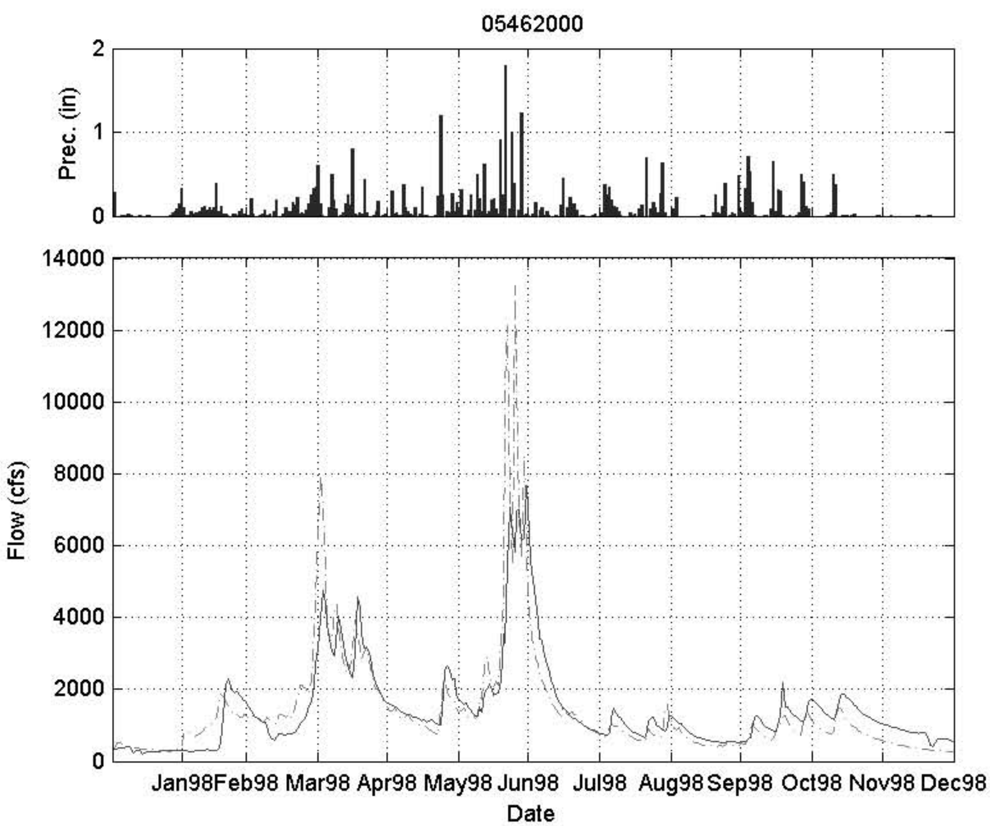

05462000
Observed
Simulated
Flow (cfs)
10^5
10^4
10^3
10^2
10^1
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

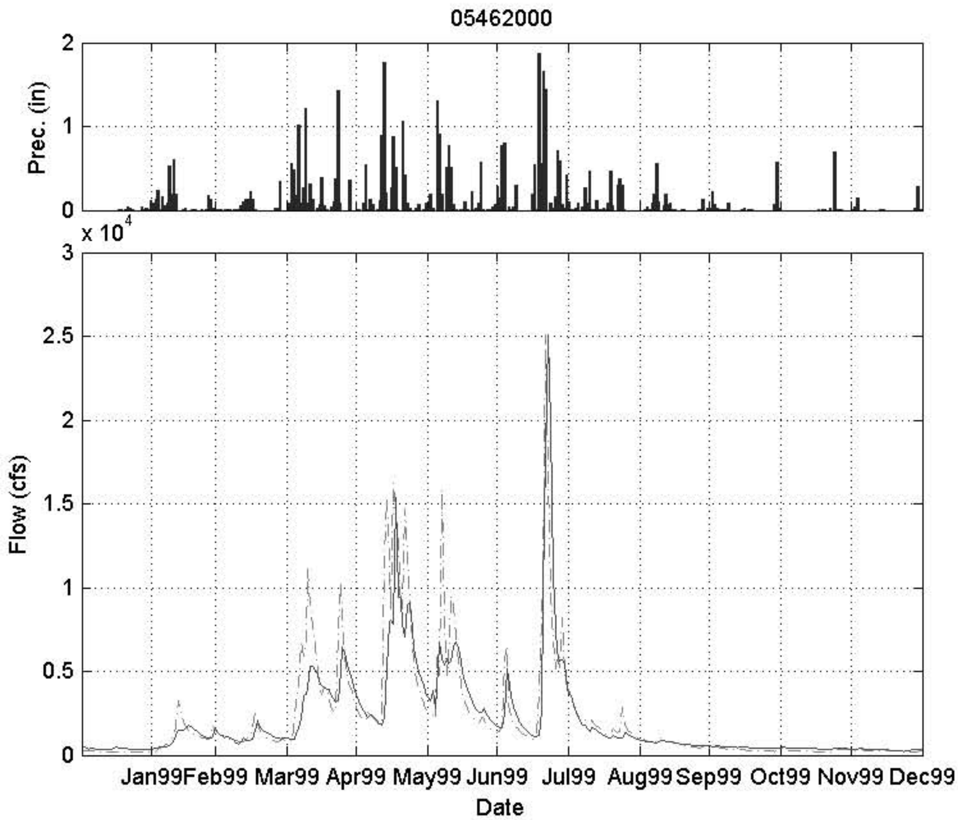

Average Monthly Runoff at Reach 224
Observed
Simulated
Runoff (in)
2
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

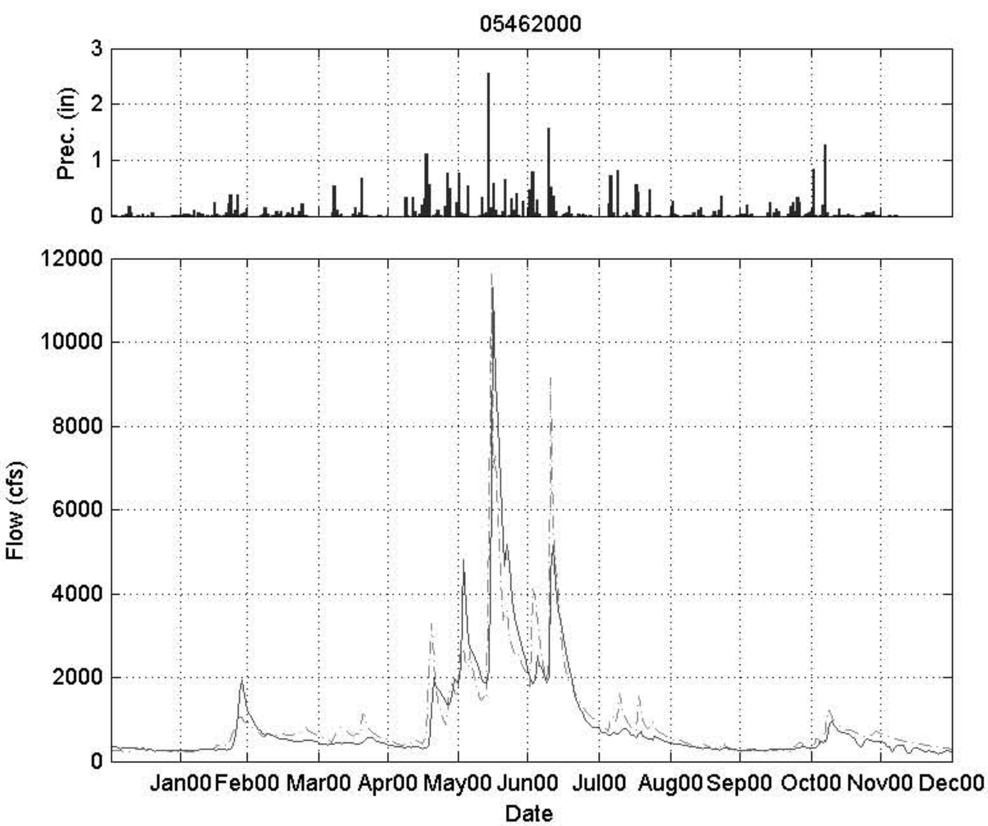

05462000
Prec. (in)
2
1
0
Flow (cfs)
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

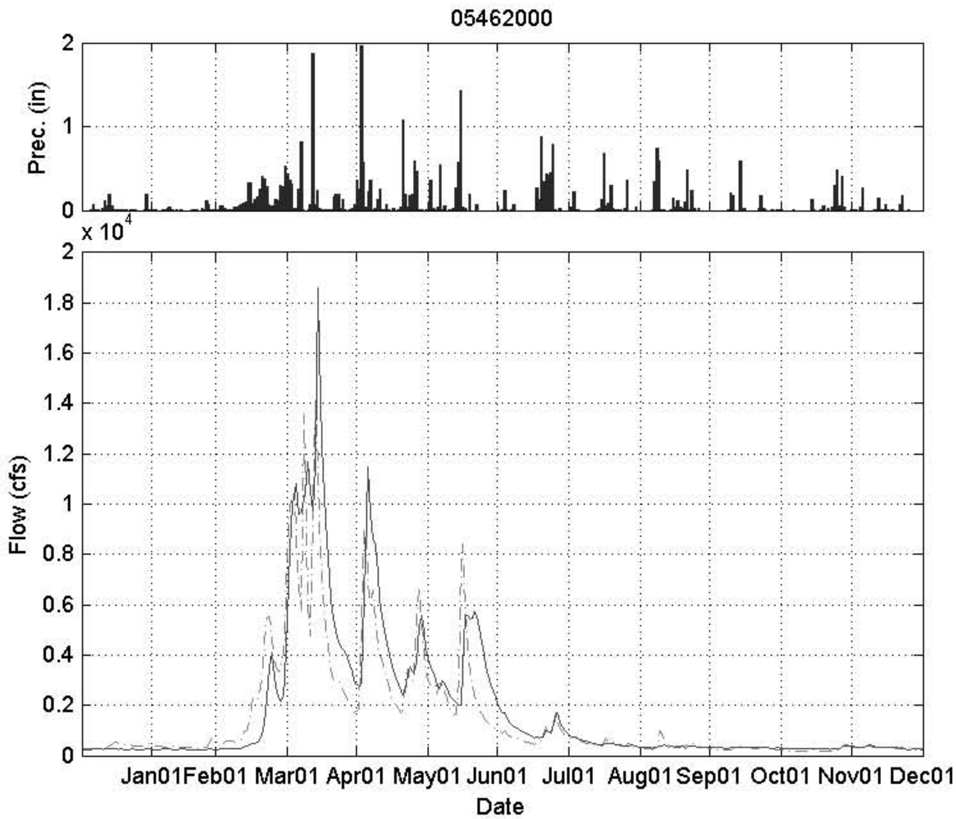

05462000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

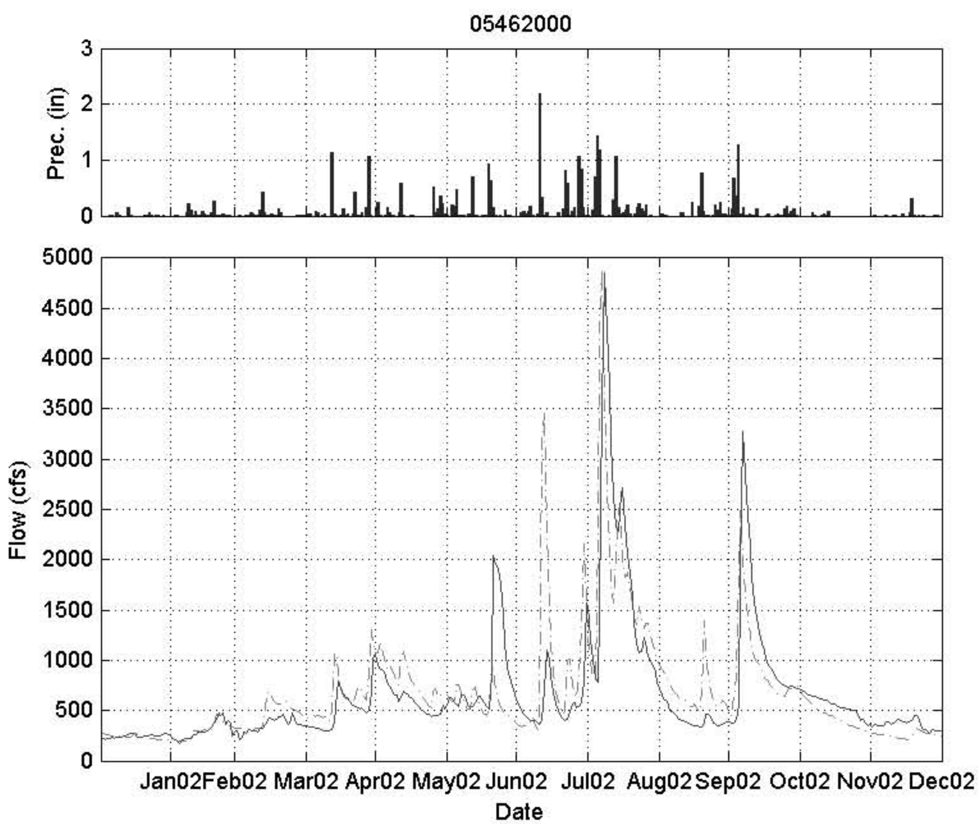

05462000
Prec. (in)
2
1
0
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

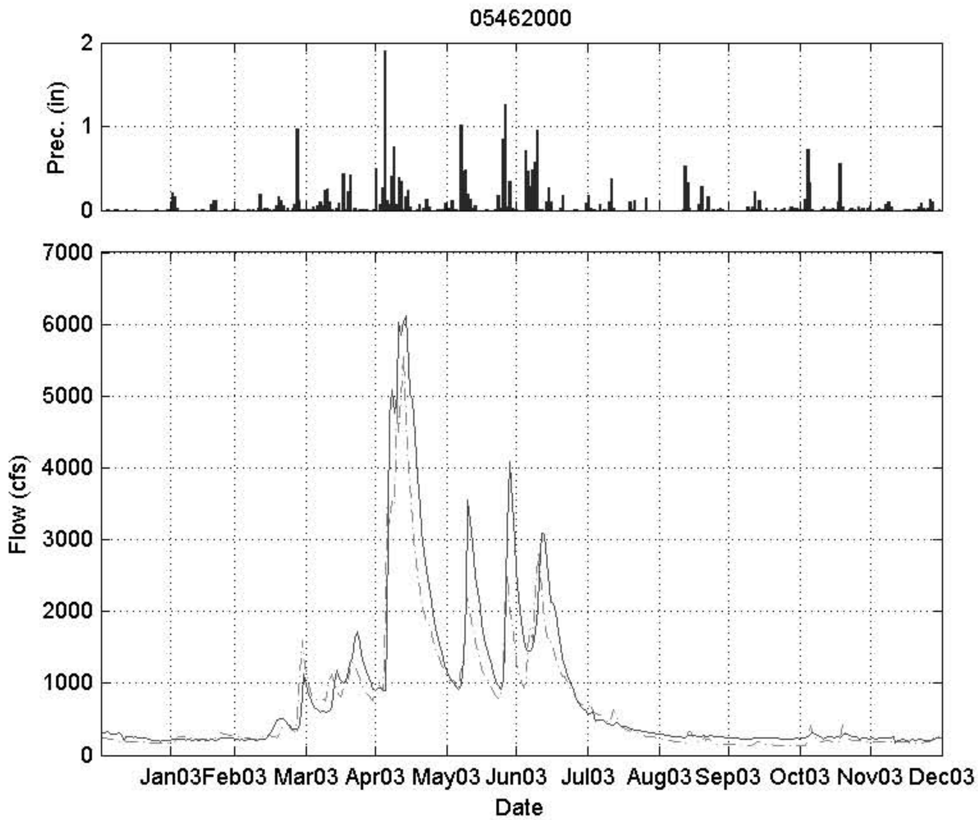

05462000
Prec. (in)
2
1
0
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

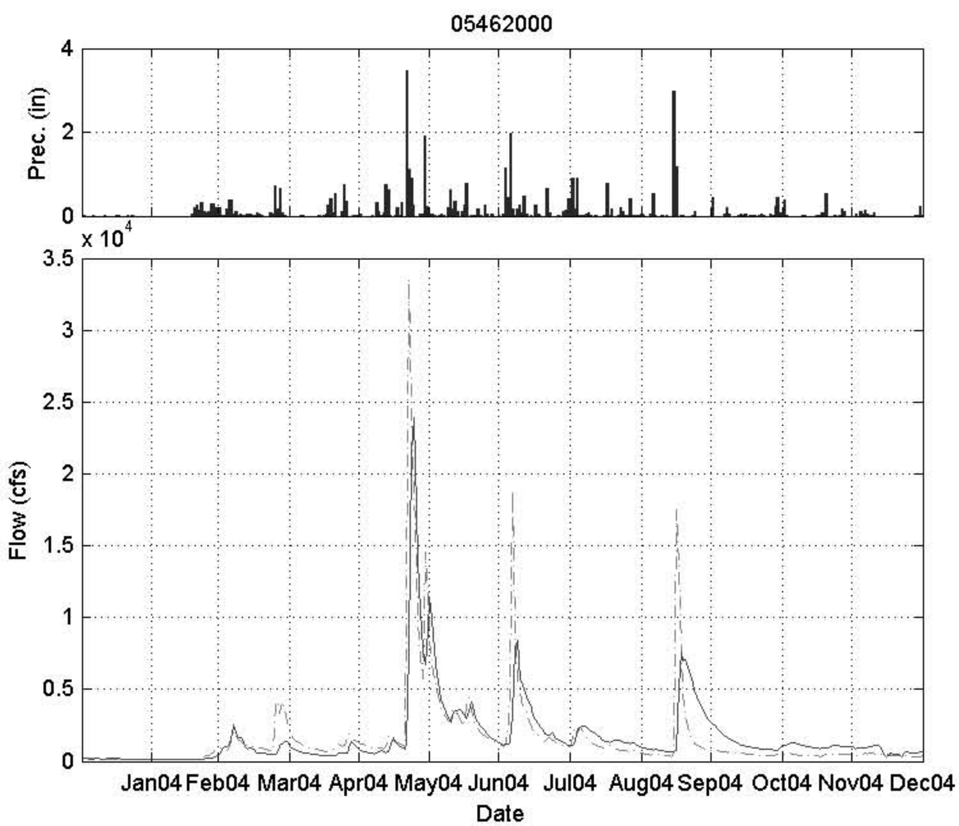

05462000
Prec. (in)
x 10^4
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

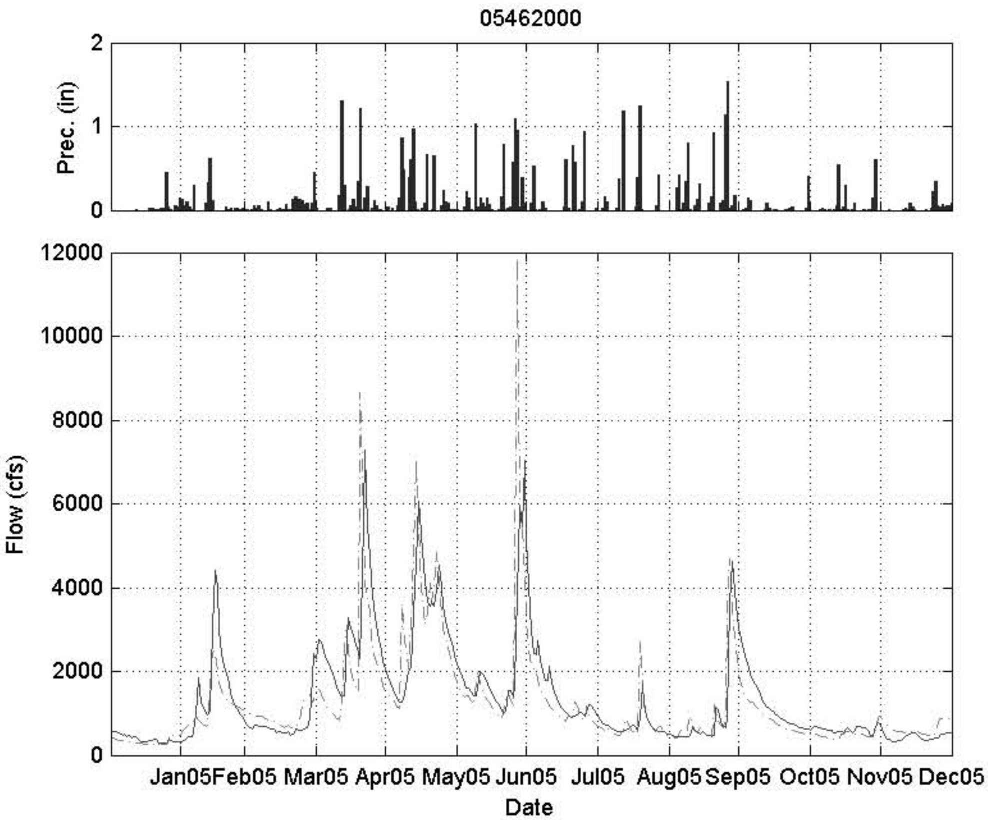

05462000
Prec. (in)
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

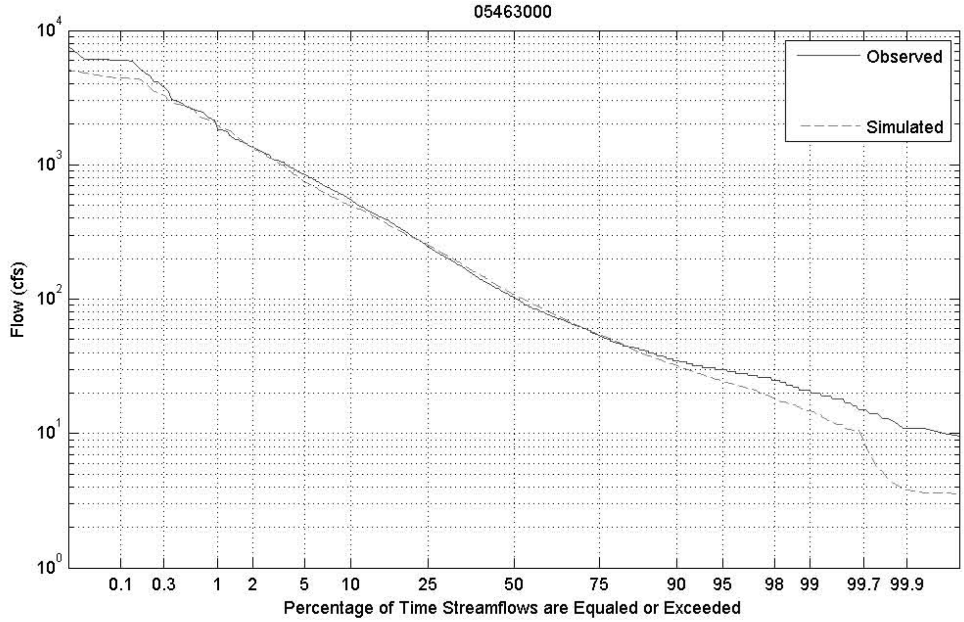

05462000
Prec. (in)
x 10^4
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

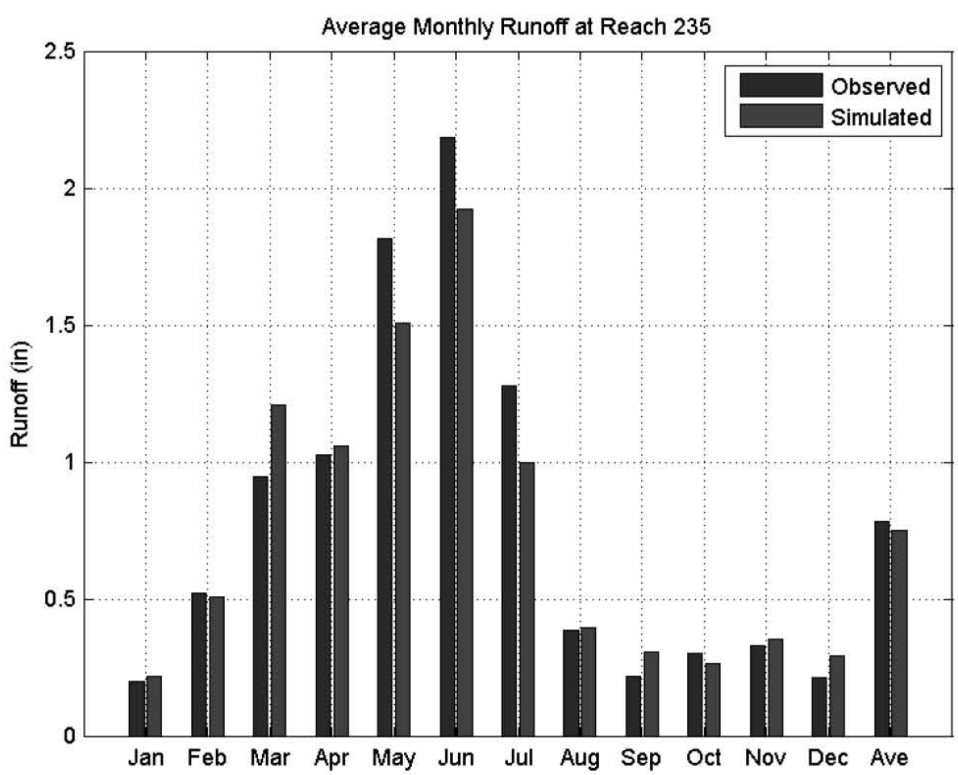

05462000
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

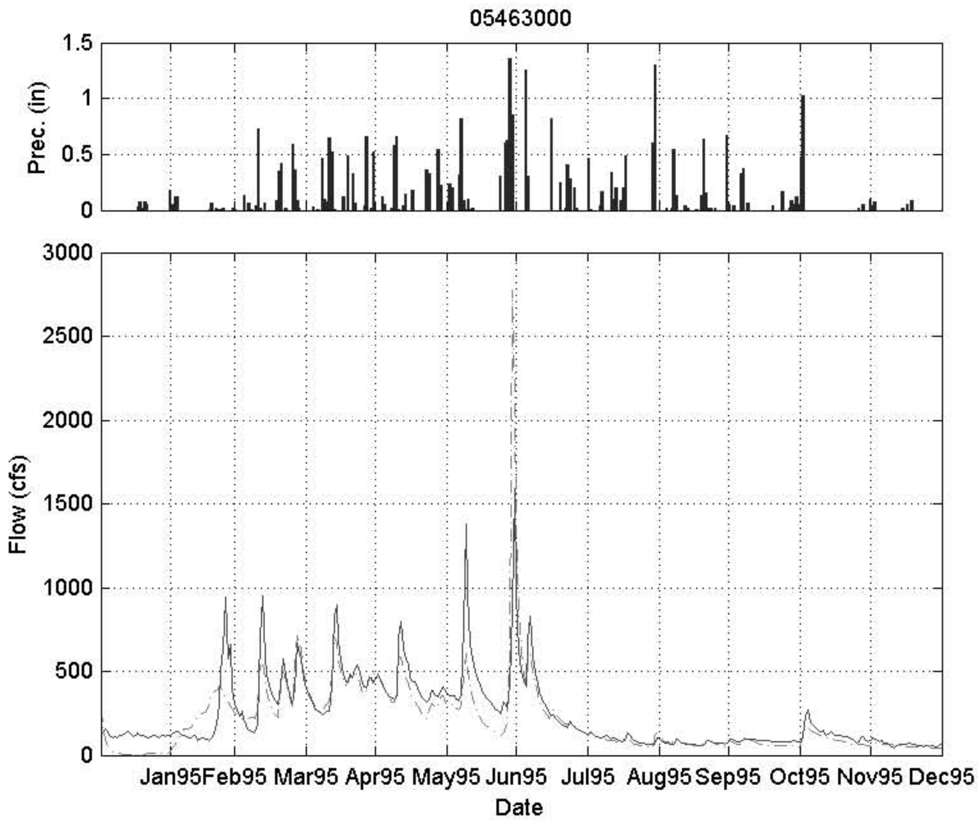

05462000
Prec. (in)
2
1
0
7000
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

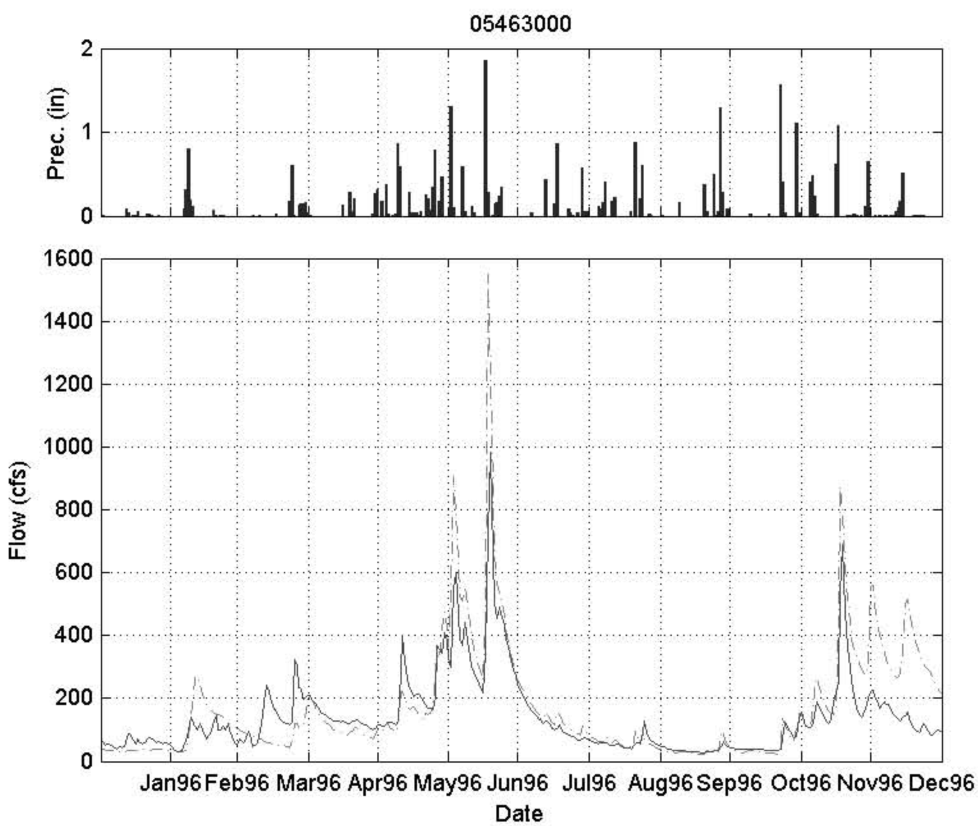

05462000
Prec. (in)
4
2
0
x 10^4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

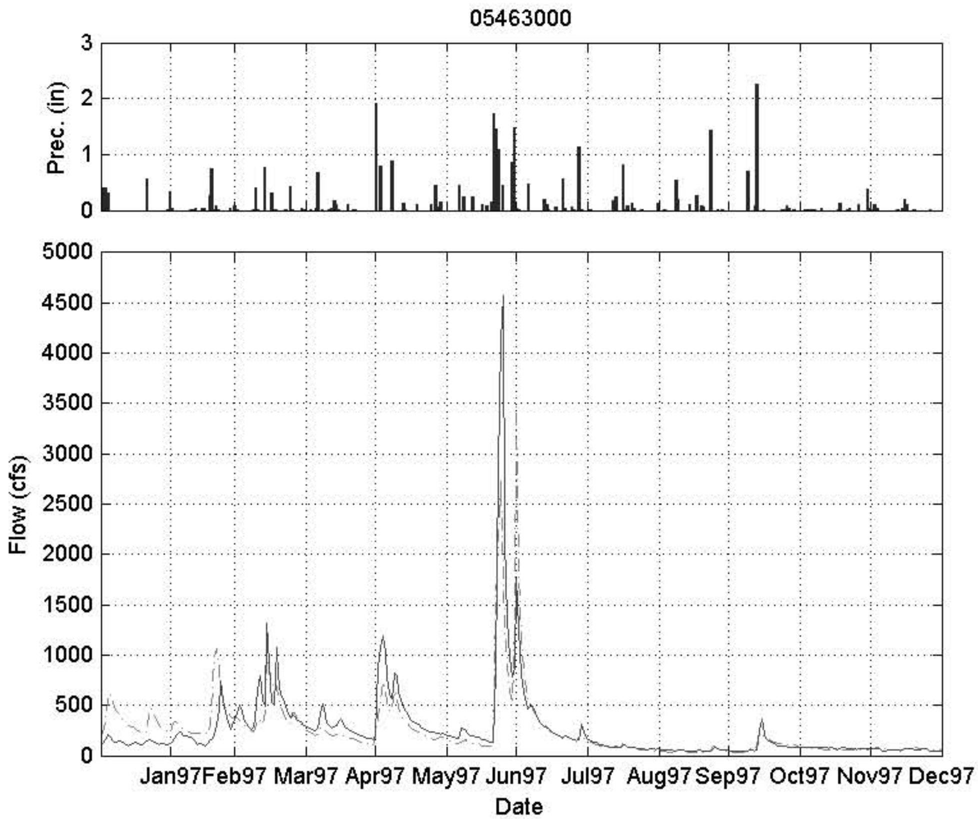

05462000
Prec. (in)
2
1
0
Flow (cfs)
12000
10000
8000
6000
4000
2000
0
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

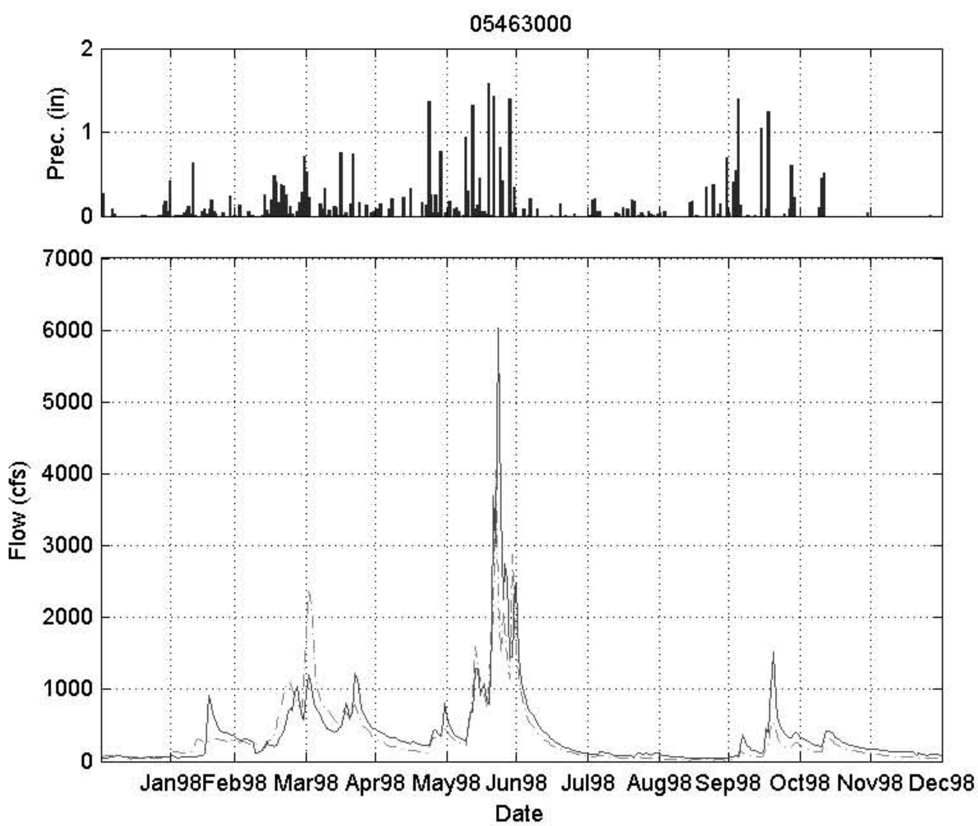

05463000
Observed
Simulated
Flow (cfs)
10^4
10^3
10^2
10^1
10^0
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

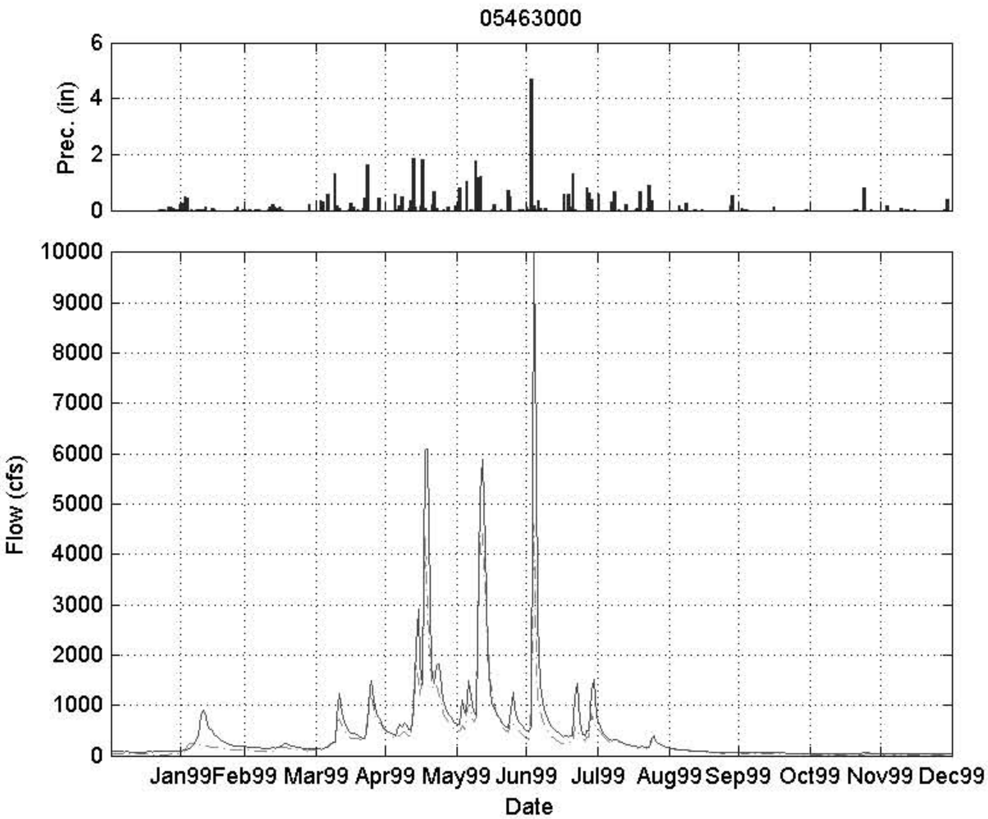

Average Monthly Runoff at Reach 235
Observed
Simulated
Runoff (in)
2.5
2
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

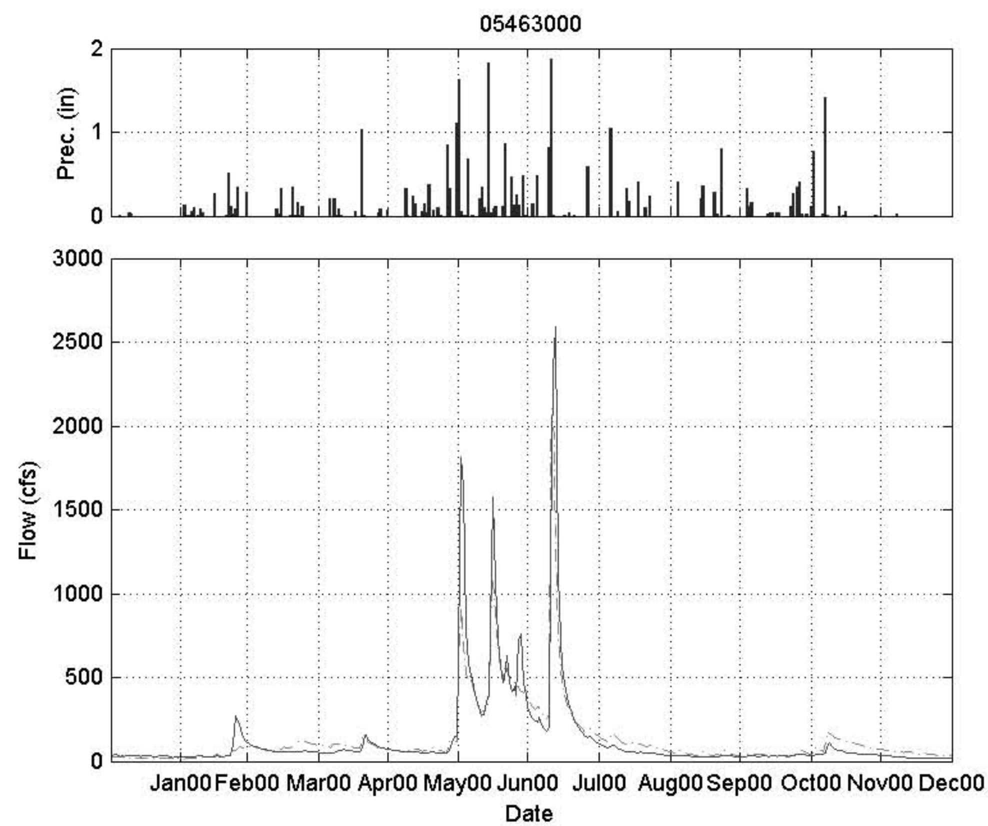

05463000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

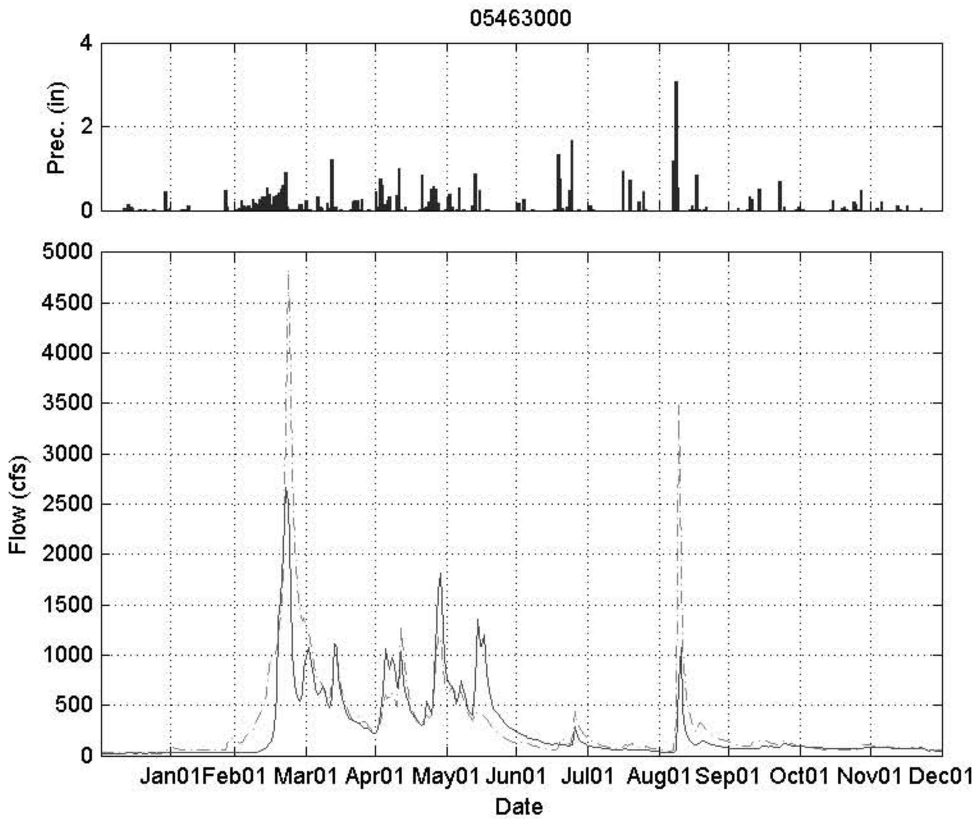

05463000
Prec. (in)
2
1
0
Flow (cfs)
1600
1400
1200
1000
800
600
400
200
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

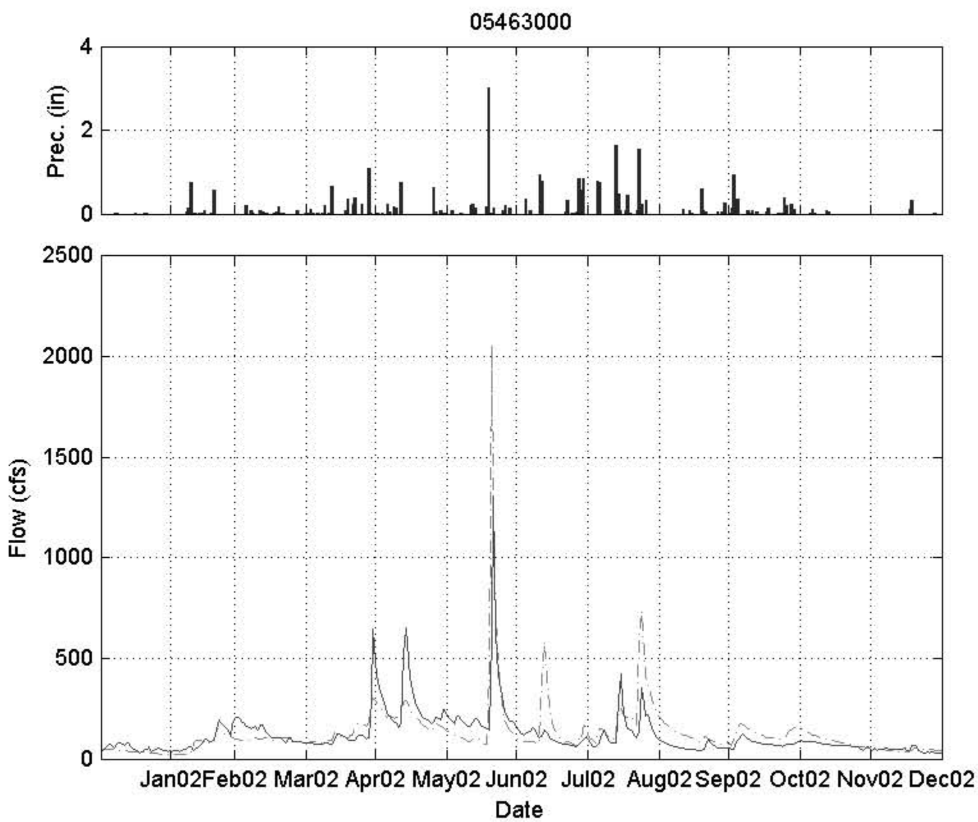

05463000
Prec. (in)
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

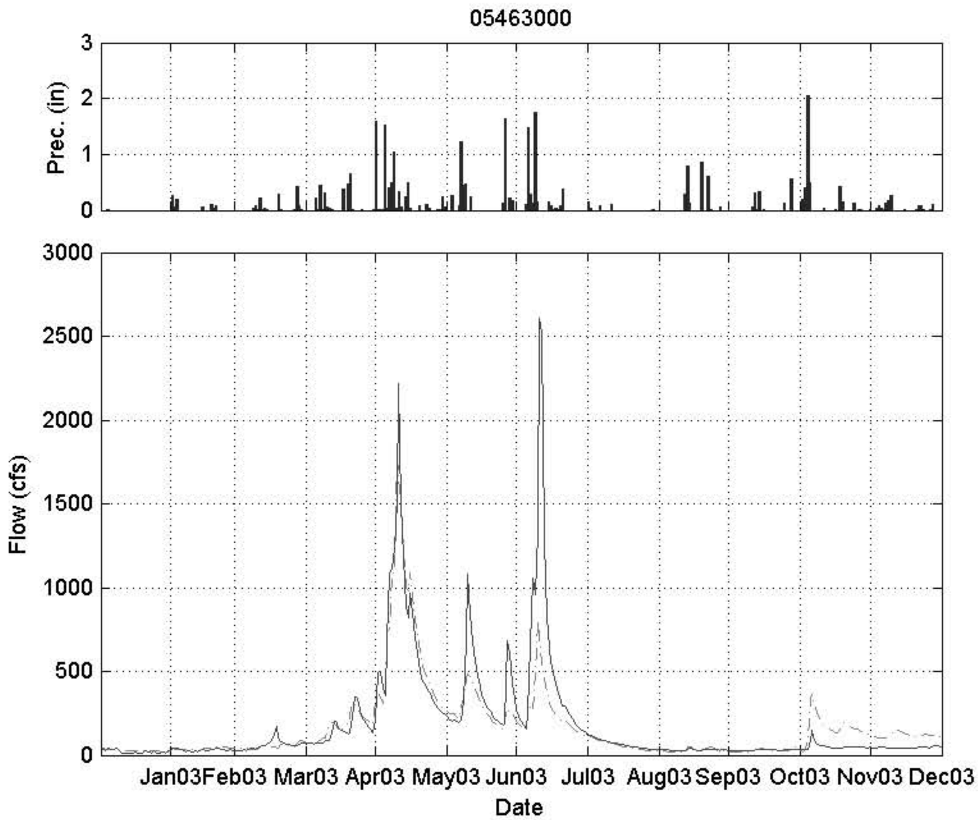

05463000
Prec. (in)
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

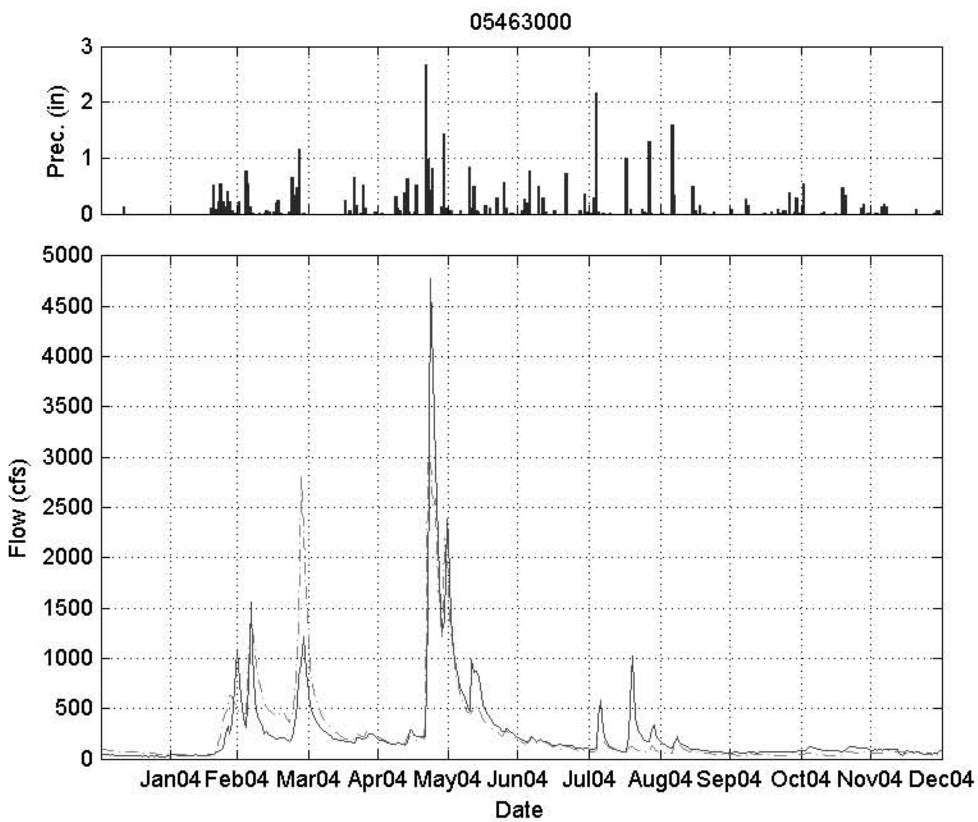

05463000
Prec. (in)
6
4
2
0
Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

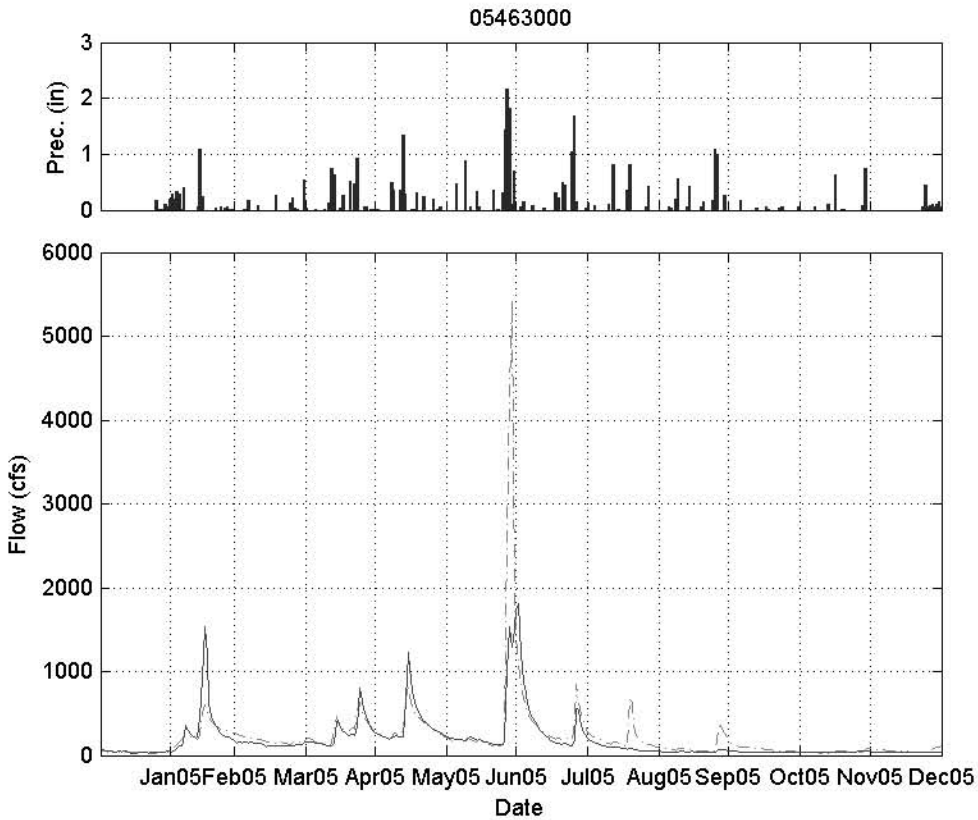

05463000
Prec. (in)
2
1
0
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

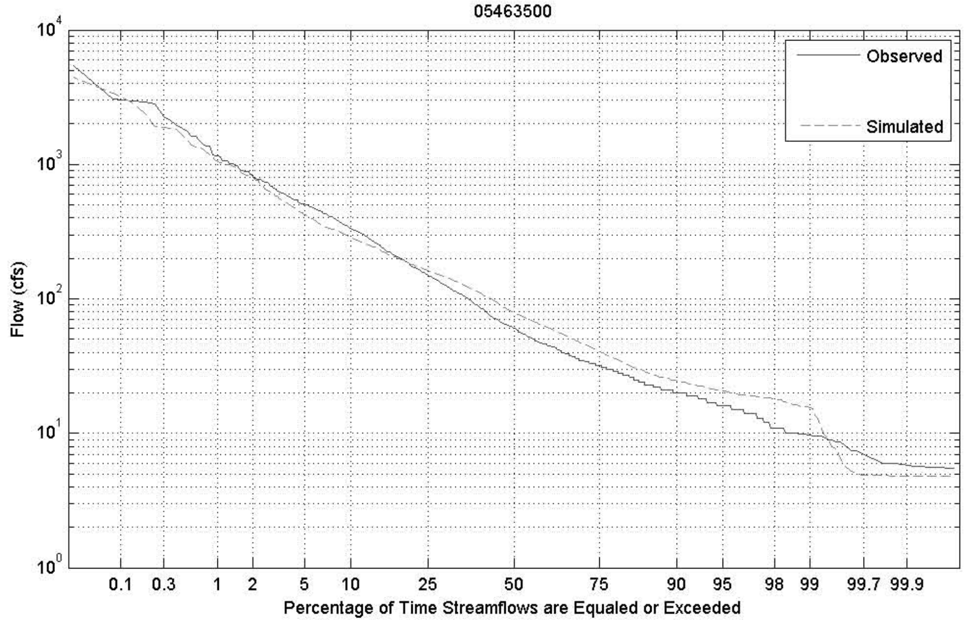

05463000
Prec. (in)
4
2
0
Flow (cfs)
5000
4500
4000
3500
3000
2500
2000
1500
1000
500
0
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

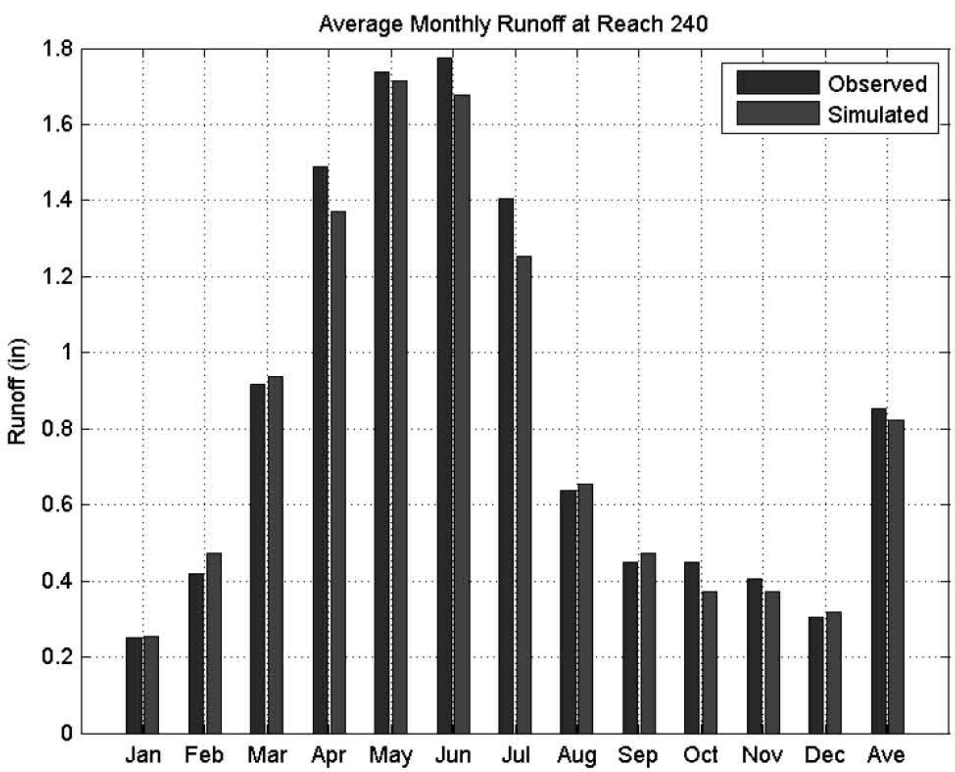

05463000
Prec. (in)
4
2
0
Flow (cfs)
2500
2000
1500
1000
500
0
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

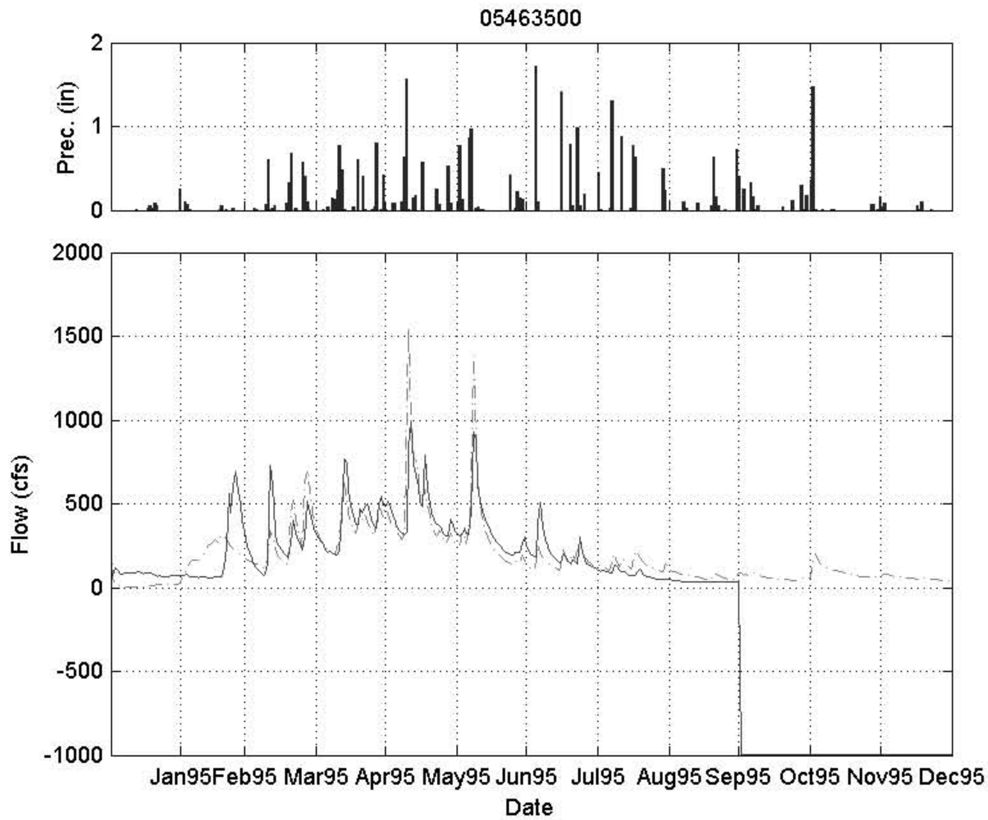

05463000
Prec. (in)
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

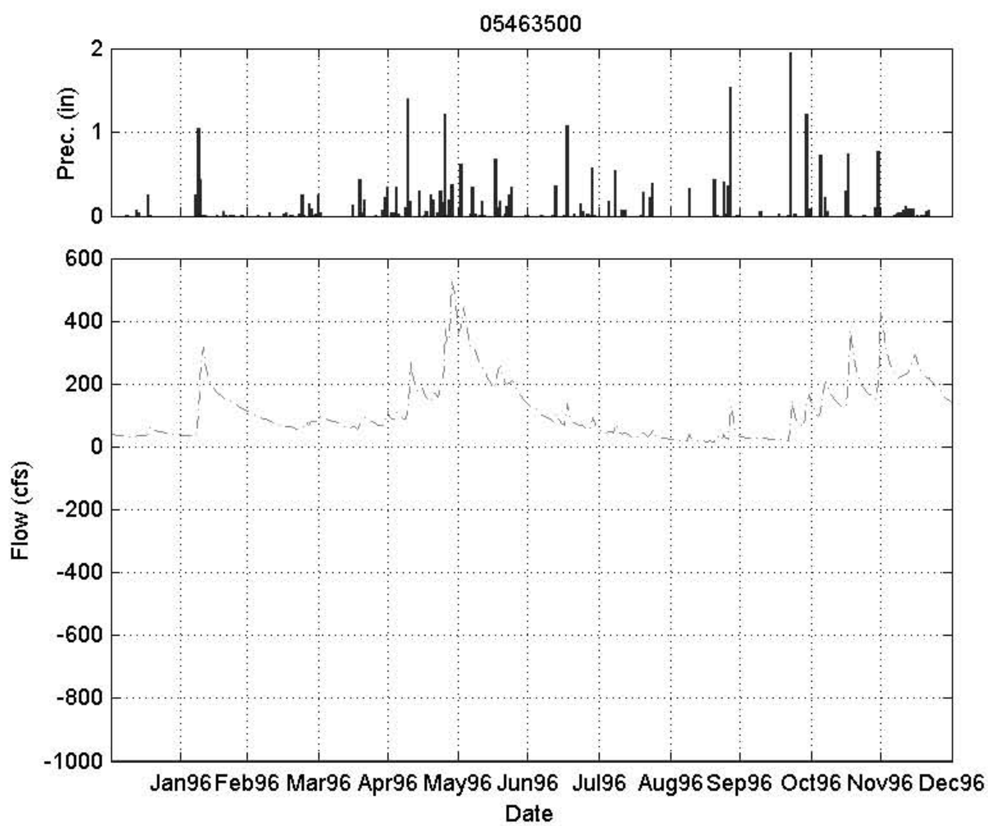

05463000
Prec. (in)
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

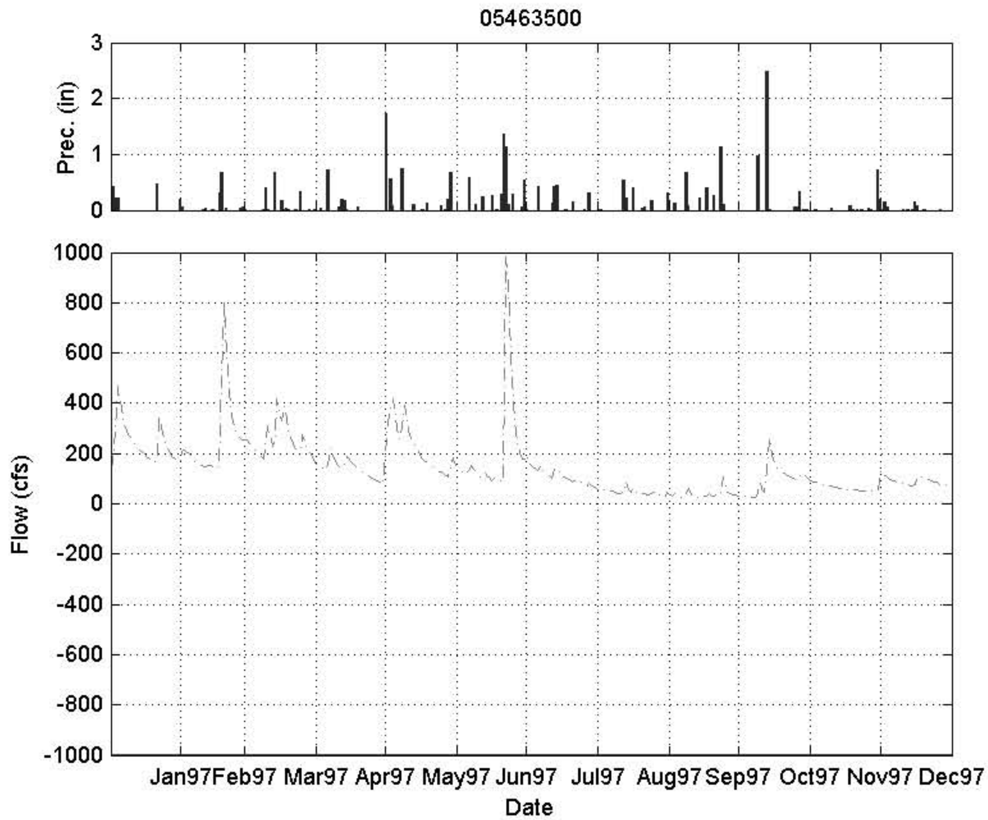

05463000
Prec. (in)
3
2
1
0
6000
5000
4000
3000
2000
1000
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

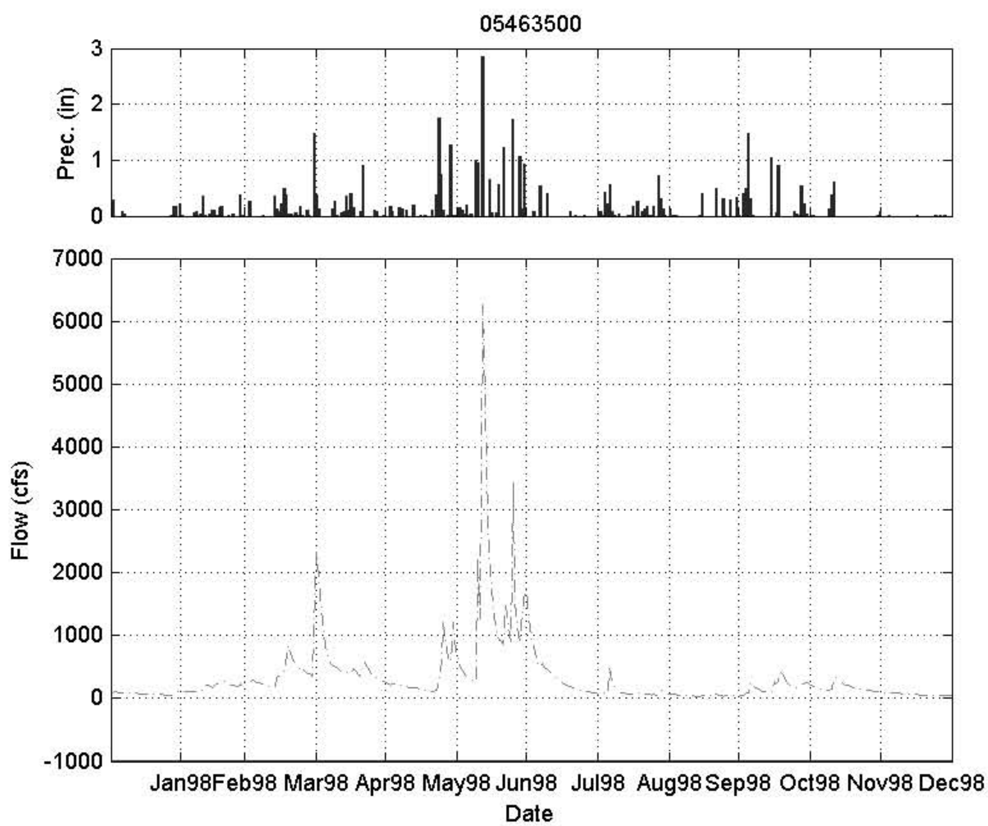

05463500
Observed
Simulated
Flow (cfs)
10^4
10^3
10^2
10^1
10^0
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

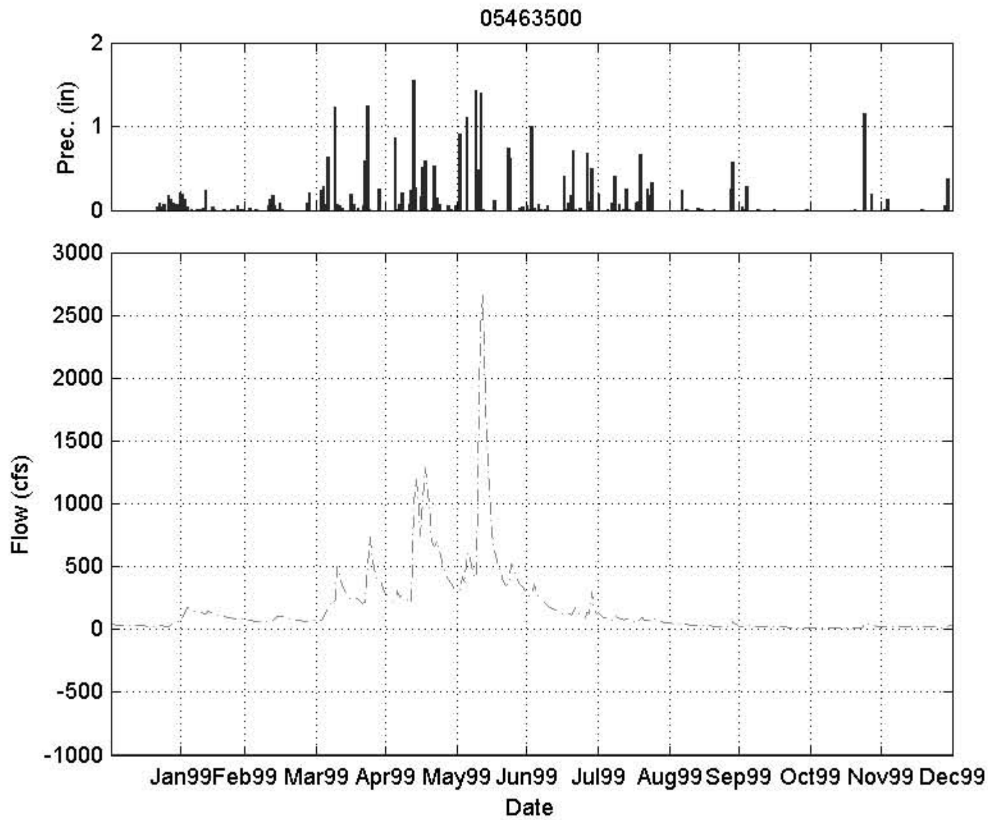

Average Monthly Runoff at Reach 240
Observed
Simulated
Runoff (in)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

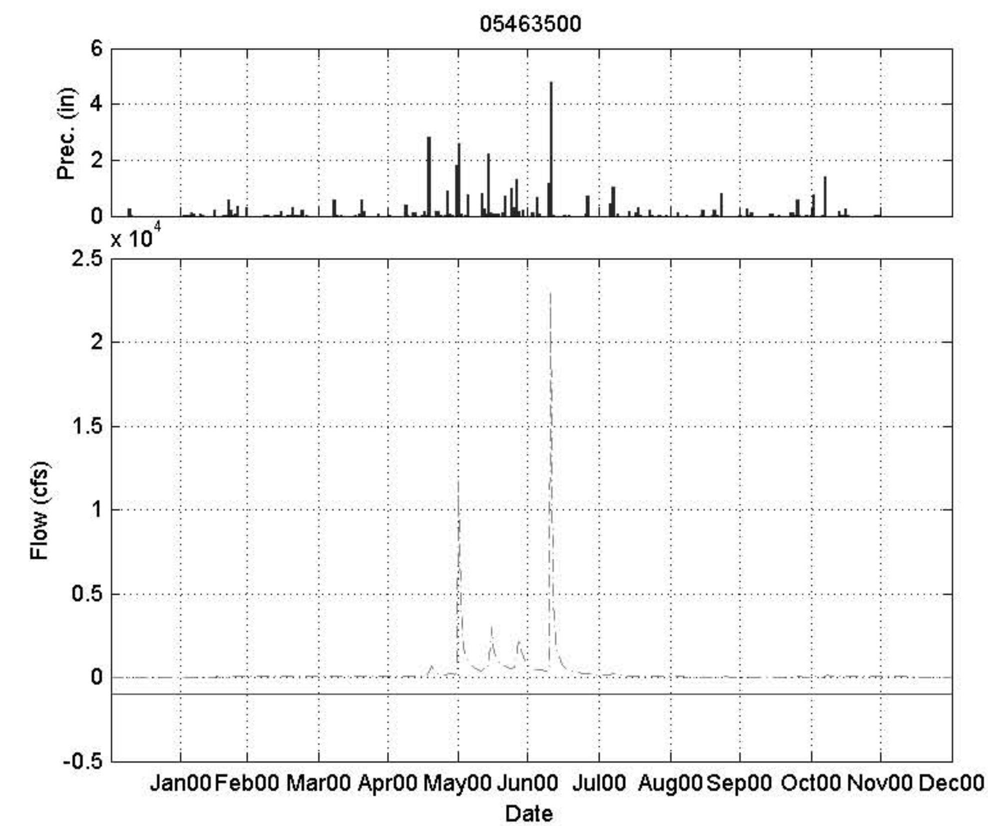

05463500
Prec. (in)
2
1
0
Flow (cfs)
2000
1500
1000
500
0
-500
-1000
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

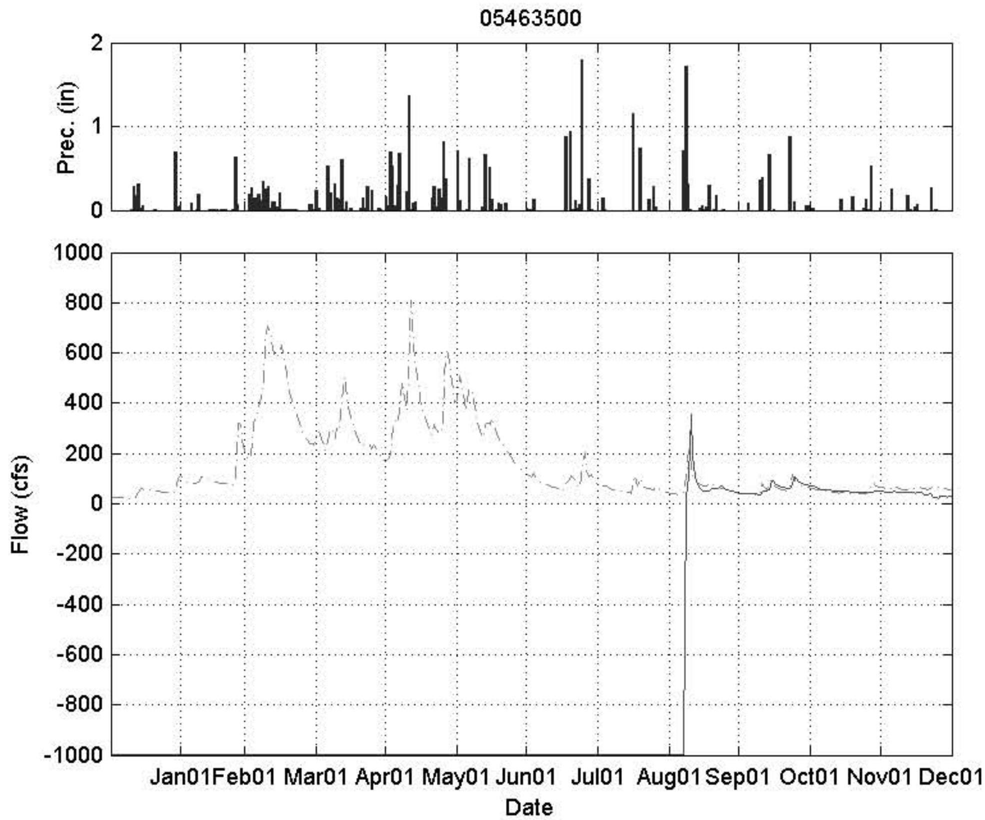

05463500
Prec. (in)
2
1
0
Flow (cfs)
600
400
200
0
-200
-400
-600
-800
-1000
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

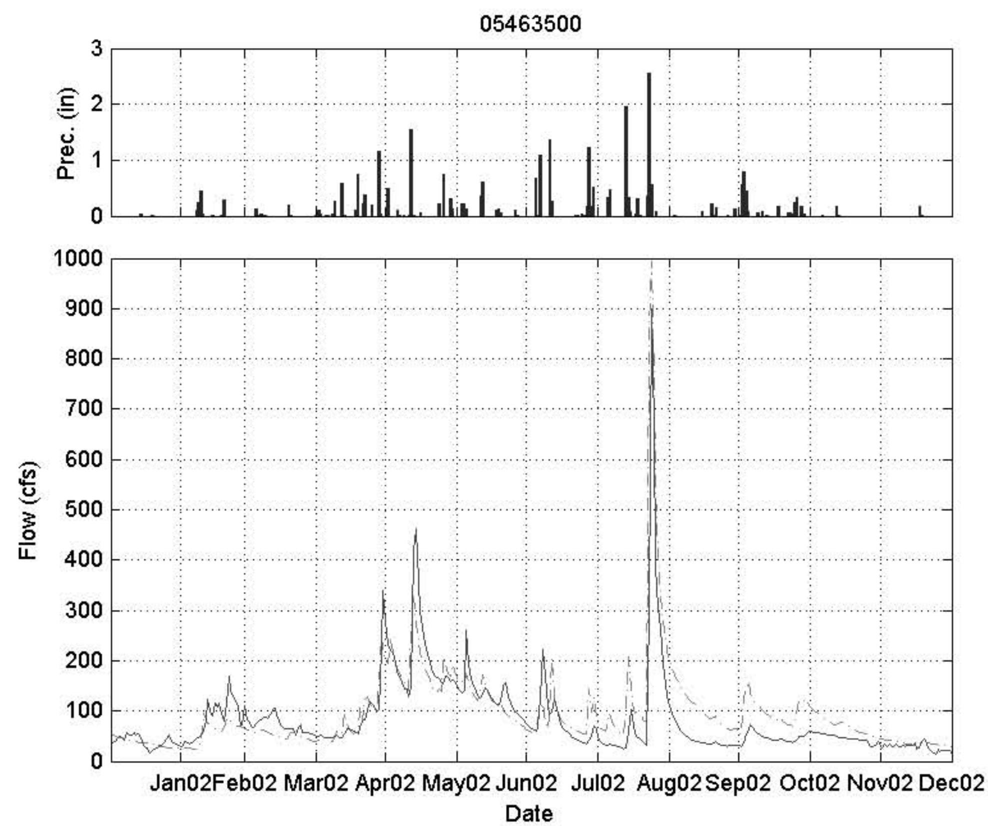

05463500
Prec. (in)
3
2
1
0
Flow (cfs)
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

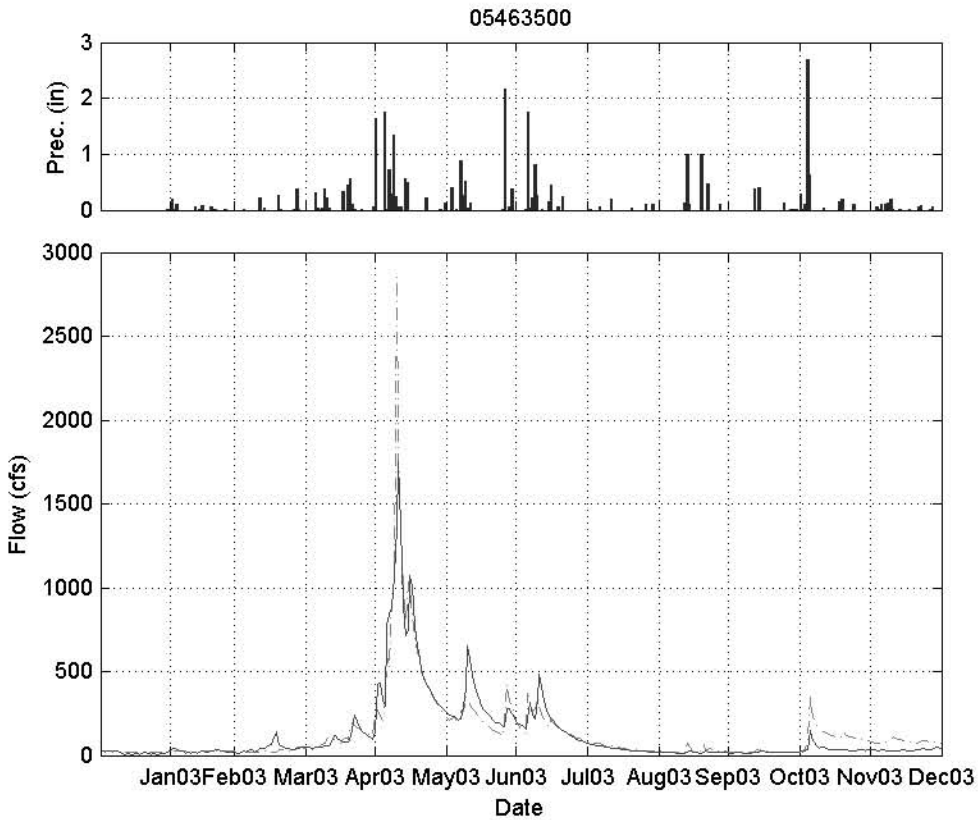

05463500
Prec. (in)
3
2
1
0
Flow (cfs)
7000
6000
5000
4000
3000
2000
1000
0
-1000
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

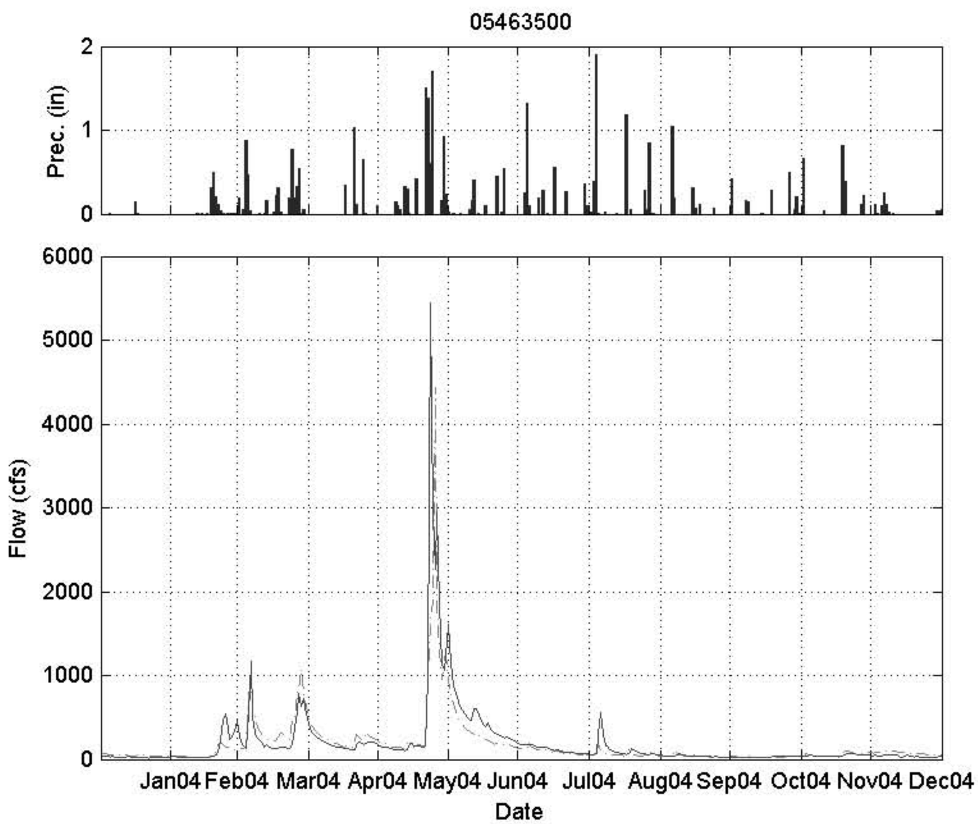

05463500
Prec. (in)
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

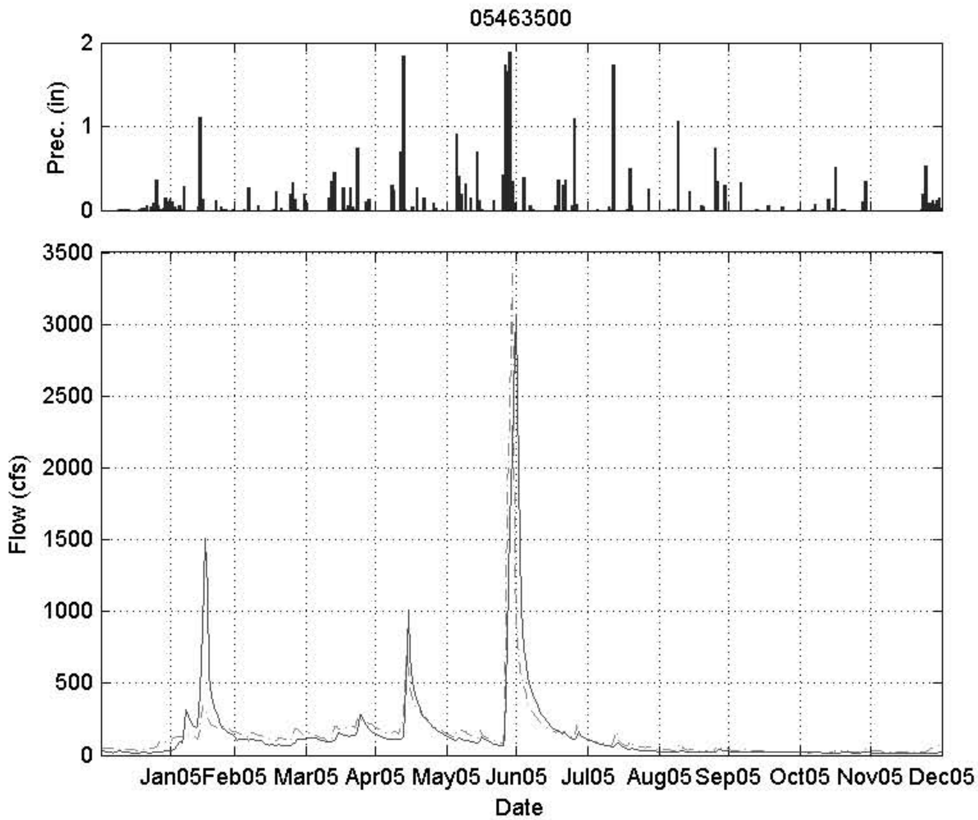

05463500
Prec. (in)
x 10^4
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

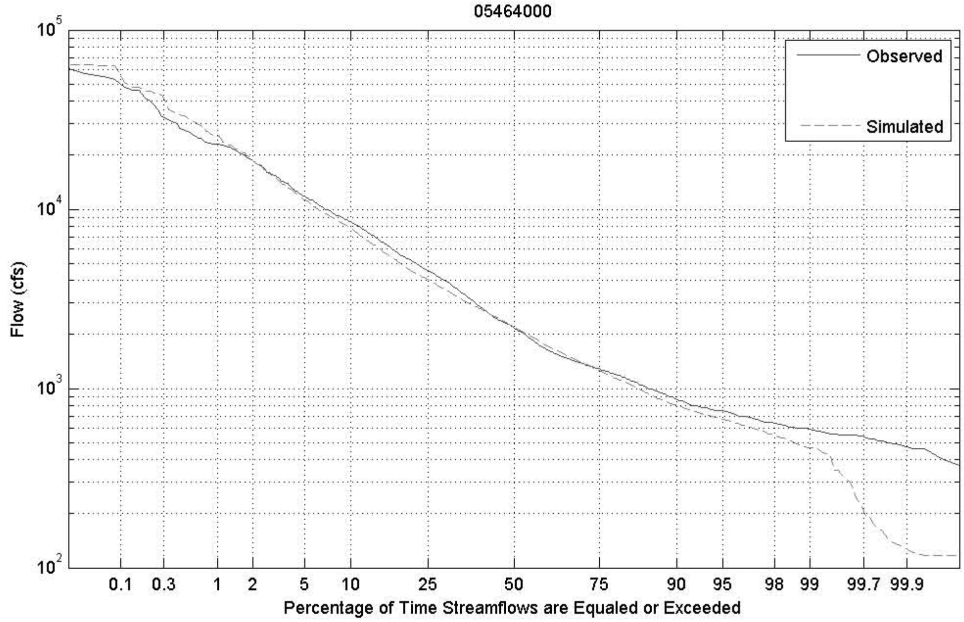

05463500
Prec. (in)
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

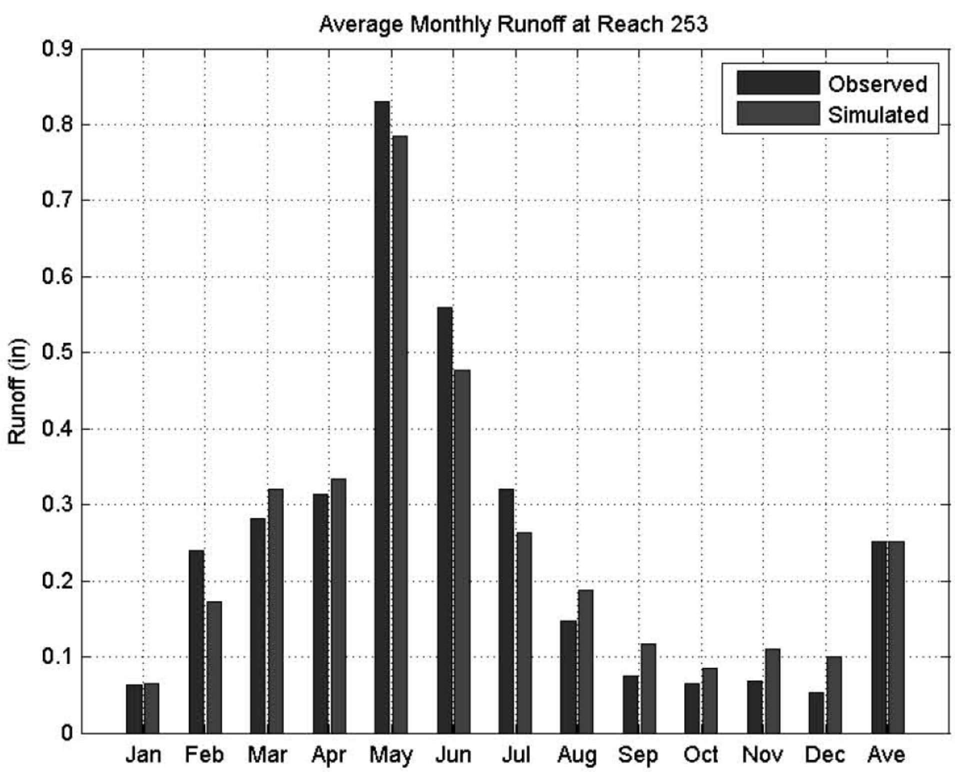

05463500
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

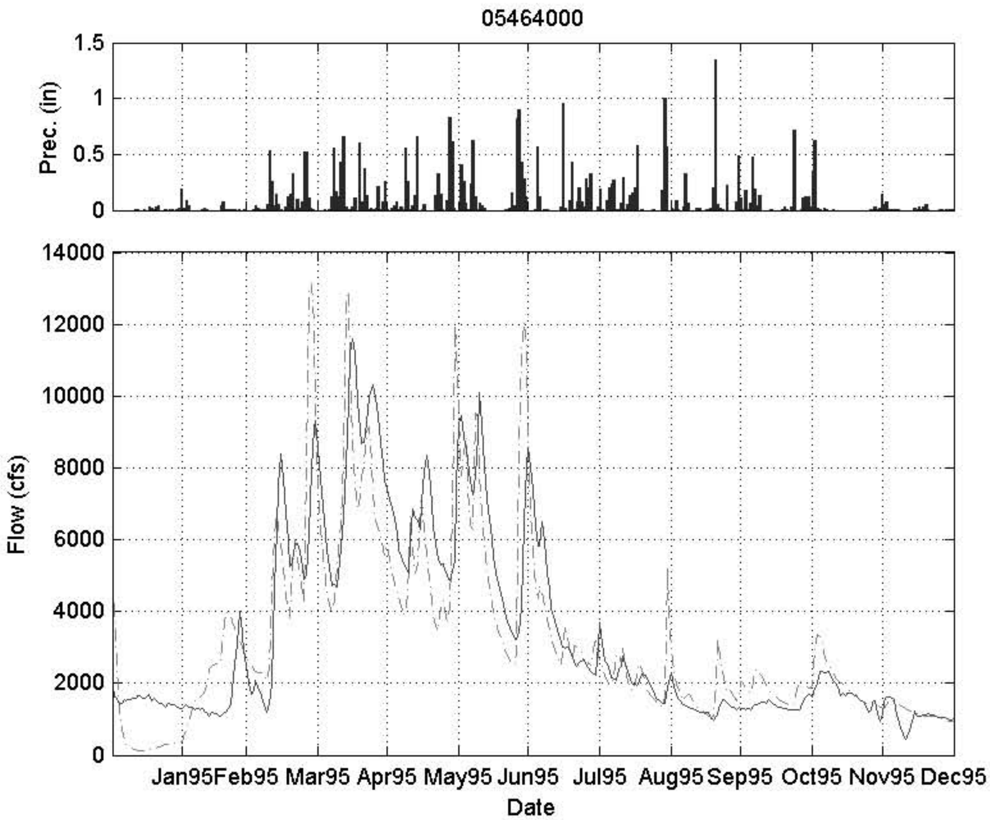

05463500
Prec. (in)
3
2
1
0
Flow (cfs)
3000
2500
2000
1500
1000
500
0
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

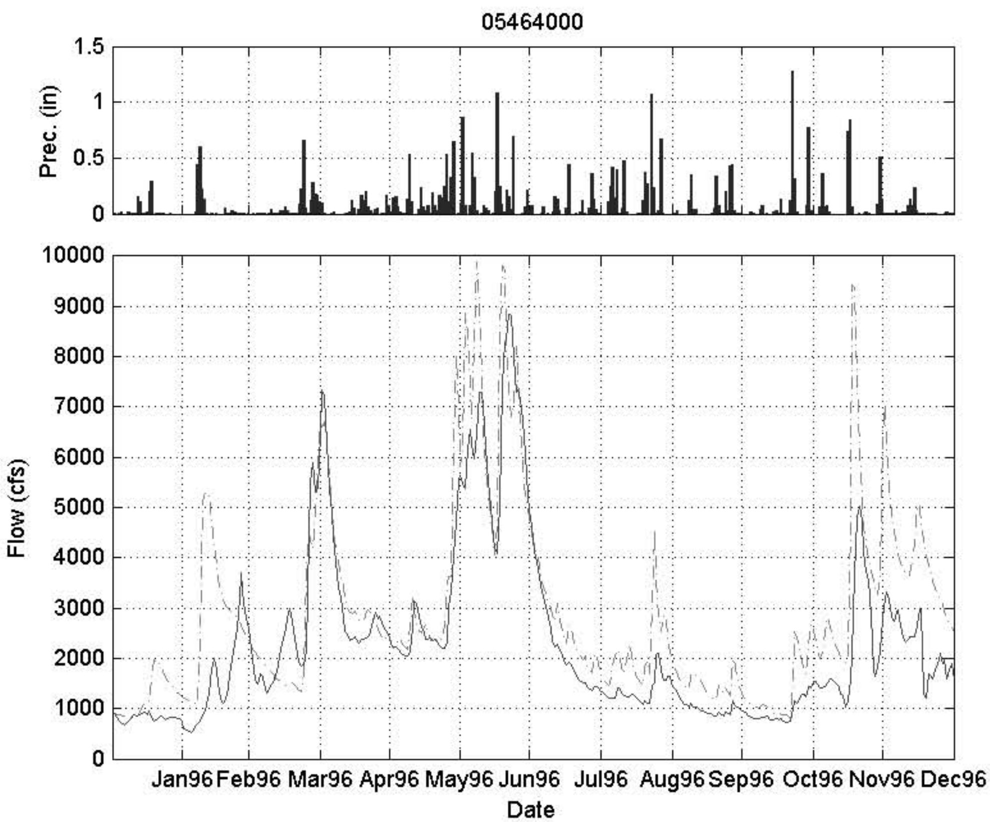

05463500
Prec. (in)
2
1
0
Flow (cfs)
6000
5000
4000
3000
2000
1000
0
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

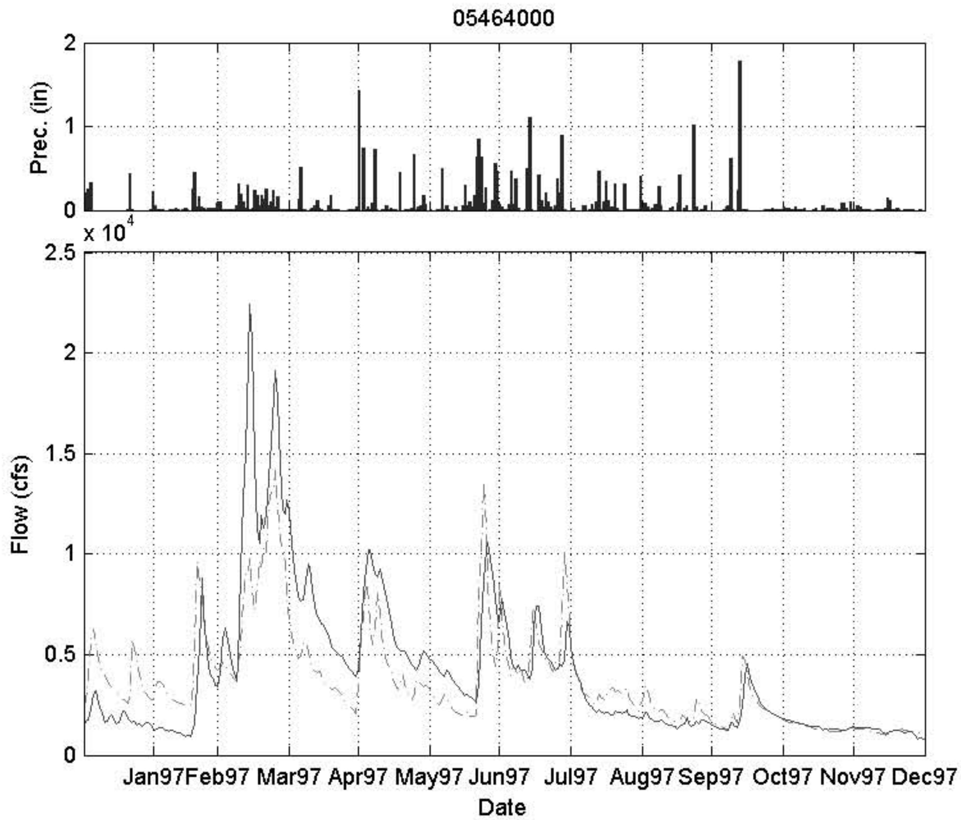

05463500
Prec. (in)
2
1
0
3500
3000
2500
2000
1500
1000
500
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

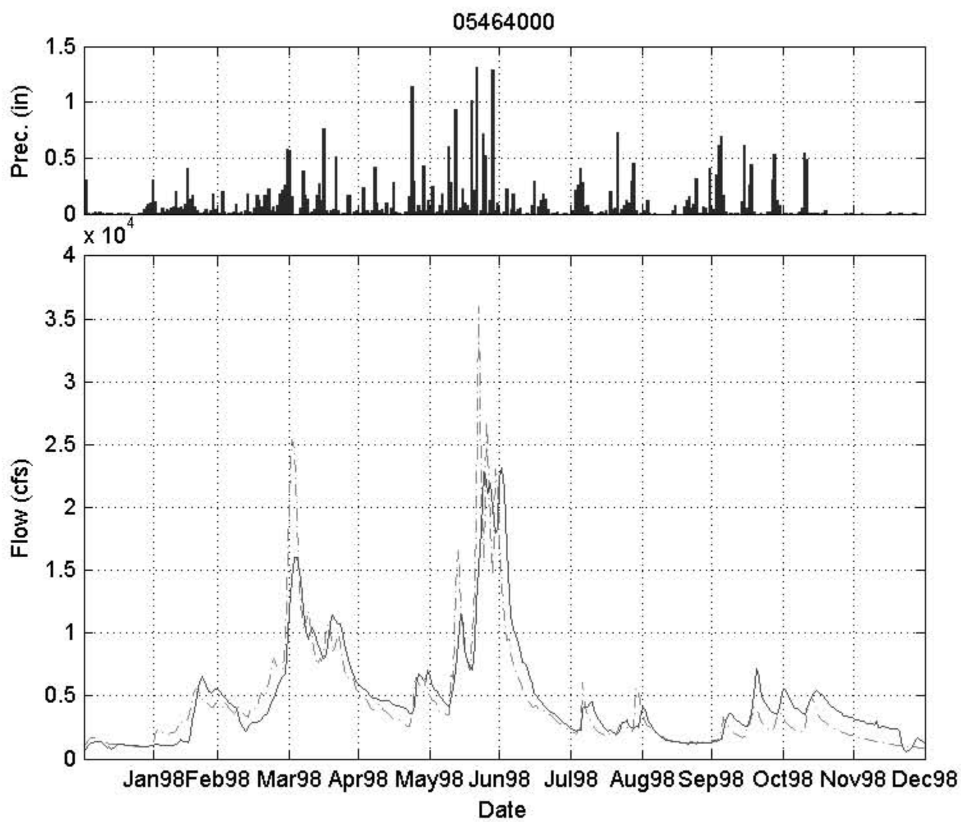

05464000
Observed
Simulated
Flow (cfs)
Percentage of Time Streamflows are Equaled or Exceeded

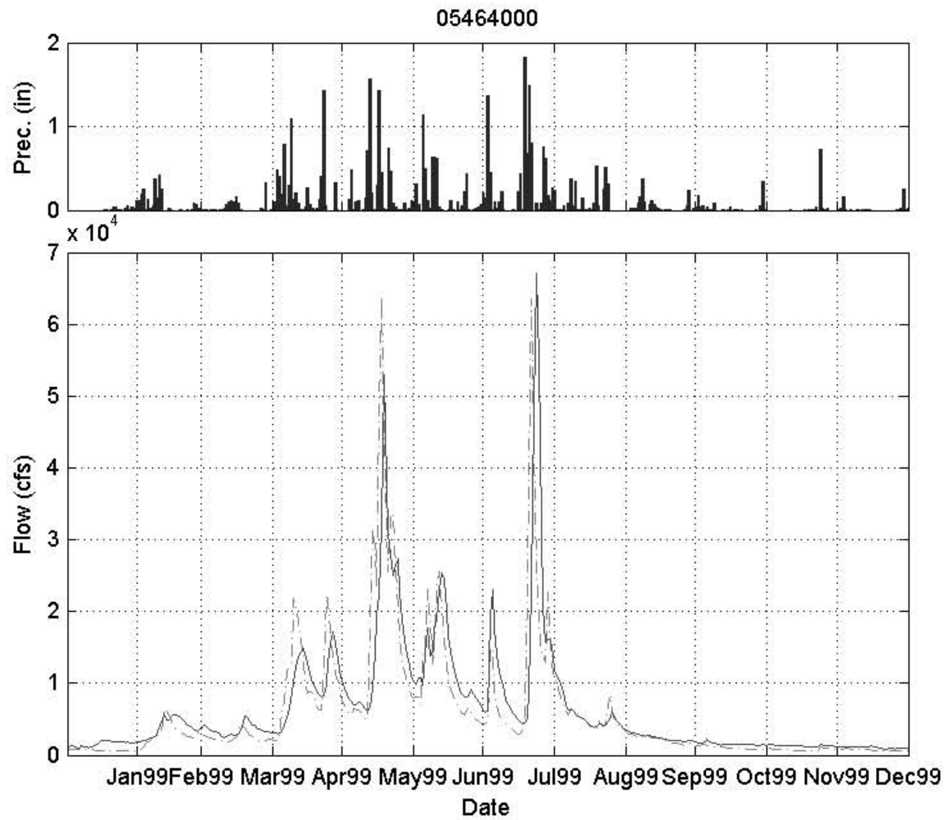

Average Monthly Runoff at Reach 253
Observed
Simulated
Runoff (in)
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

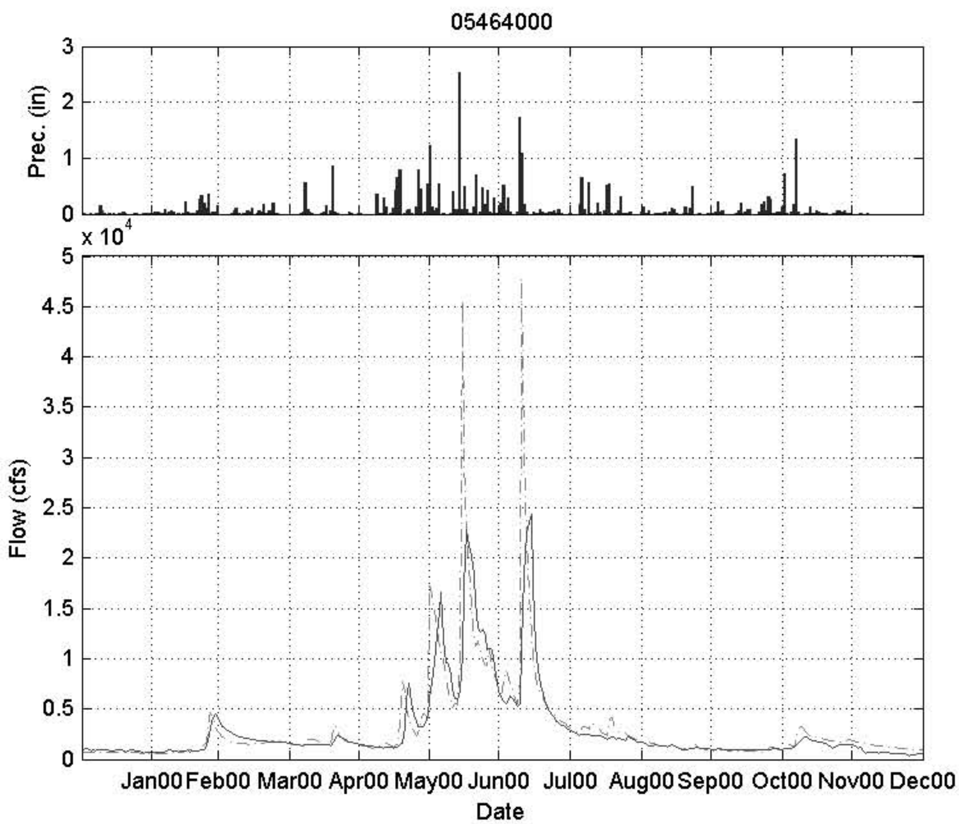

05464000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
14000
12000
10000
8000
6000
4000
2000
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

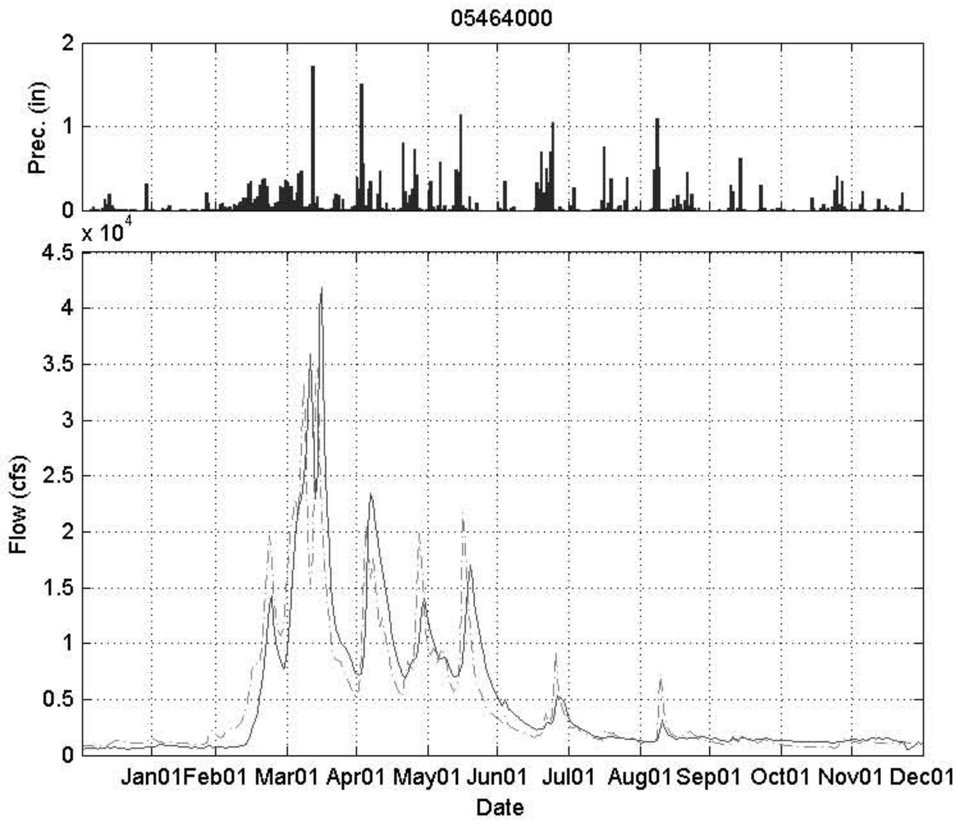

05464000
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
10000
9000
8000
7000
6000
5000
4000
3000
2000
1000
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

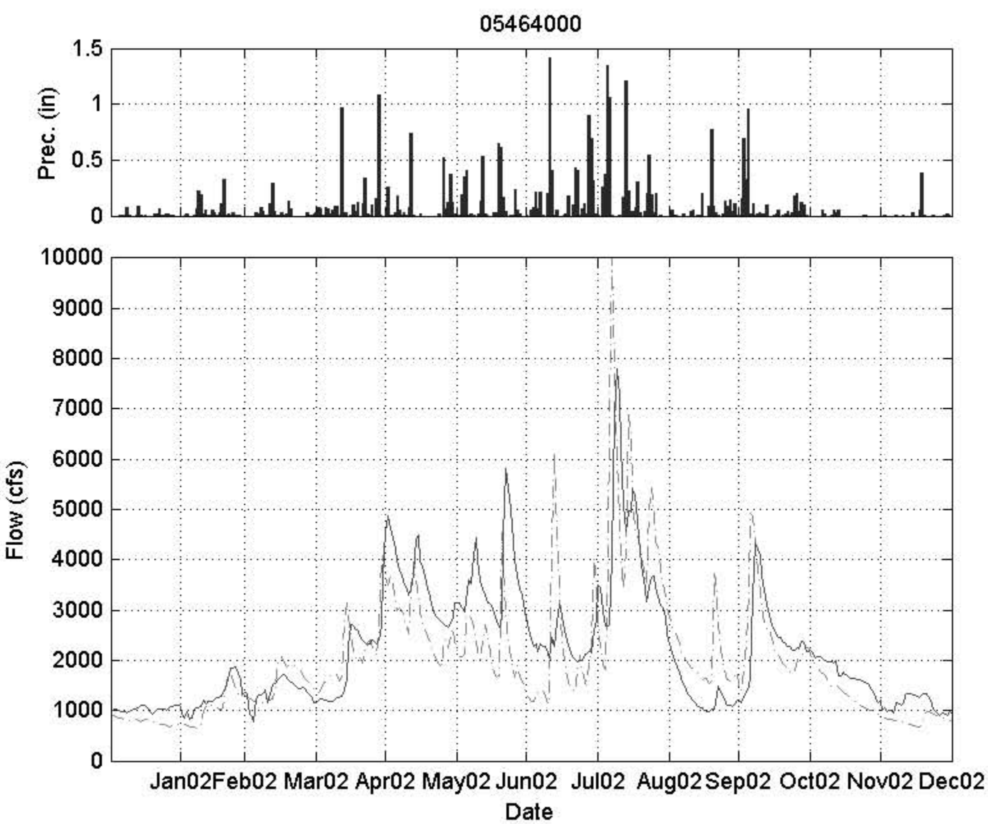

05464000
Prec. (in)
x 10^4
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

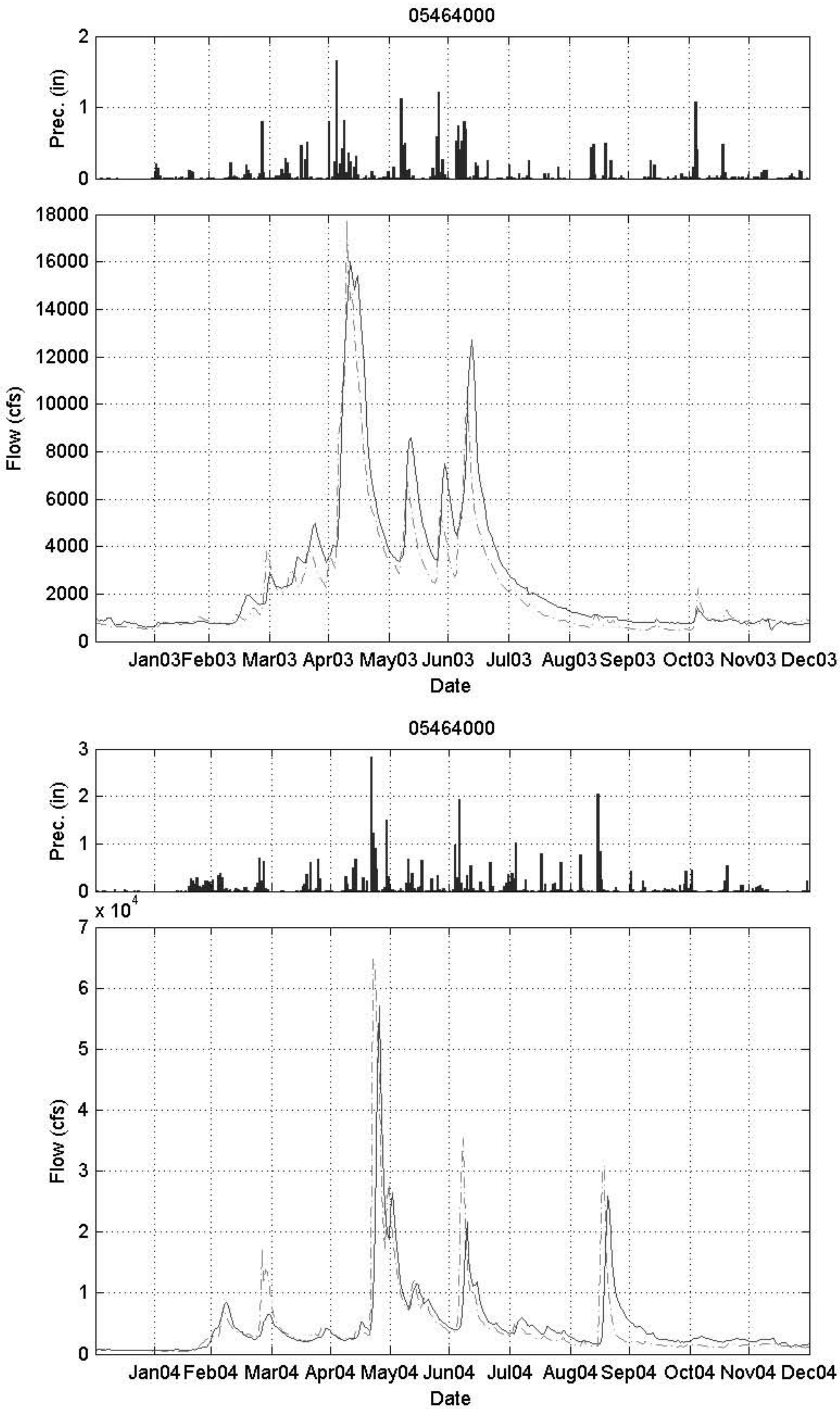

05464000
Prec. (in)
x 10^4
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

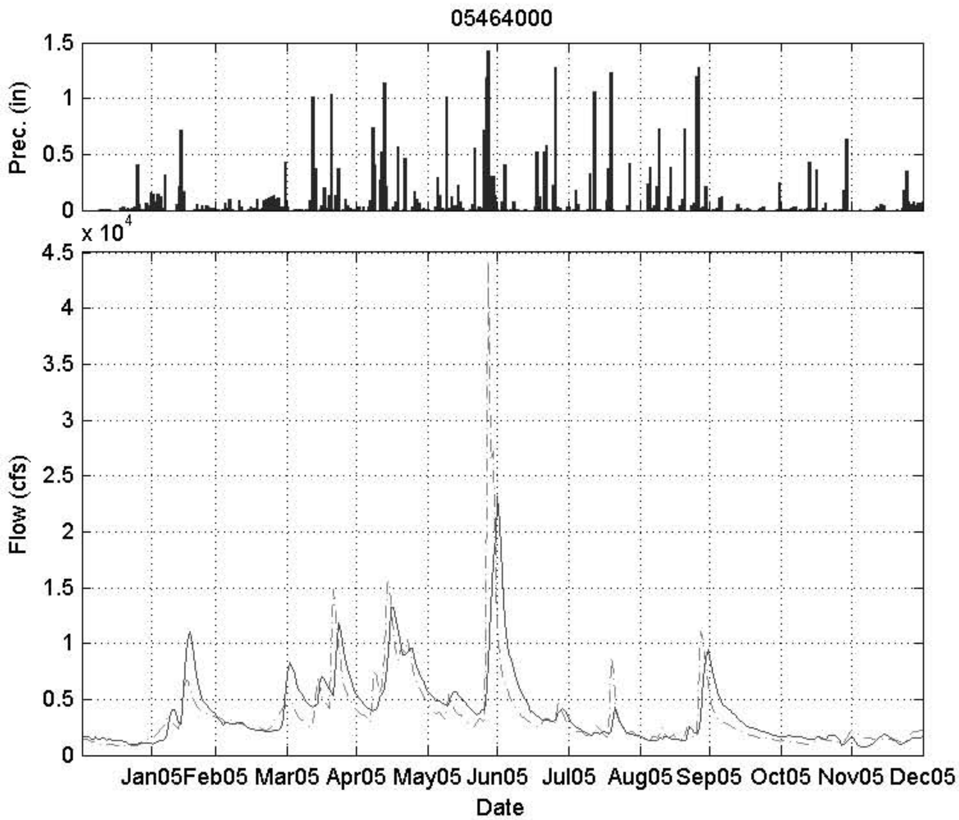

05464000
Prec. (in)
2
1
0
x 10^4
7
6
5
4
3
2
1
0
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

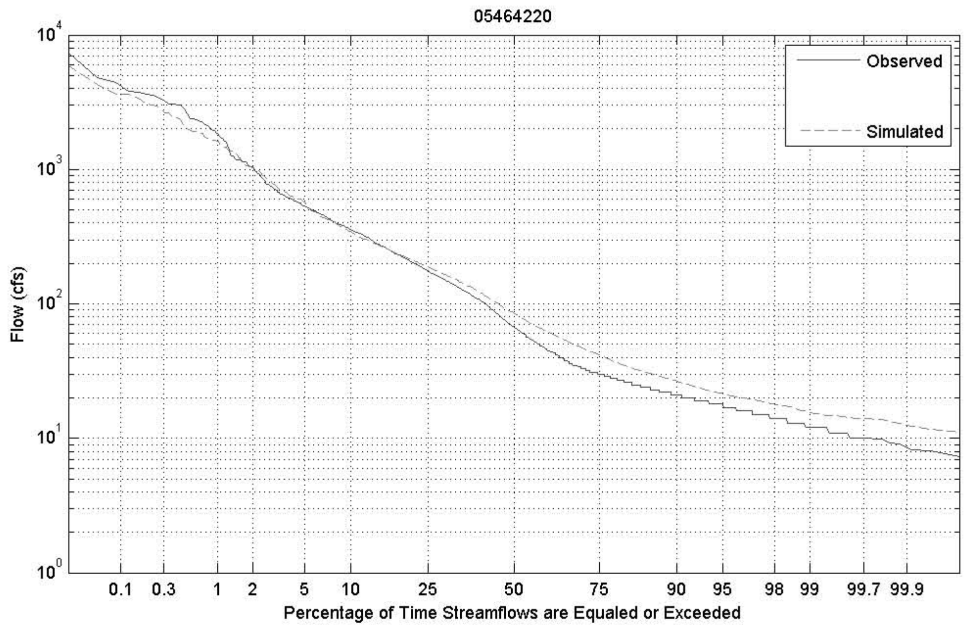

05464000
Prec. (in)
3
2
1
0
x 10^4
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

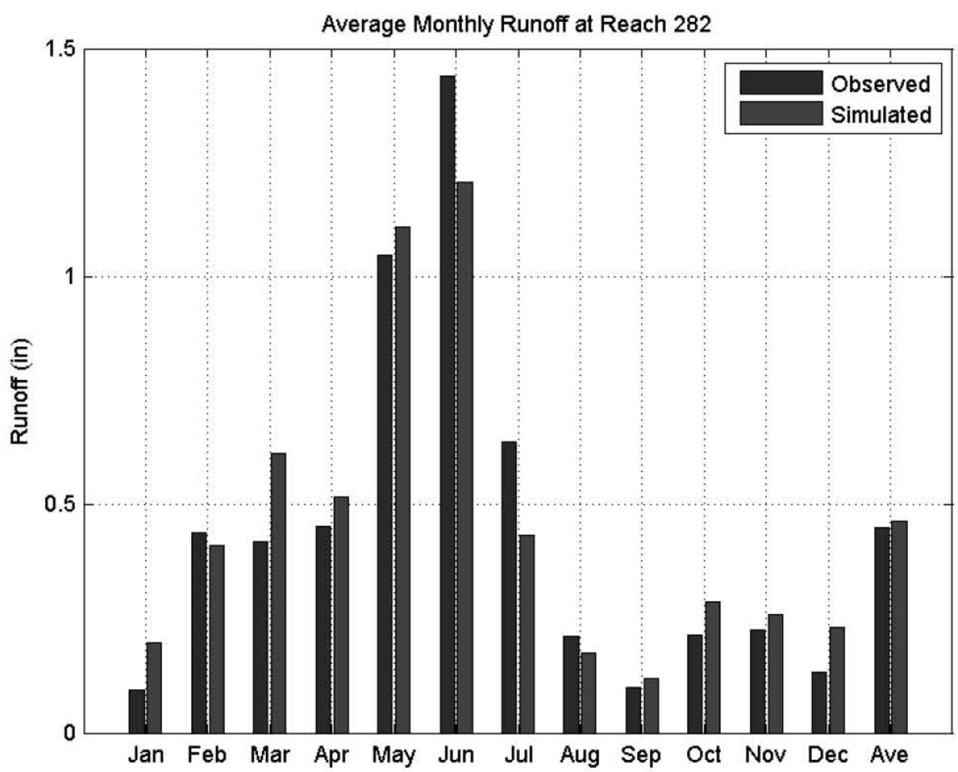

05464000
Prec. (in)
x 10^4
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

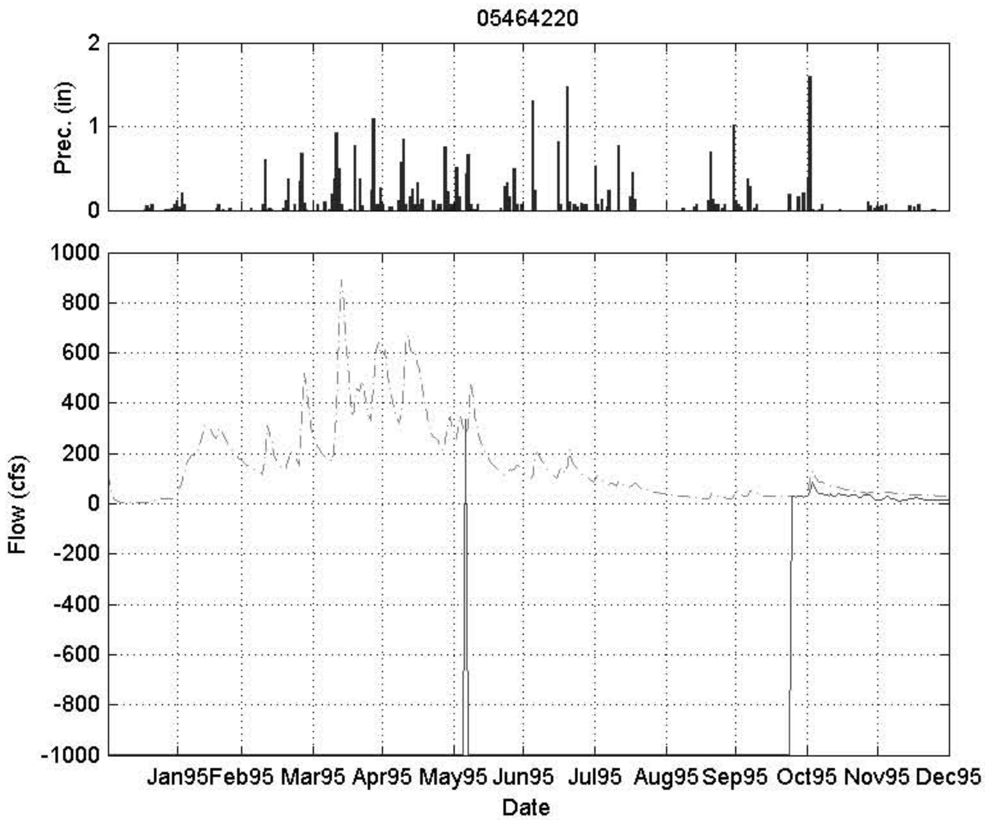

05464000
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

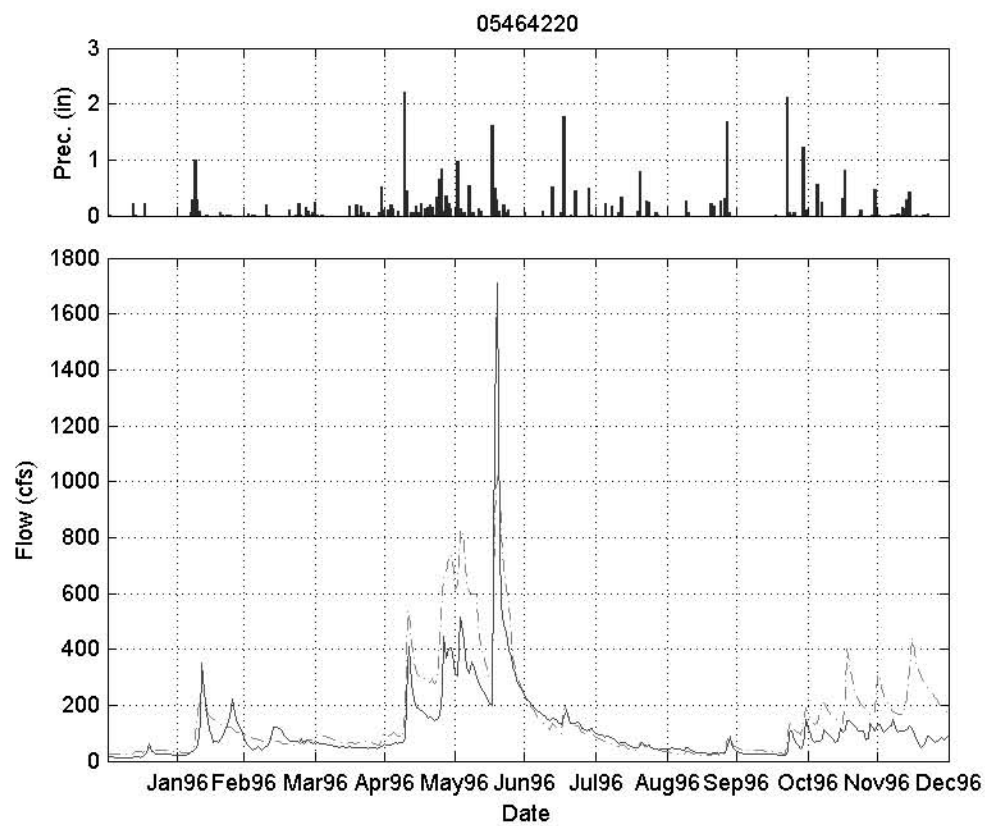

05464000
Prec. (in)
2
1
0
18000
16000
14000
12000
10000
8000
6000
4000
2000
0
Flow (cfs)
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date
05464000
Prec. (in)
3
2
1
0
x 10^4
7
6
5
4
3
2
1
0
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

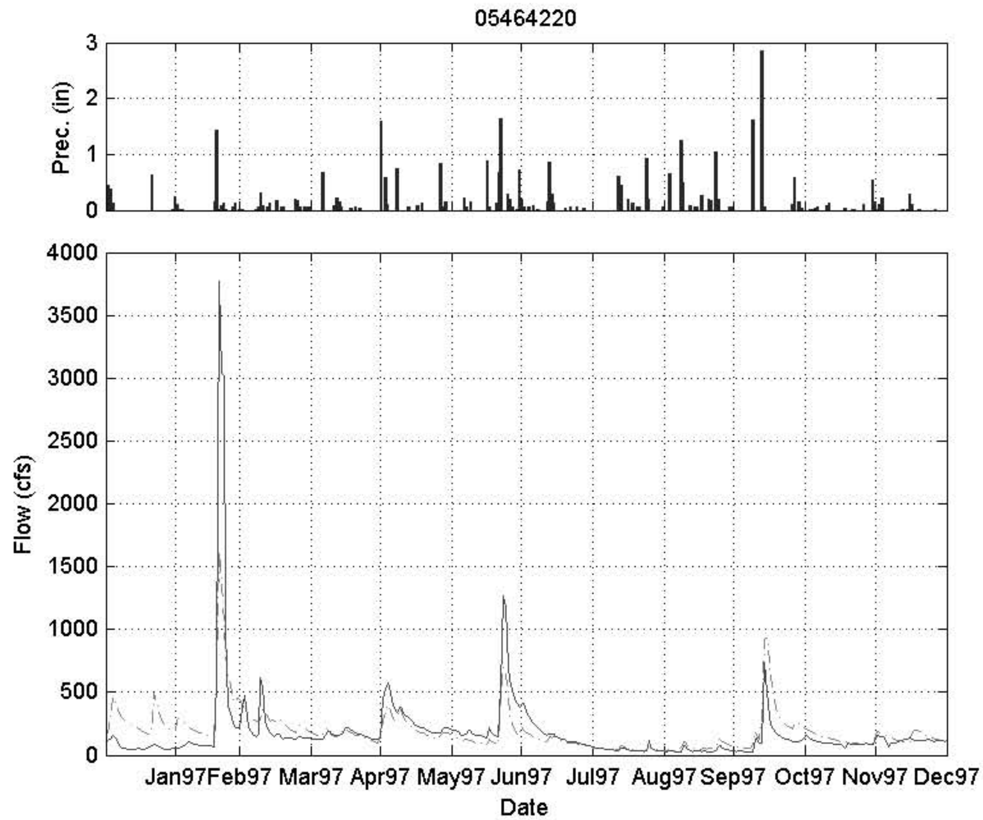

05464000
Prec. (in)
1.5
1
0.5
0
x 10^4
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

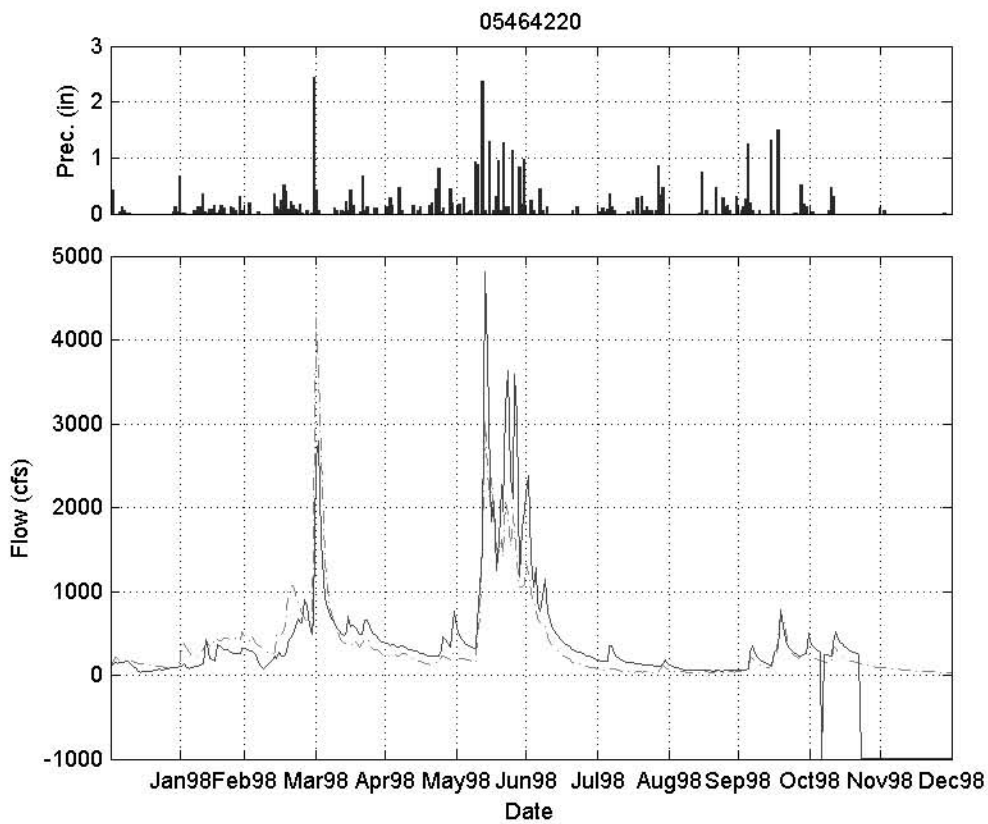

05464220
Observed
Simulated
Flow (cfs)
10^4
10^3
10^2
10^1
10^0
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

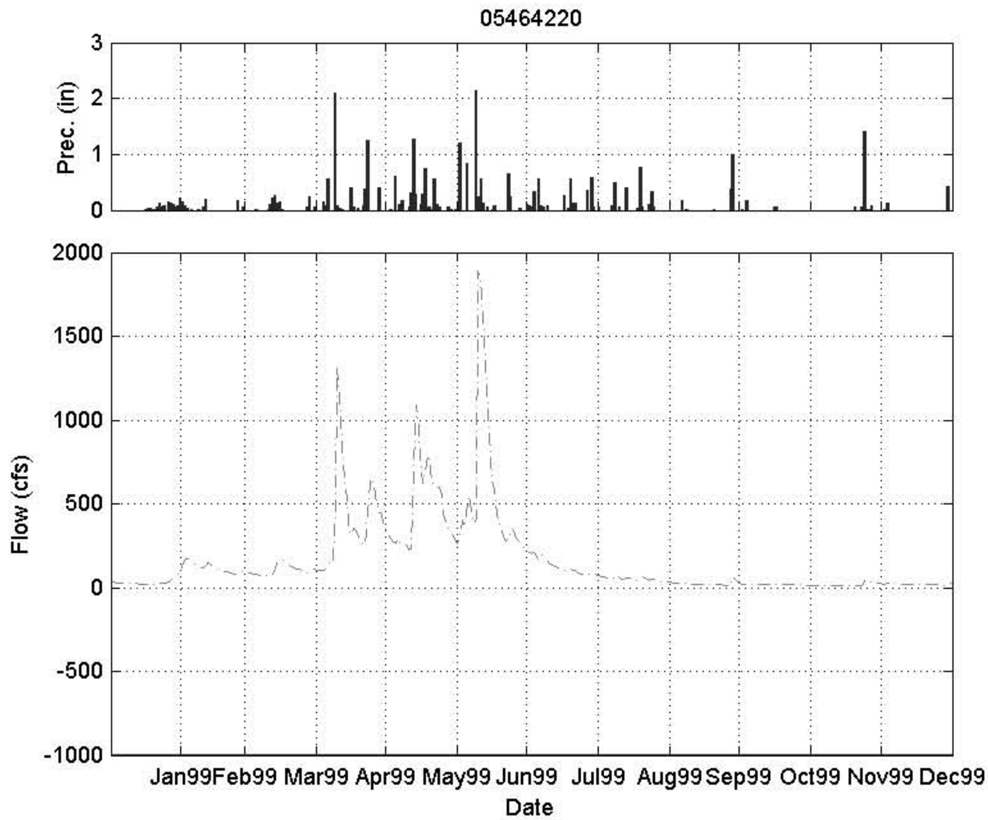

Average Monthly Runoff at Reach 282
Observed
Simulated
Runoff (in)
1.5
1
0.5
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

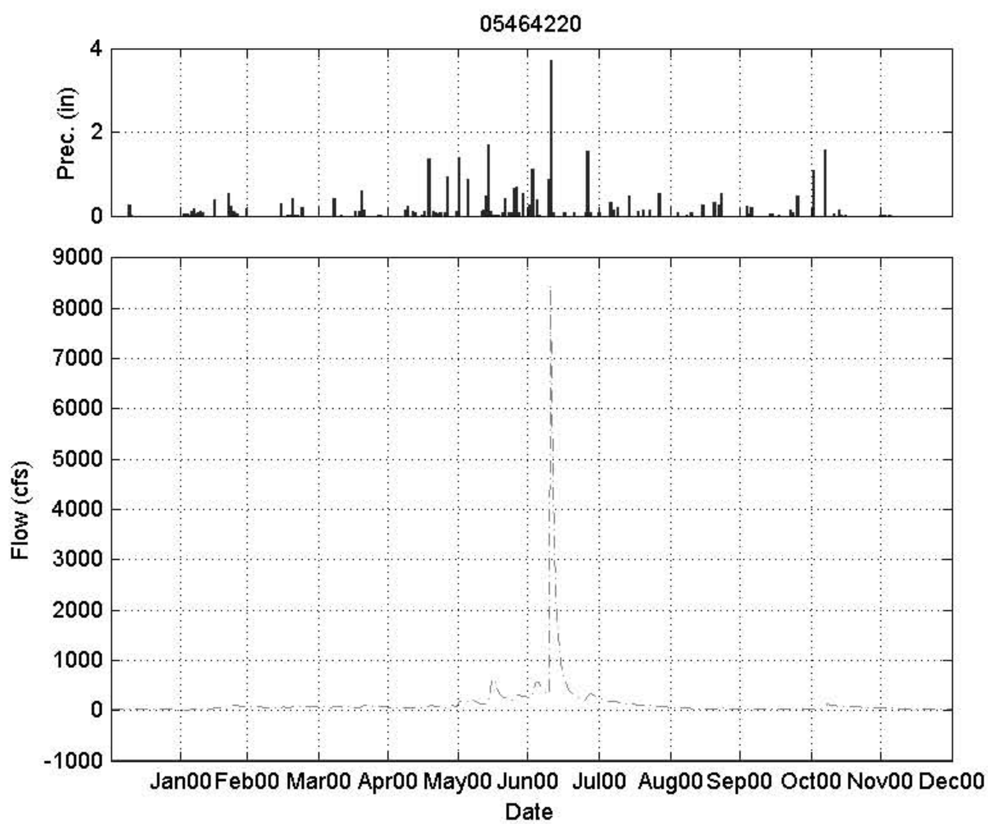

05464220
Prec. (in)
Flow (cfs)
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

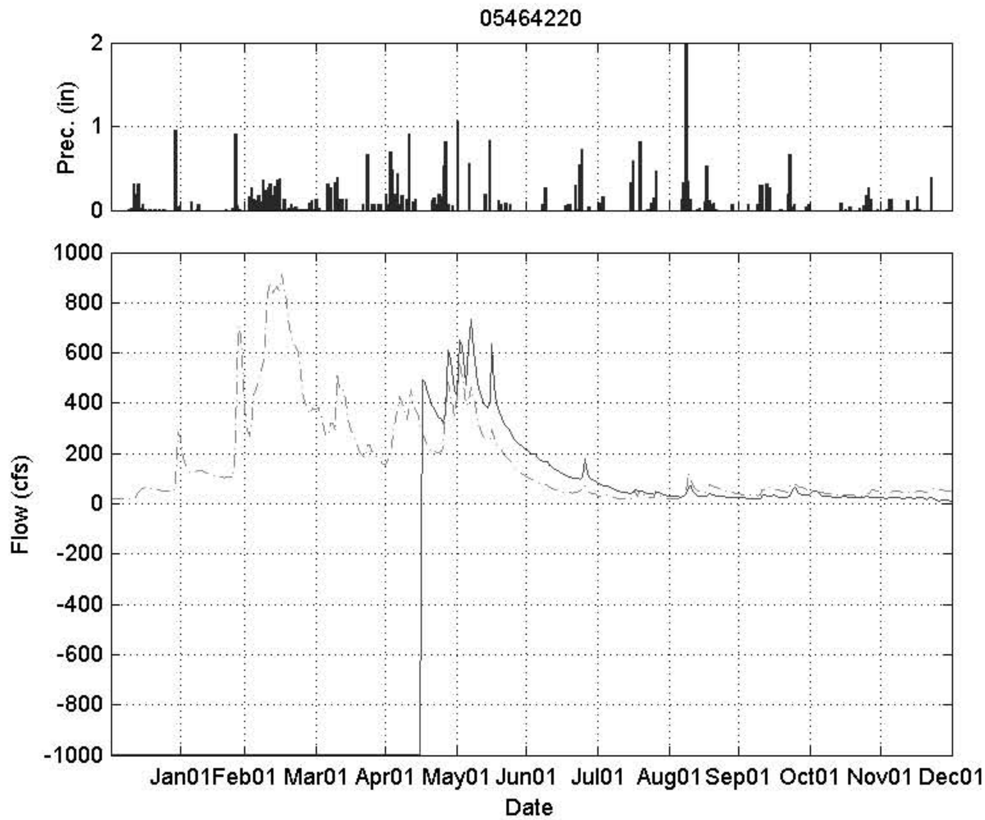

05464220
Prec. (in)
Flow (cfs)
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

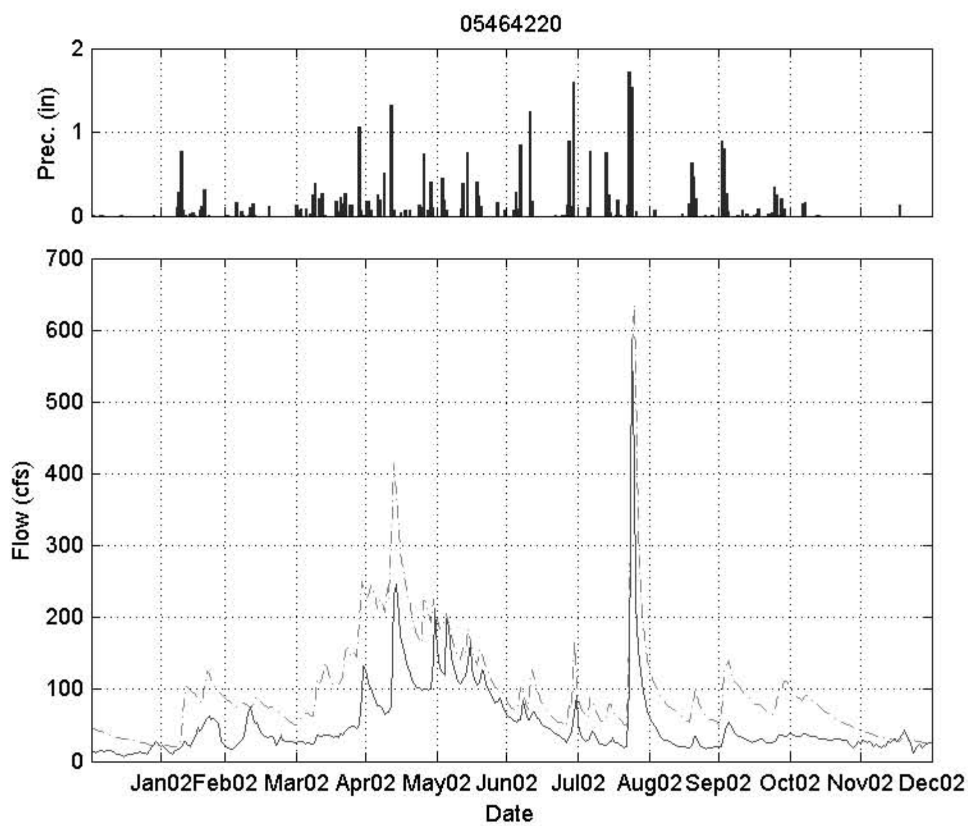

05464220
Prec. (in)
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

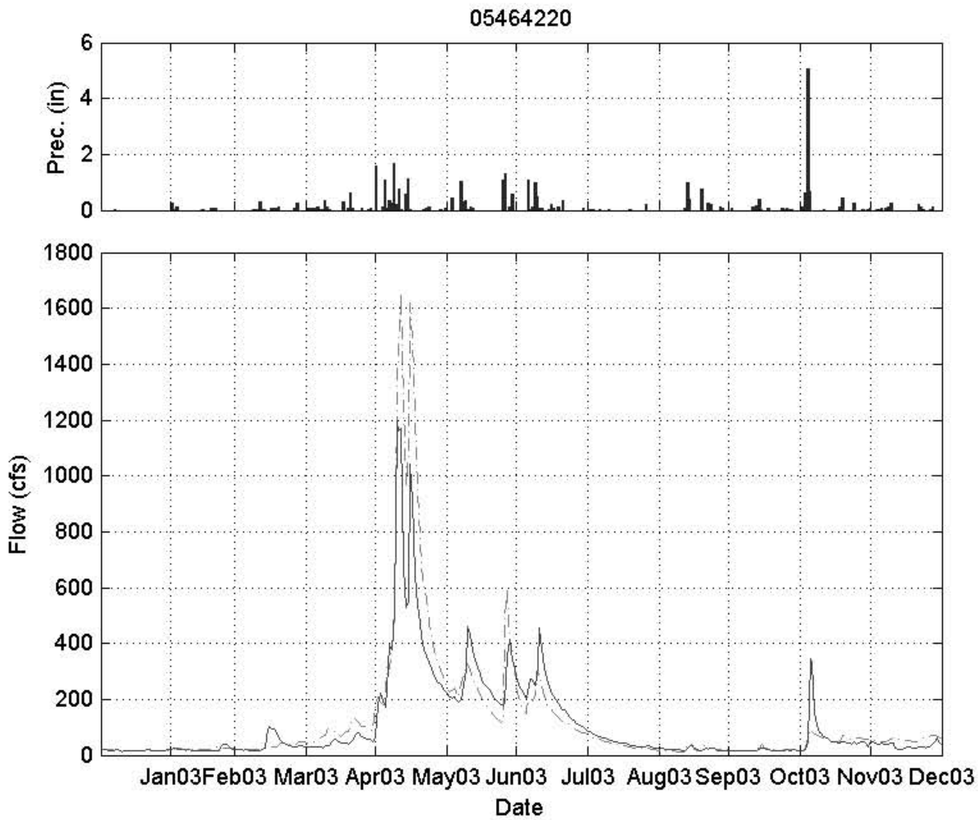

05464220
Prec. (in)
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

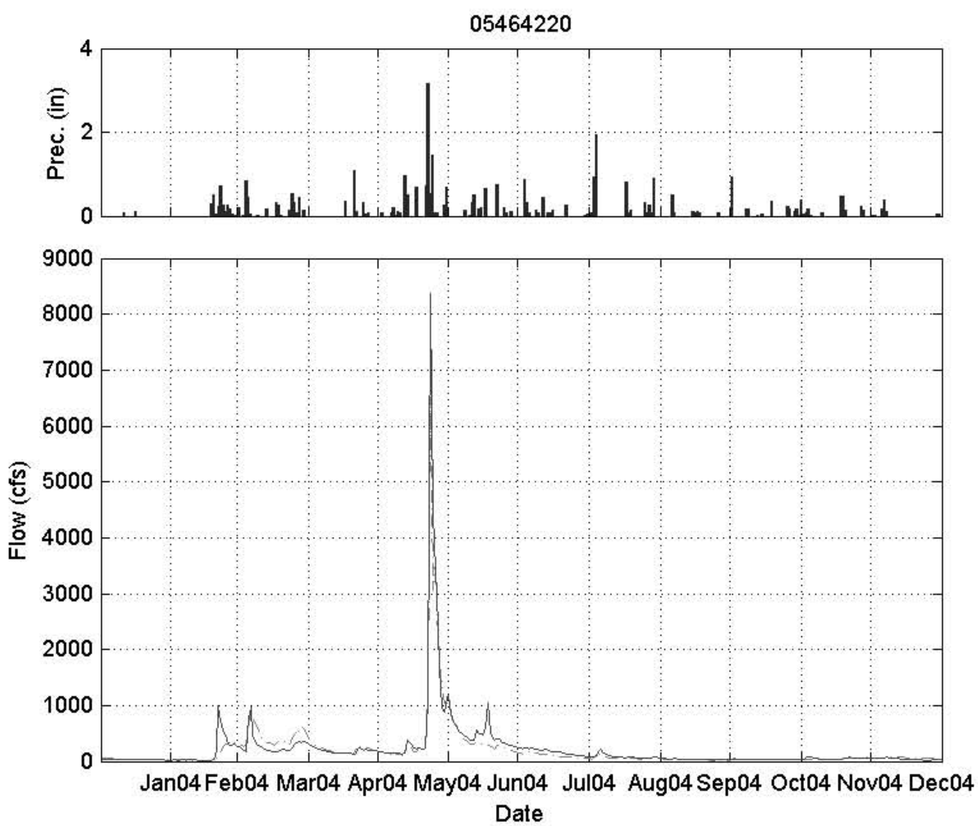

05464220
Prec. (in)
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

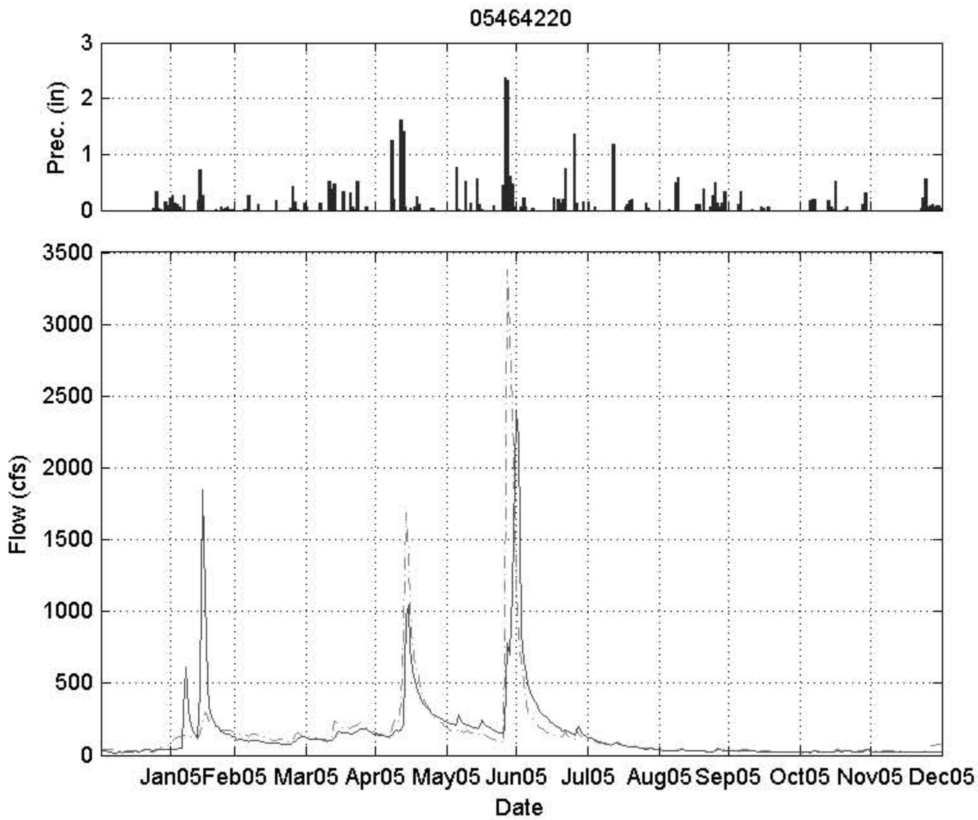

05464220
Prec. (in)
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

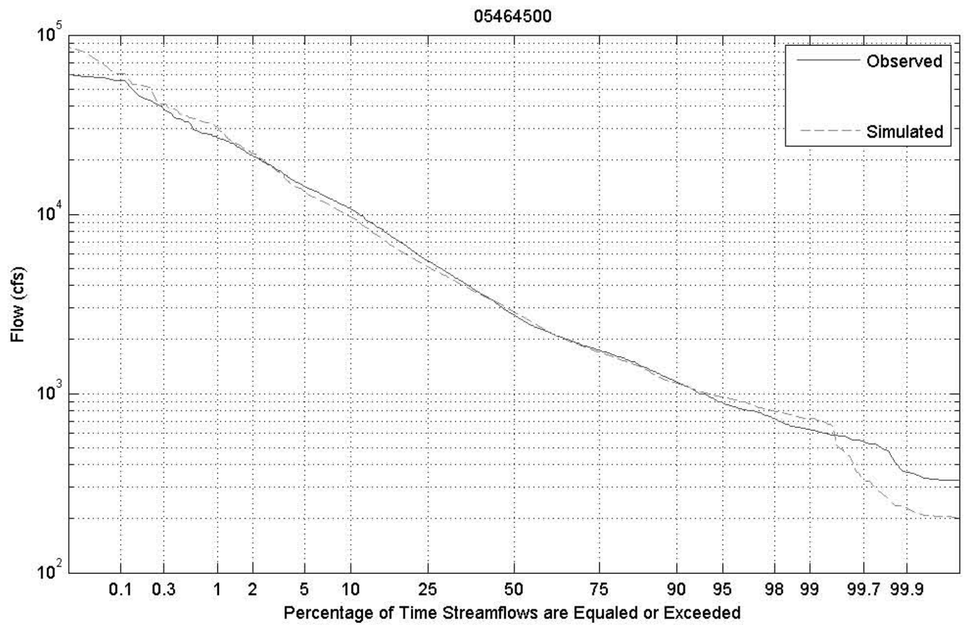

05464220
Prec. (in)
2
1
0
Flow (cfs)
1000
800
600
400
200
0
-200
-400
-600
-800
-1000
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

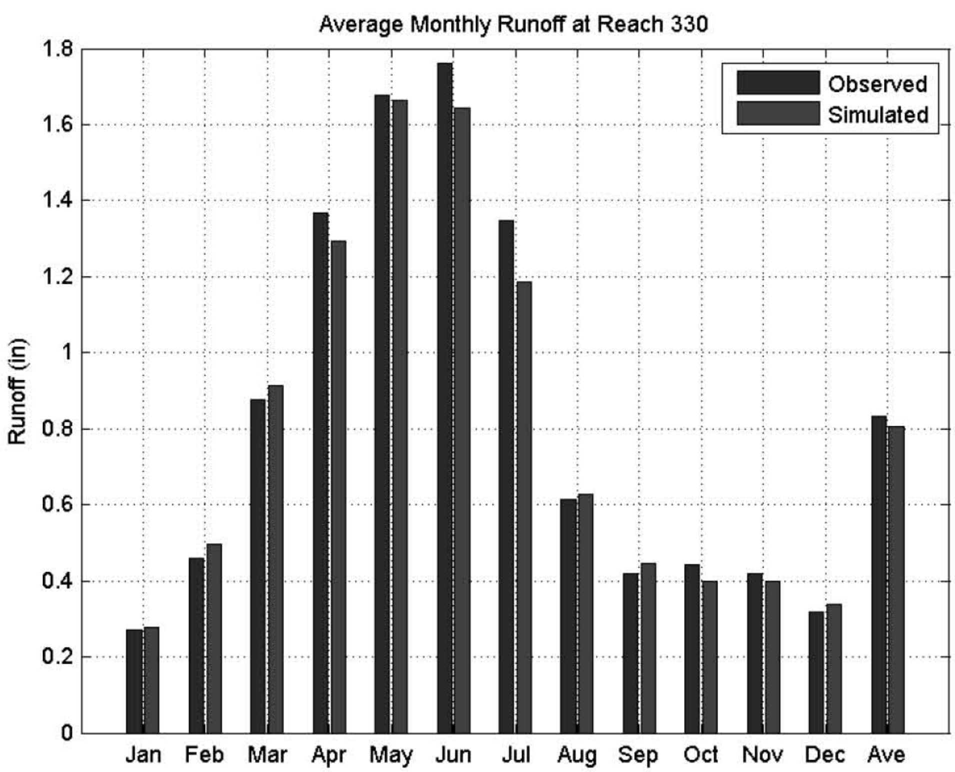

05464220
Prec. (in)
2
1
0
Flow (cfs)
700
600
500
400
300
200
100
0
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

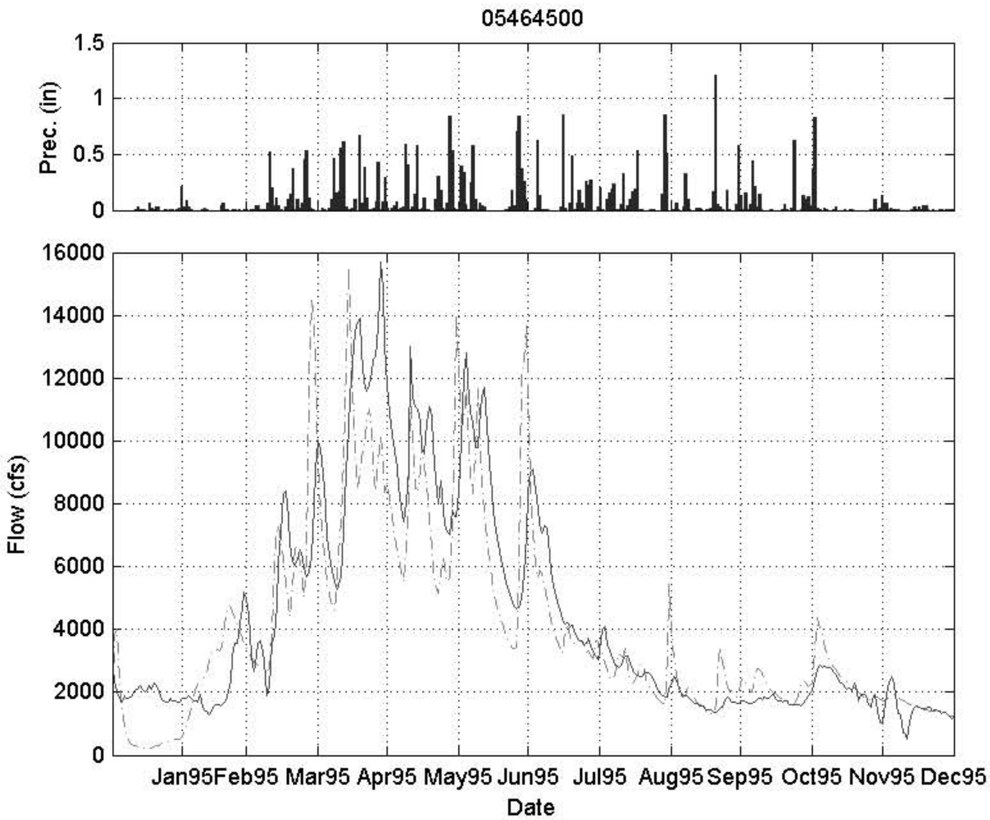

05464220
Prec. (in)
0
2
4
6
Flow (cfs)
0
200
400
600
800
1000
1200
1400
1600
1800
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date

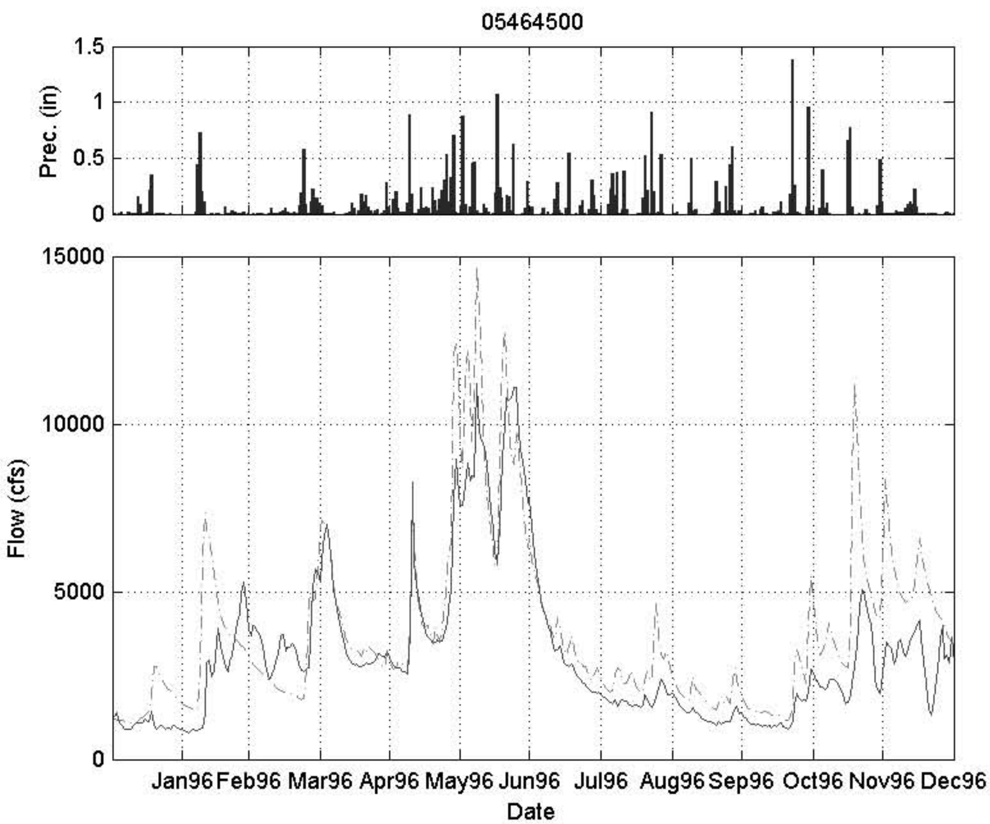

05464220
Prec. (in)
0
2
4
Flow (cfs)
0
1000
2000
3000
4000
5000
6000
7000
8000
9000
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

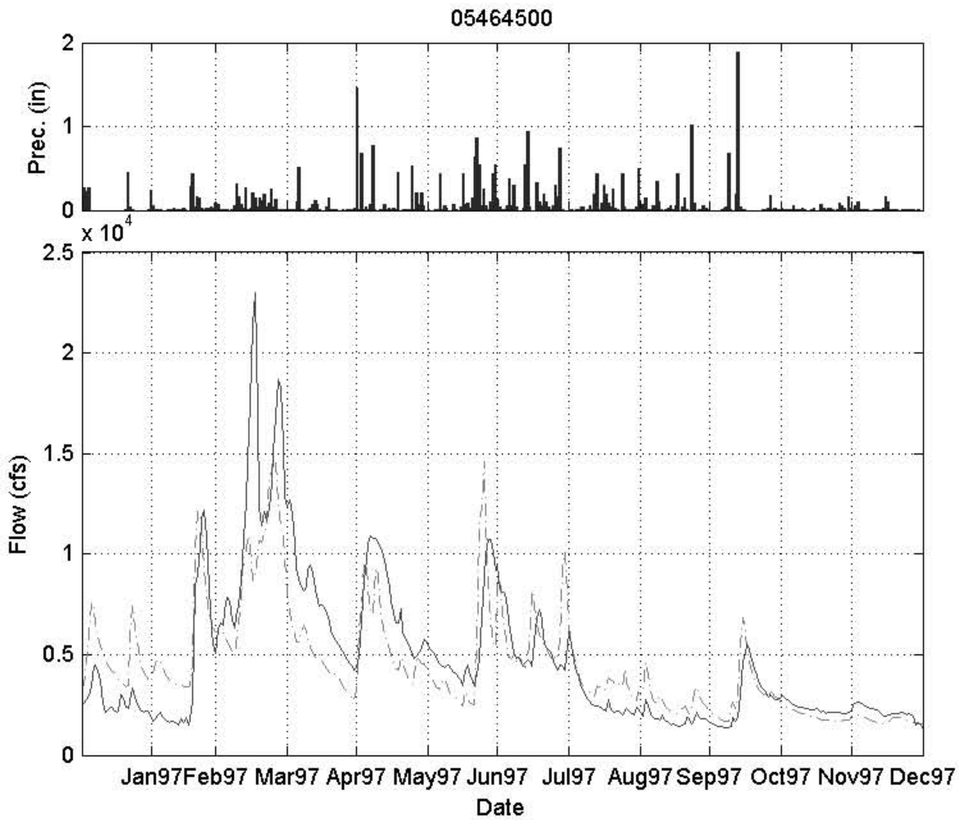

05464220
Prec. (in)
3
2
1
0
Flow (cfs)
3500
3000
2500
2000
1500
1000
500
0
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

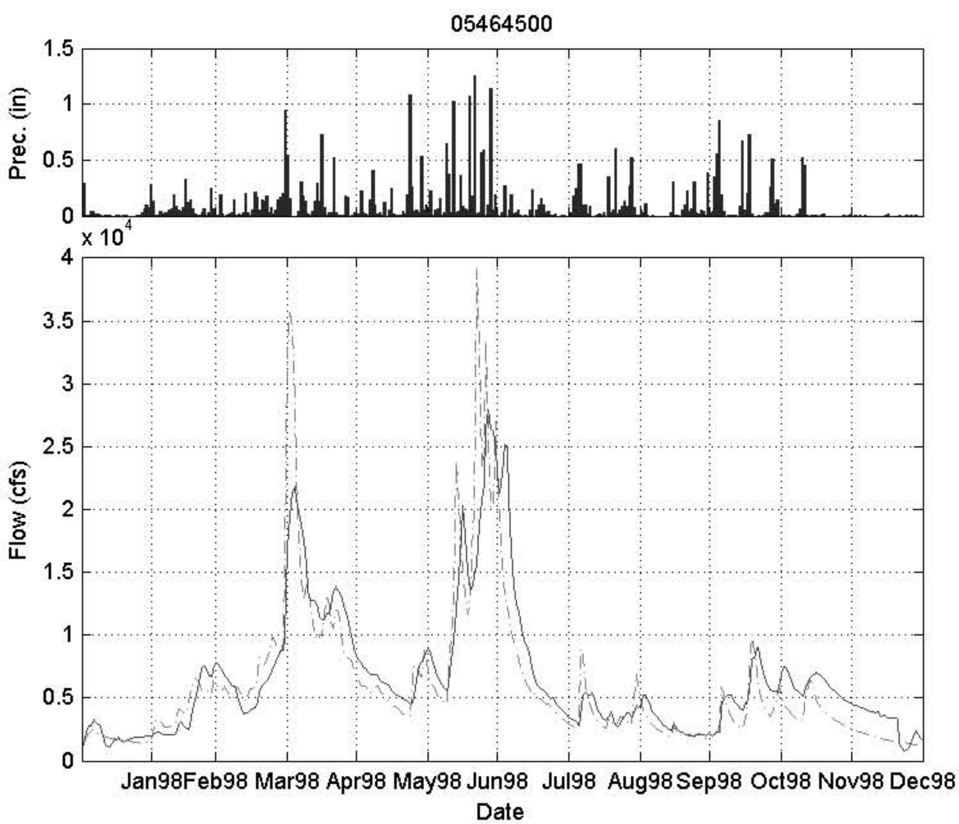

05464500
Observed
Simulated
Flow (cfs)
10^5
10^4
10^3
10^2
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded

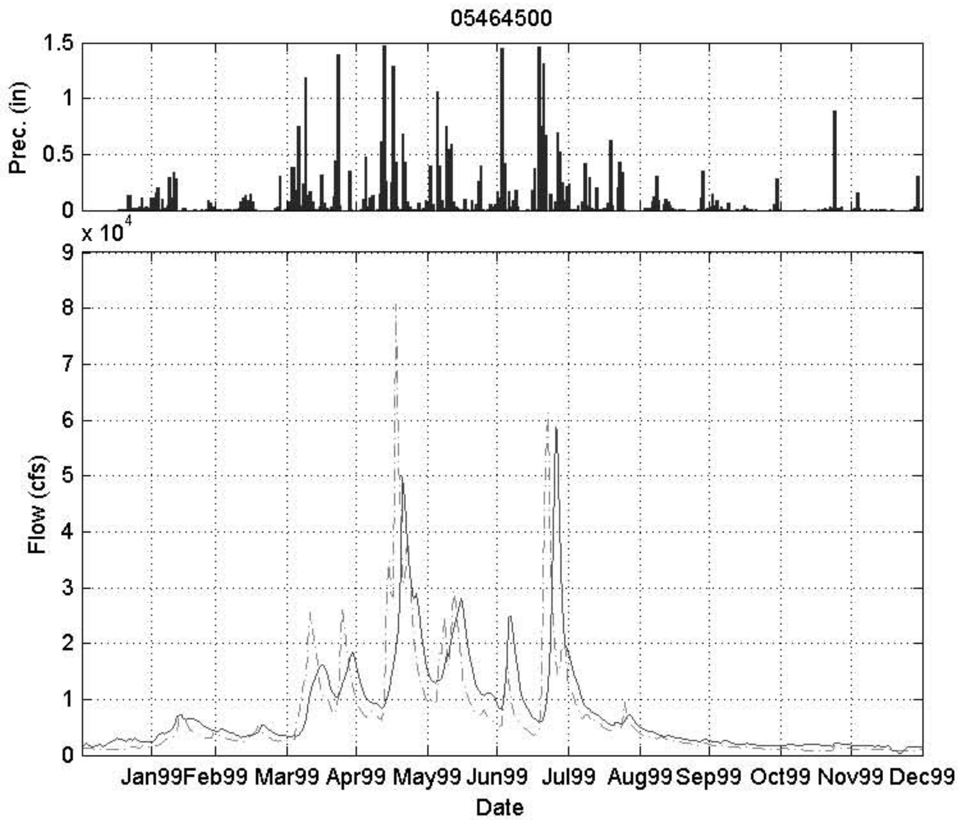

Average Monthly Runoff at Reach 330
Observed
Simulated
Runoff (in)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave

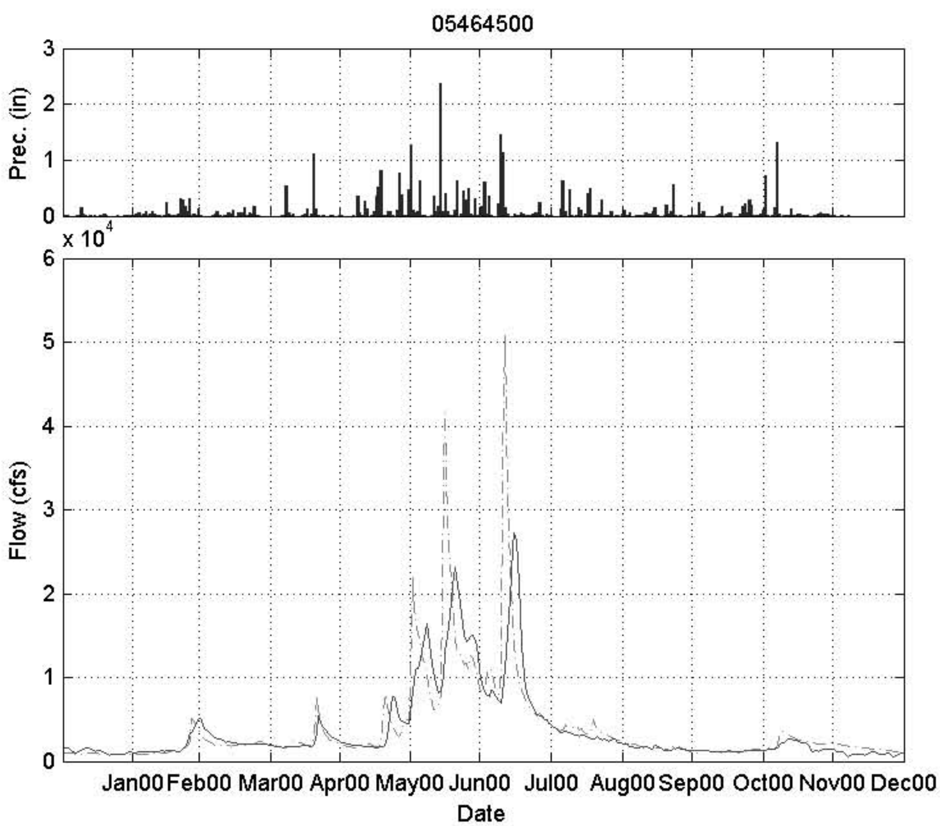

05464500
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
16000
14000
12000
10000
8000
6000
4000
2000
0
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date

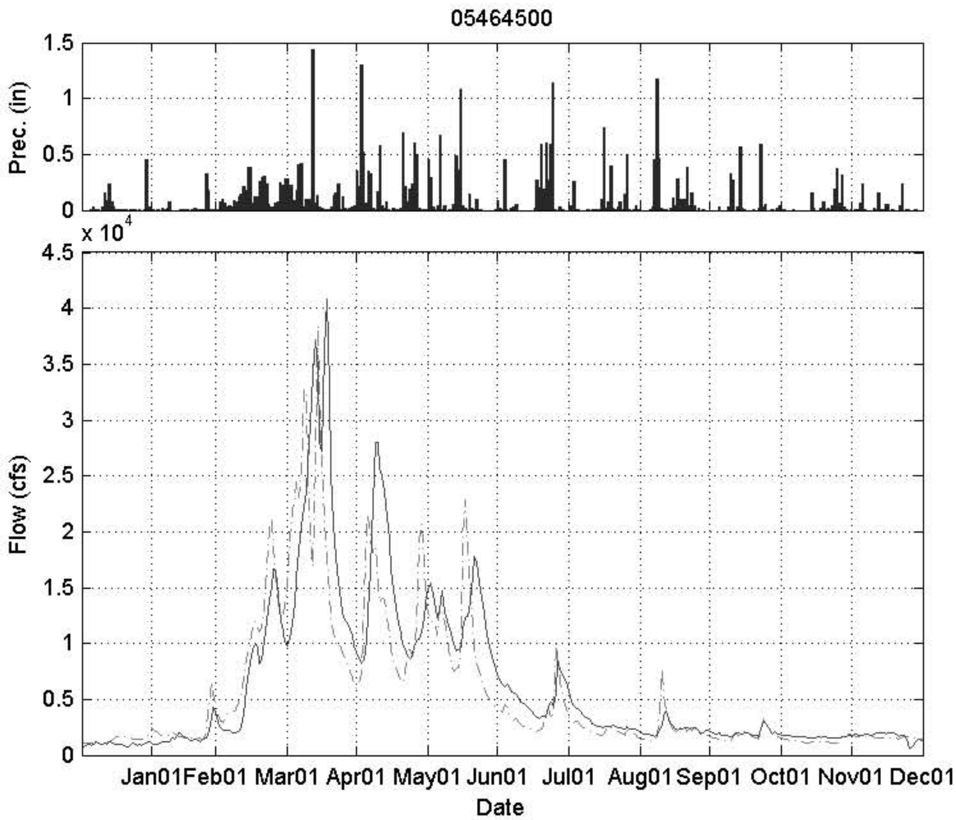

05464500
Prec. (in)
1.5
1
0.5
0
Flow (cfs)
15000
10000
5000
0
Jan96 Feb96 Mar96 Apr96 May96 Jun96 Jul96 Aug96 Sep96 Oct96 Nov96 Dec96
Date

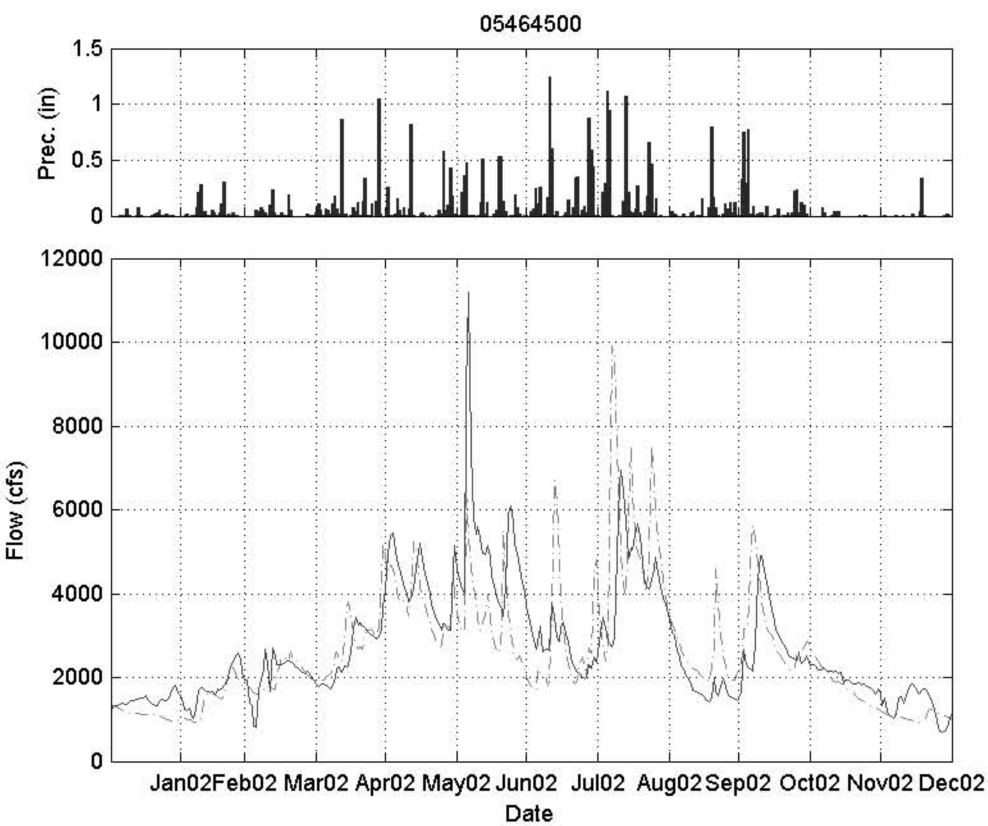

05464500
Prec. (in)
x 10^4
Flow (cfs)
Jan97 Feb97 Mar97 Apr97 May97 Jun97 Jul97 Aug97 Sep97 Oct97 Nov97 Dec97
Date

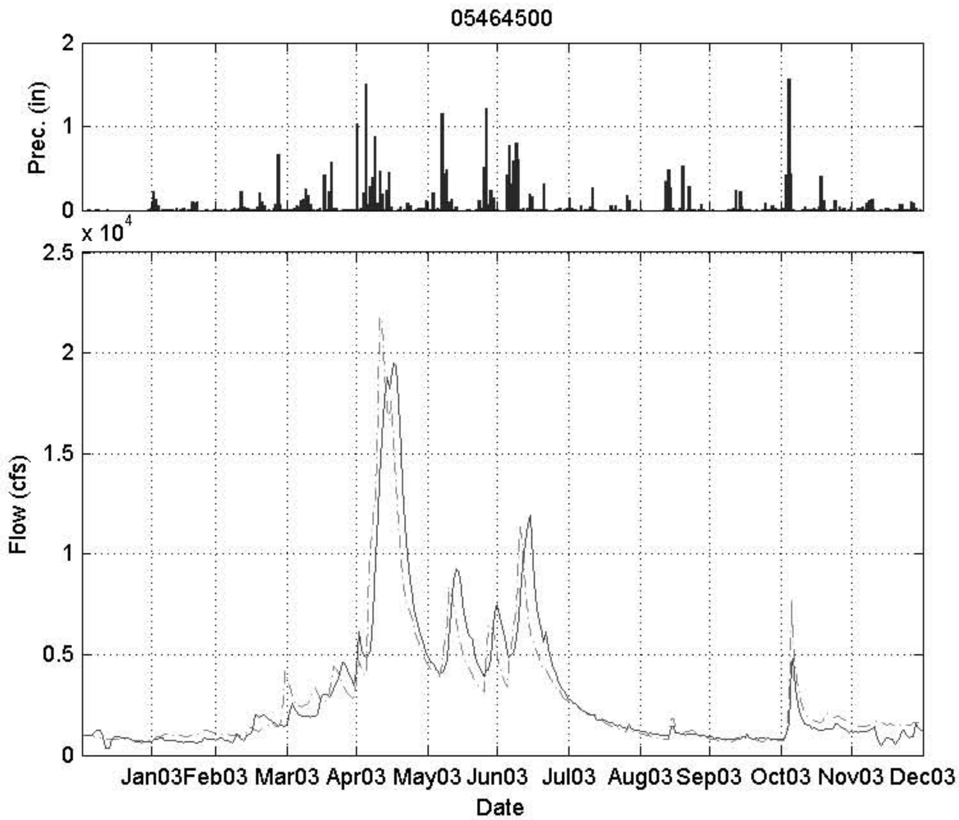

05464500
Prec. (in)
x 10^4
Flow (cfs)
Jan98 Feb98 Mar98 Apr98 May98 Jun98 Jul98 Aug98 Sep98 Oct98 Nov98 Dec98
Date

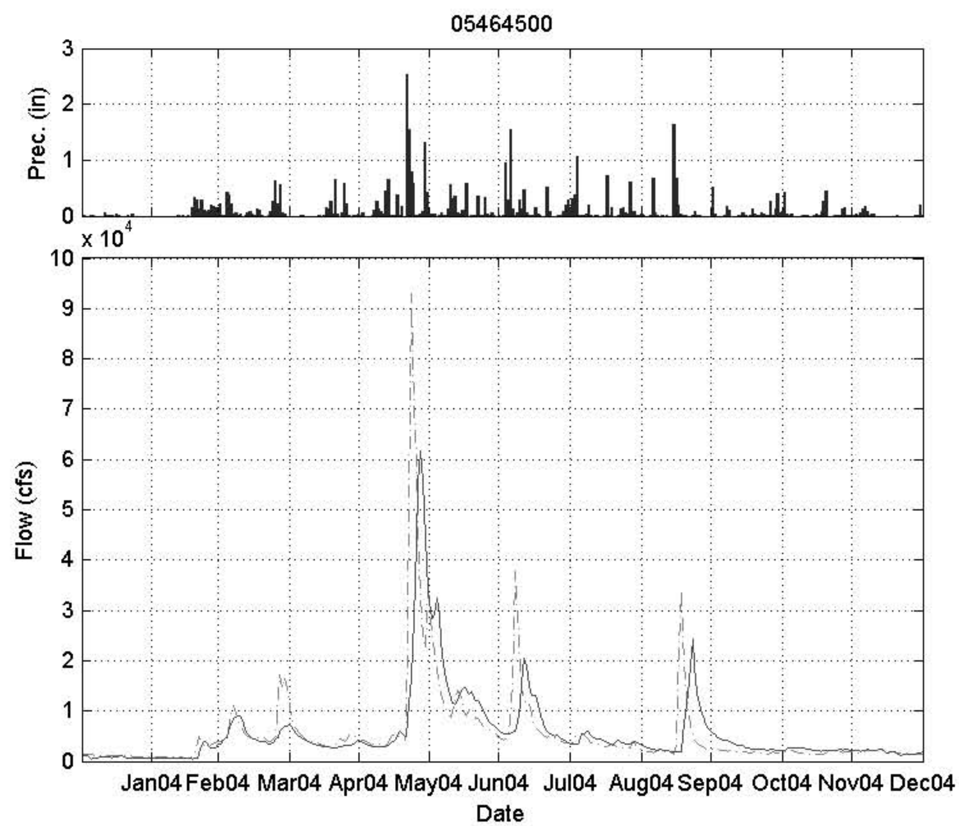

05464500
Prec. (in)
1.5
1
0.5
0
x 10^4
9
8
7
6
5
4
3
2
1
0
Flow (cfs)
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date

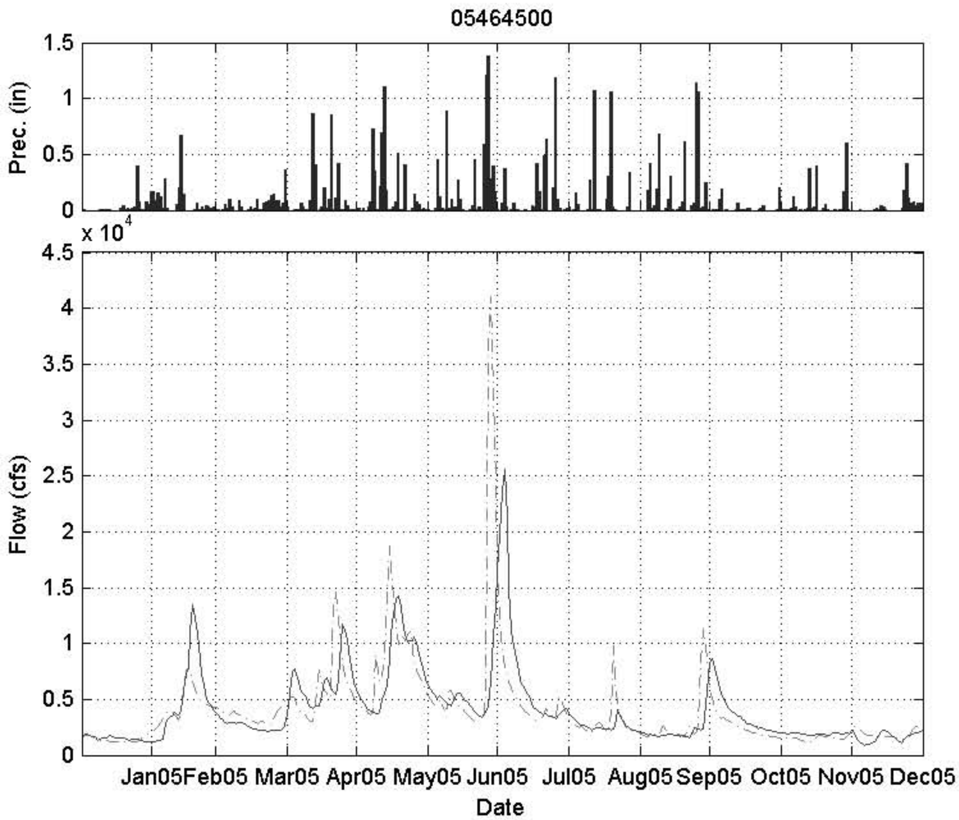

05464500
Prec. (in)
3
2
1
0
x 10^4
6
5
4
3
2
1
0
Flow (cfs)
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date

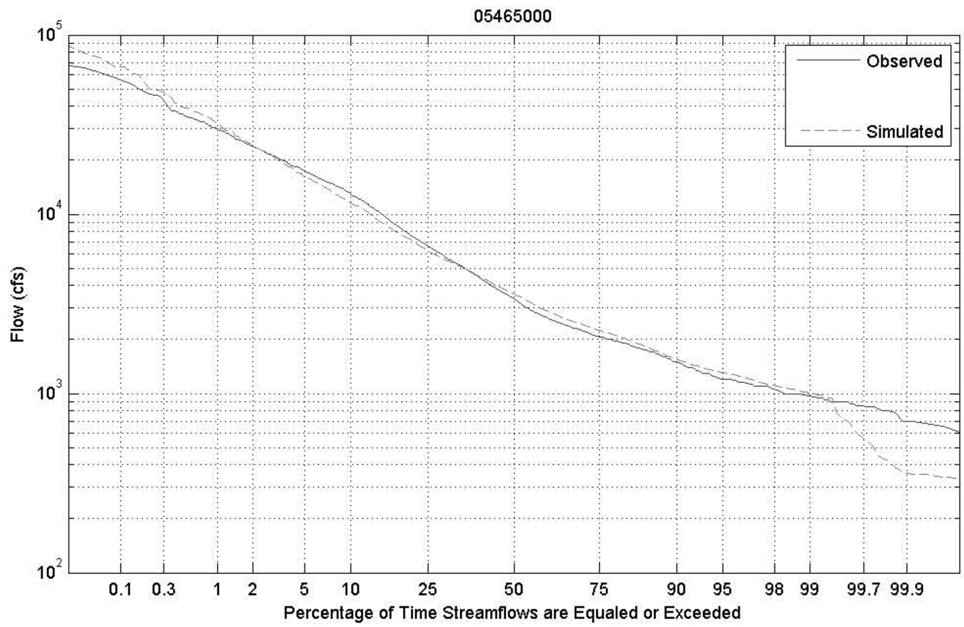

05464500
Prec. (in)
x 10^4
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date

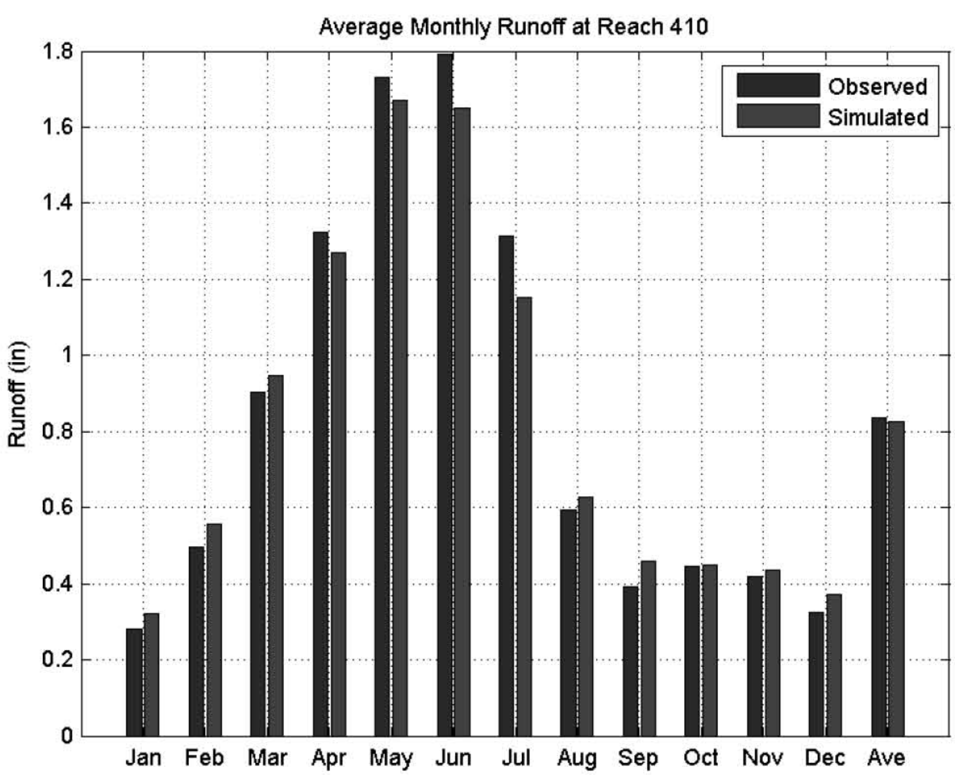

05464500
Prec. (in)
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date

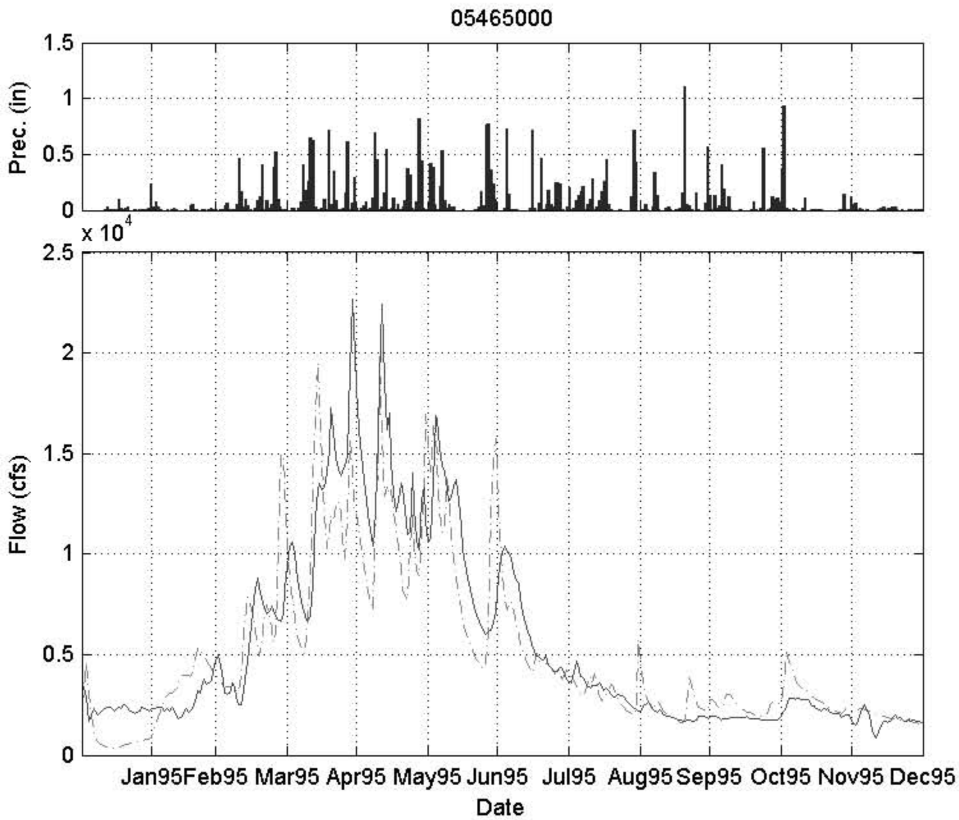

05464500
Prec. (in)
Flow (cfs)
x 10^4
Jan03 Feb03 Mar03 Apr03 May03 Jun03 Jul03 Aug03 Sep03 Oct03 Nov03 Dec03
Date


05464500
Prec. (in)
Flow (cfs)
x 10^4
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date


05464500
Prec. (in)
1.5
1
0.5
0
x 10^4
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date


05465000
Observed
Simulated
Flow (cfs)
10^5
10^4
10^3
10^2
0.1 0.3 1 2 5 10 25 50 75 90 95 98 99 99.7 99.9
Percentage of Time Streamflows are Equaled or Exceeded


Average Monthly Runoff at Reach 410
Observed
Simulated
Runoff (in)
1.8
1.6
1.4
1.2
1
0.8
0.6
0.4
0.2
0
Jan Feb Mar Apr May Jun Jul Aug Sep Oct Nov Dec Ave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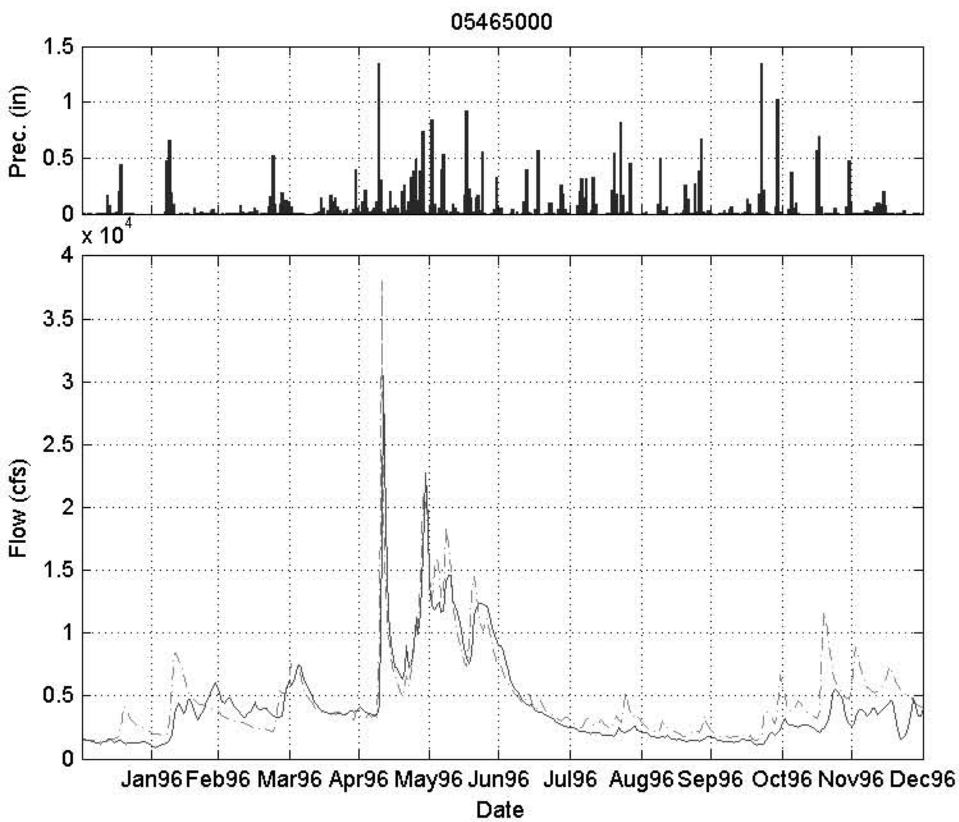
Prec. (in)
Flow (cfs)
x 10^4
Jan95 Feb95 Mar95 Apr95 May95 Jun95 Jul95 Aug95 Sep95 Oct95 Nov95 Dec95
Date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Flow (cfs)
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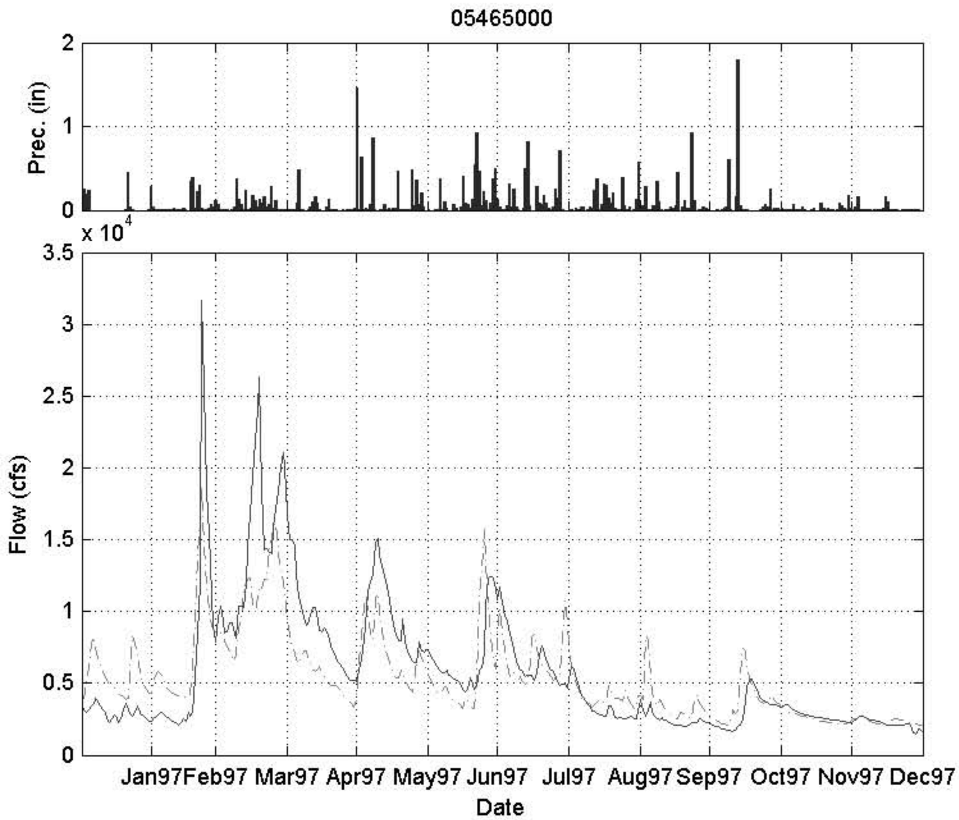
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Prec. (in)
x 10^4
Flow (cfs)
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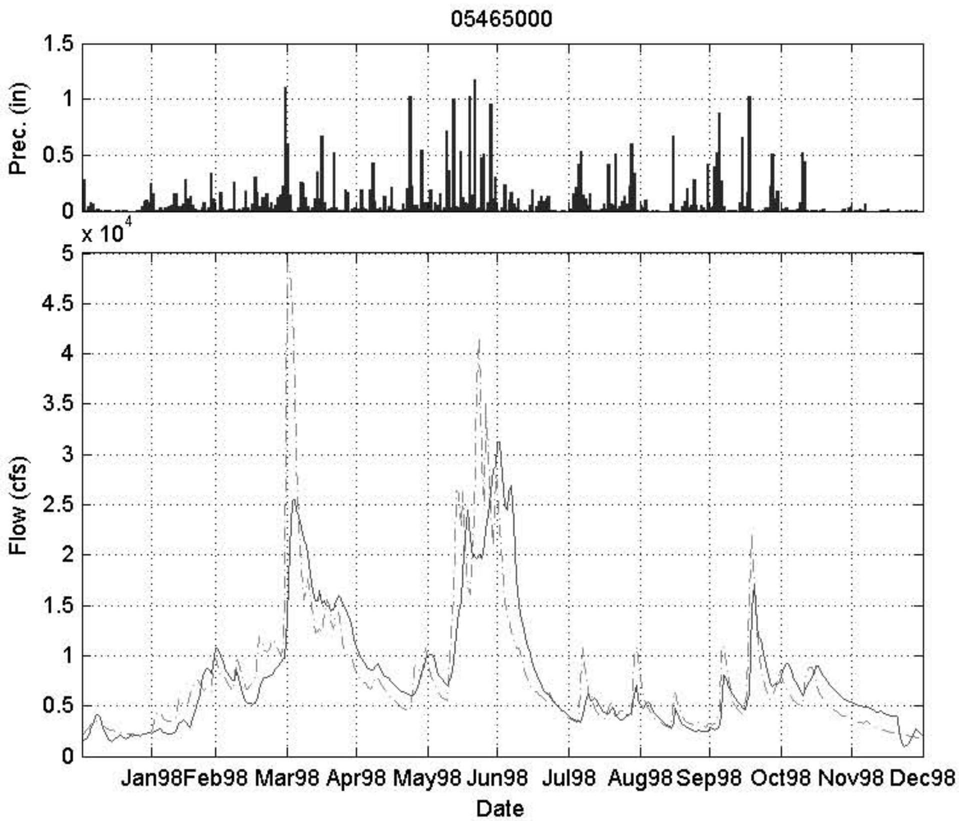
Date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Flow (cfs)
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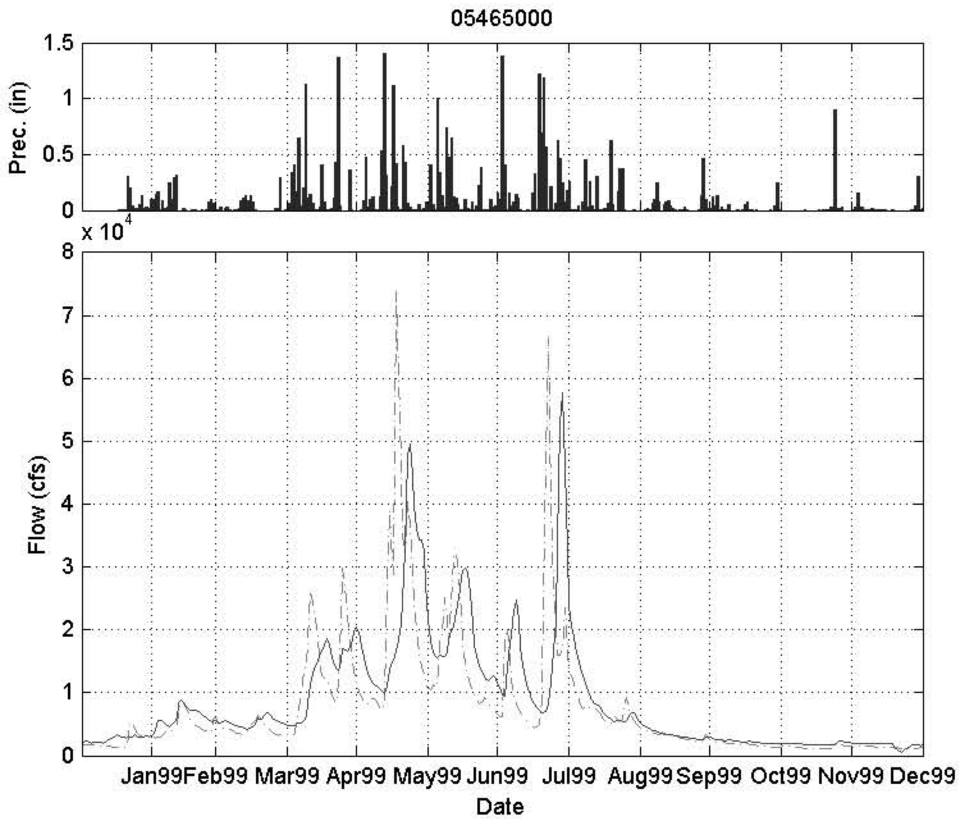
Date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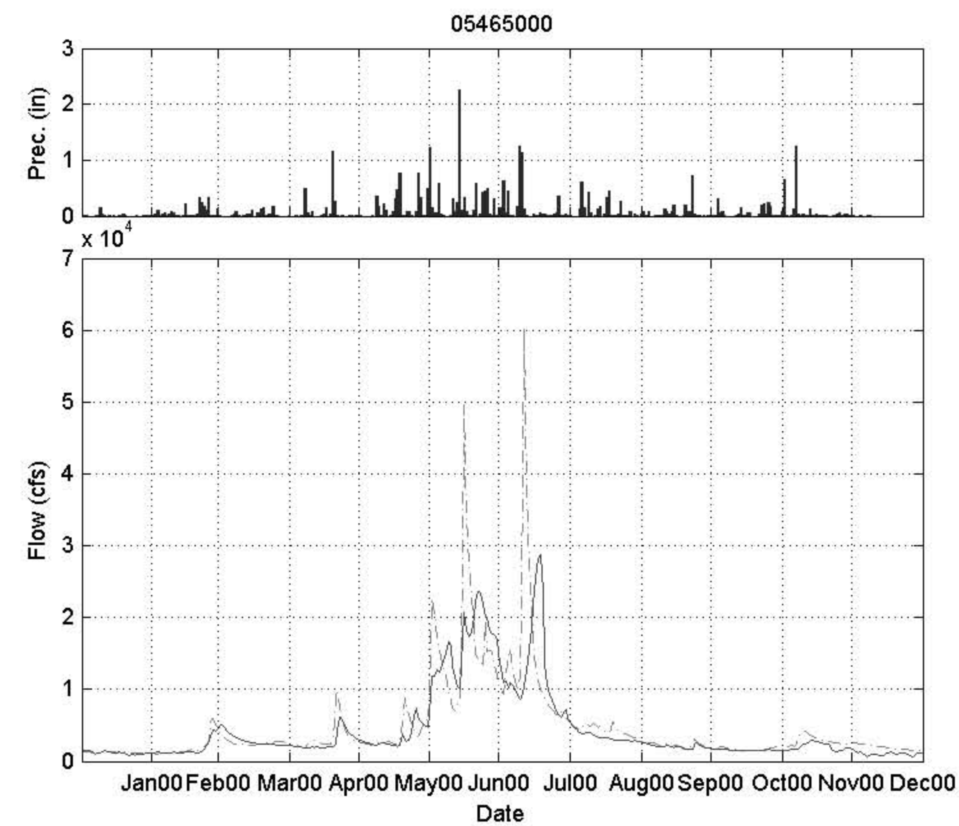
Prec. (in)
1.5
1
0.5
0
x 10^4
Flow (cfs)
8
7
6
5
4
3
2
1
0
Jan99 Feb99 Mar99 Apr99 May99 Jun99 Jul99 Aug99 Sep99 Oct99 Nov99 Dec99
Date


05465000
Prec. (in)
3
2
1
0
x 10^4
Flow (cfs)
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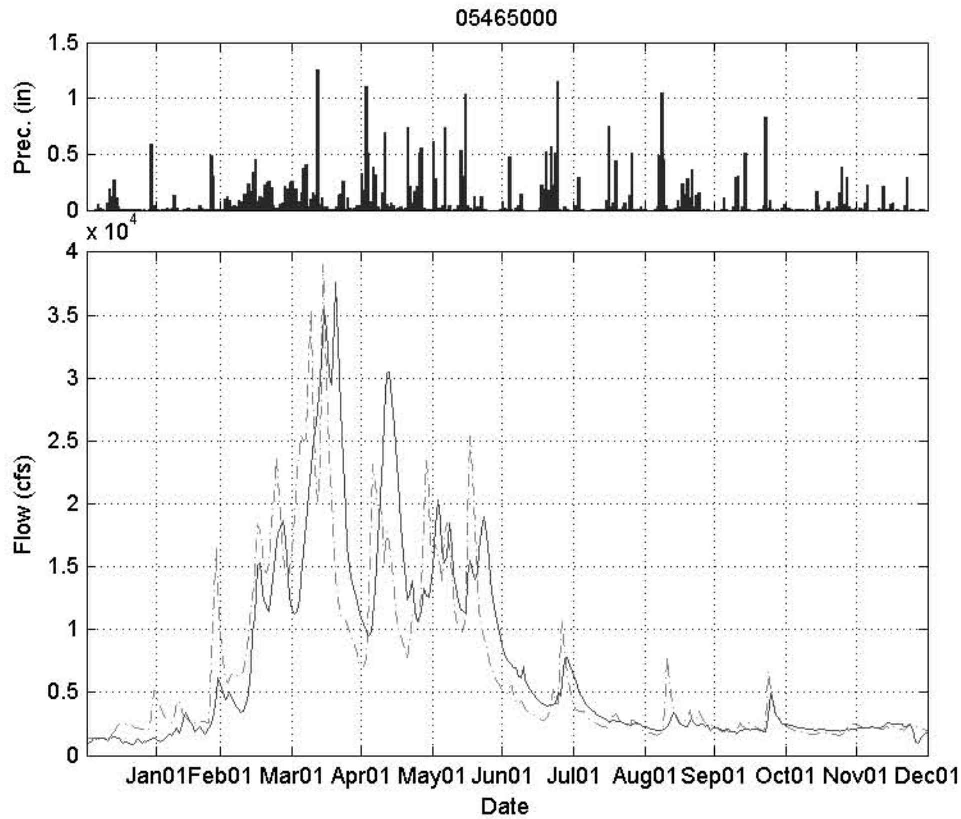
6
5
4
3
2
1
0
Jan00 Feb00 Mar00 Apr00 May00 Jun00 Jul00 Aug00 Sep00 Oct00 Nov00 Dec00
Date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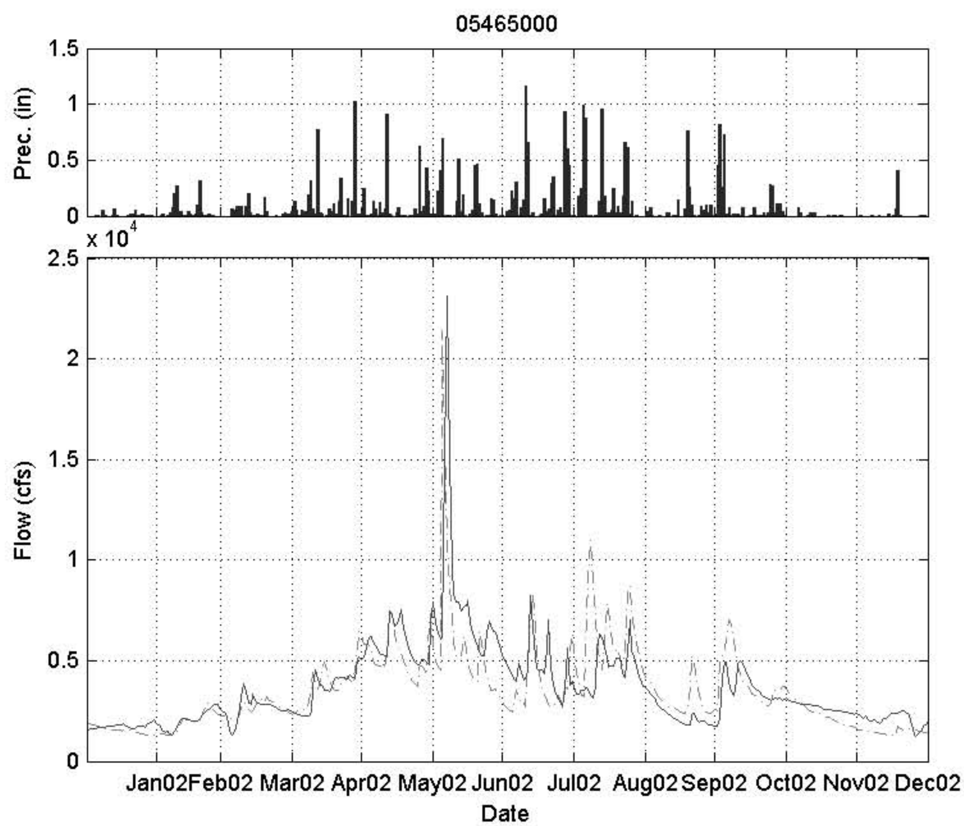
Prec. (in)
1.5
1
0.5
0
x 10^4
4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan01 Feb01 Mar01 Apr01 May01 Jun01 Jul01 Aug01 Sep01 Oct01 Nov01 Dec01
Date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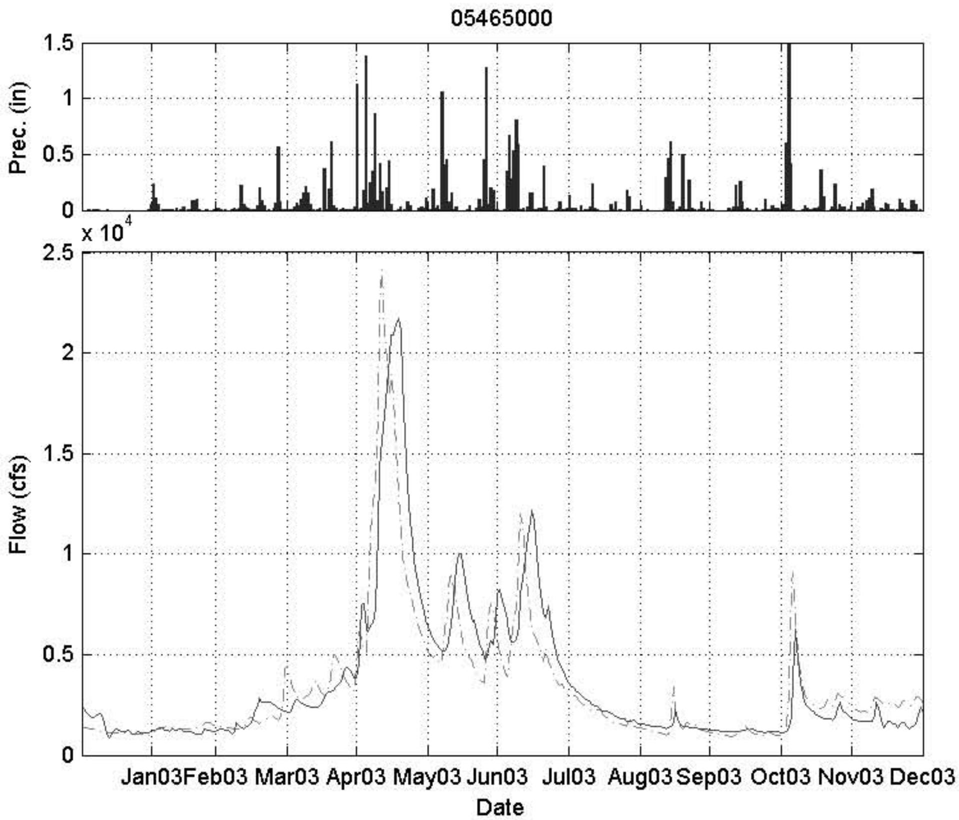
Prec. (in)
1.5
1
0.5
0
x 10^4
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan02 Feb02 Mar02 Apr02 May02 Jun02 Jul02 Aug02 Sep02 Oct02 Nov02 Dec02
Date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Prec. (in)
x 10^4
Flow (cfs)
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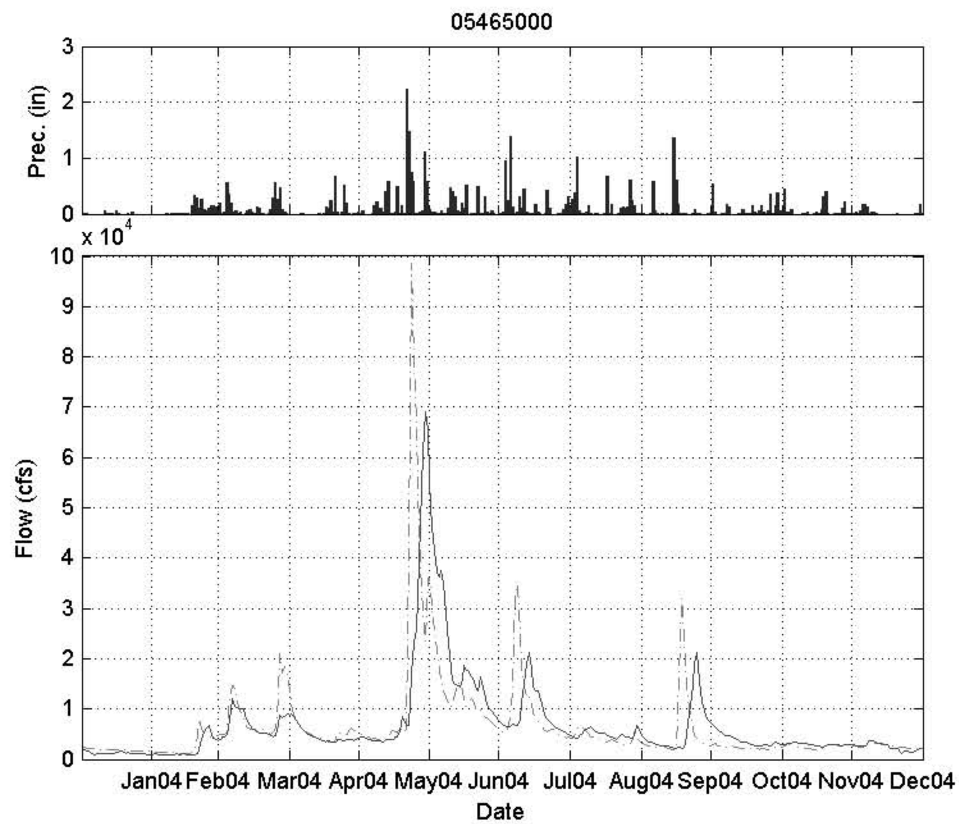
Date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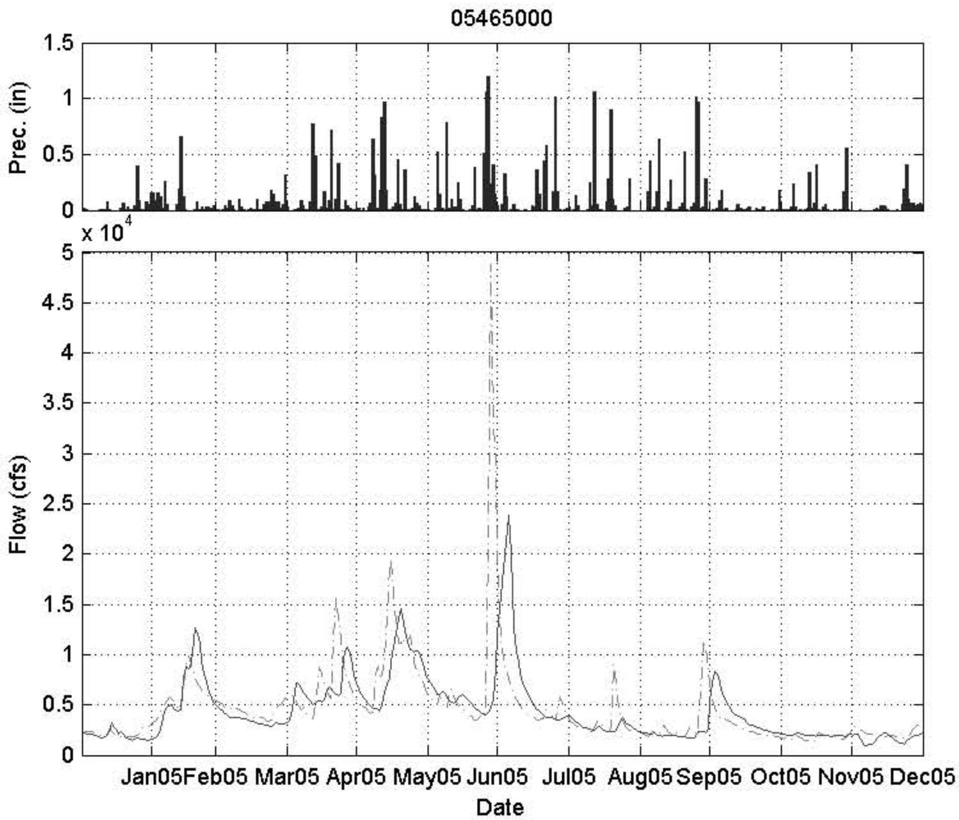
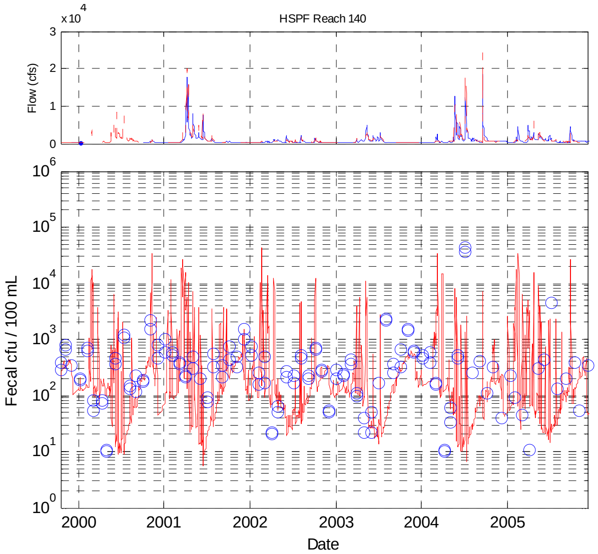
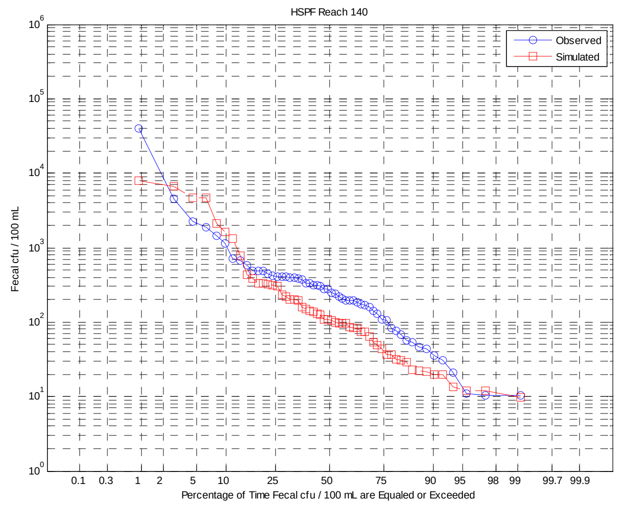
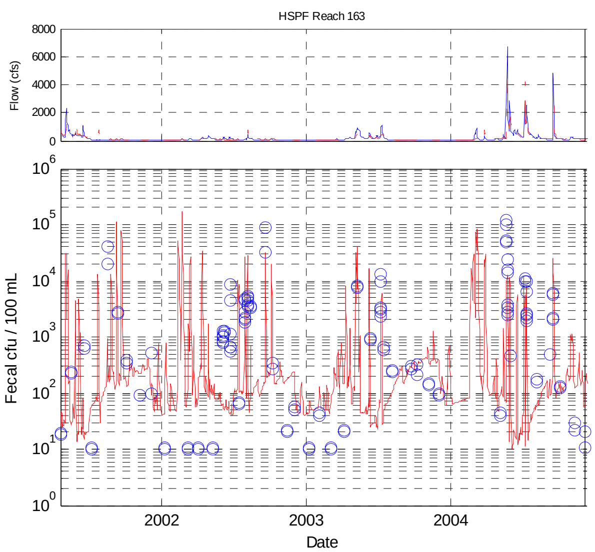
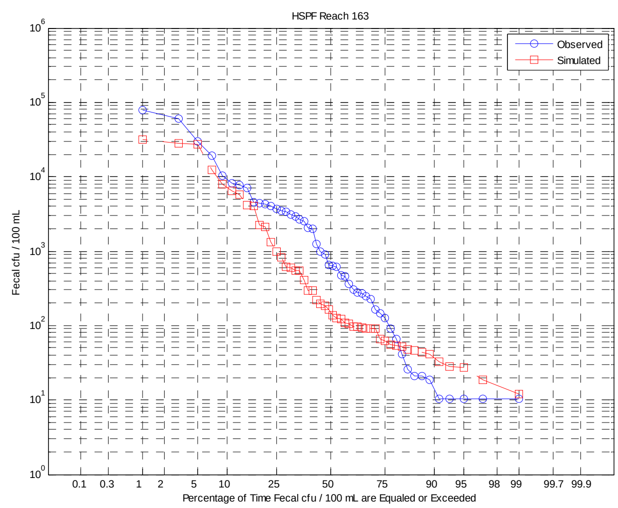
Prec. (in)
x 10^4
Flow (cfs)
Jan04 Feb04 Mar04 Apr04 May04 Jun04 Jul04 Aug04 Sep04 Oct04 Nov04 Dec04
Date

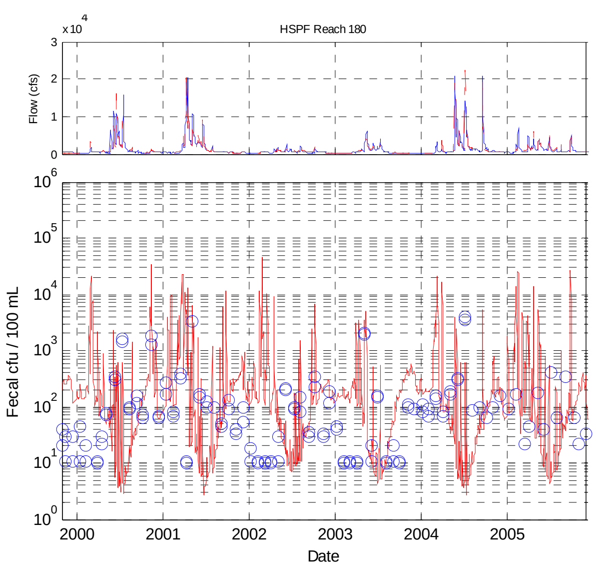

05465000
Prec. (in)
1.5
1
0.5
0
x 10^4
5
4.5
4
3.5
3
2.5
2
1.5
1
0.5
0
Flow (cfs)
Jan05 Feb05 Mar05 Apr05 May05 Jun05 Jul05 Aug05 Sep05 Oct05 Nov05 Dec05
Date

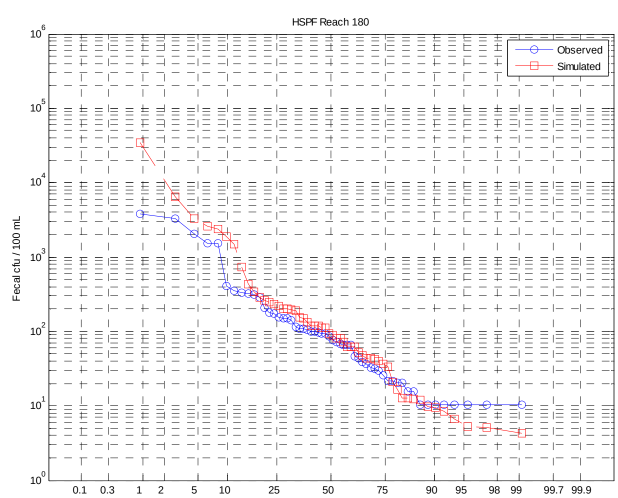

HSPF Reach 140
x 10^4
Flow (cfs)
Fecal cfu / 100 mL
2000
2001
2002
2003
2004
2005
Date

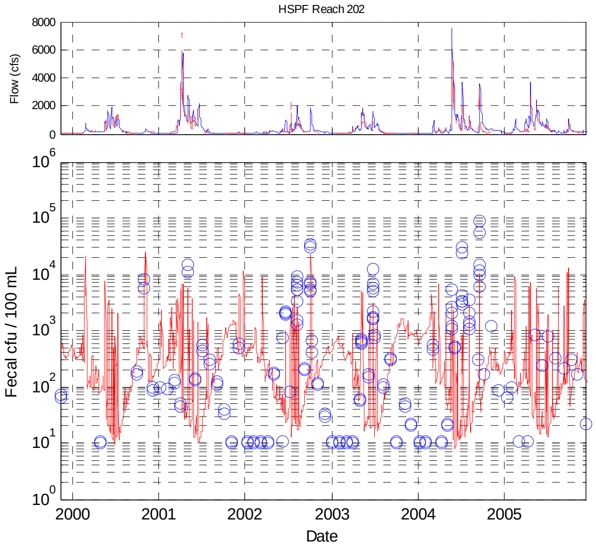

HSPF Reach 140
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

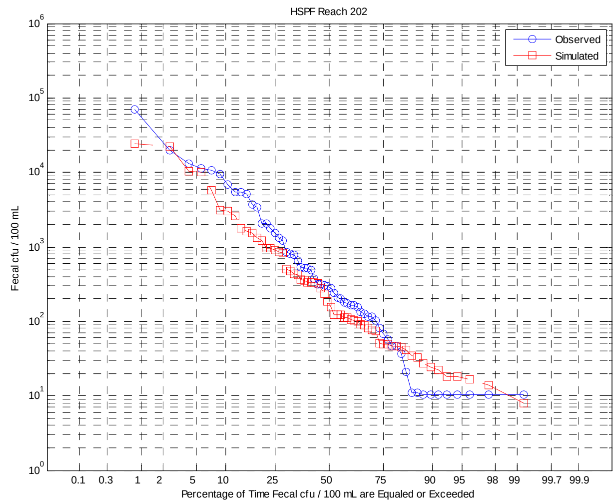

HSPF Reach 163
Flow (cfs)
Fecal cfu / 100 mL
2002
2003
2004
Date

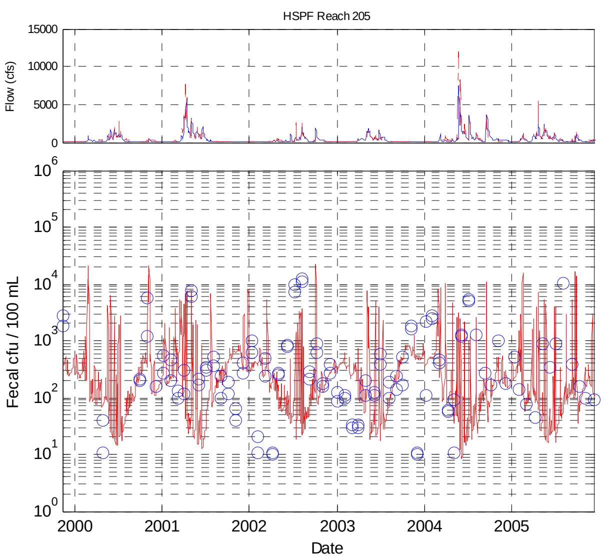

HSPF Reach 163
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

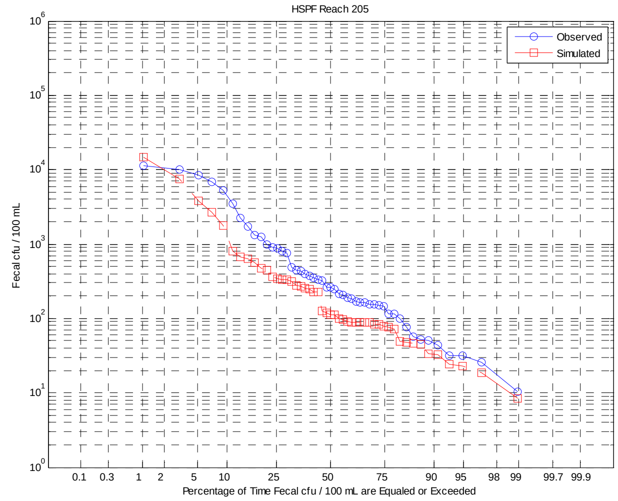

HSPF Reach 180
x 10^4
Flow (cfs)
Fecal cfu / 100 mL
2000
2001
2002
2003
2004
2005
Date

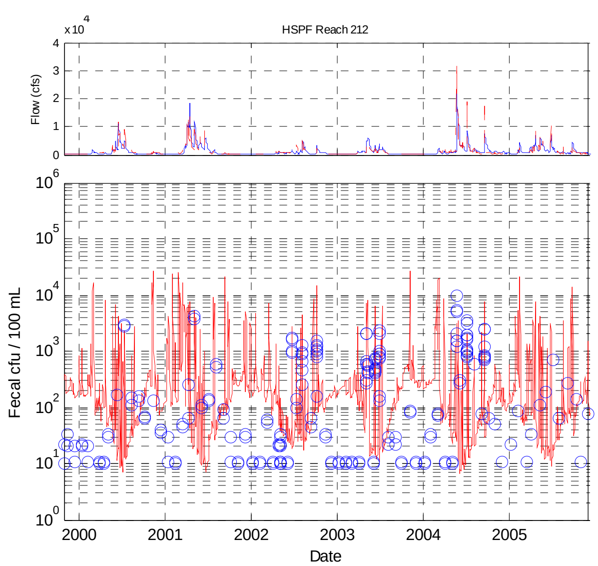

HSPF Reach 180
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

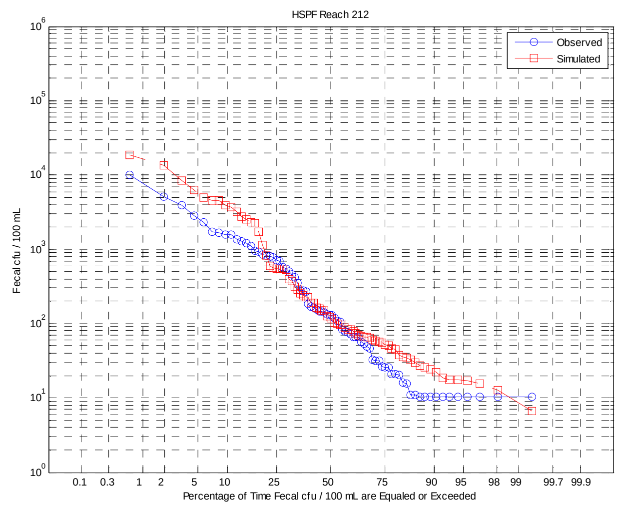

HSPF Reach 202
Flow (cfs)
Fecal cfu / 100 mL
Date

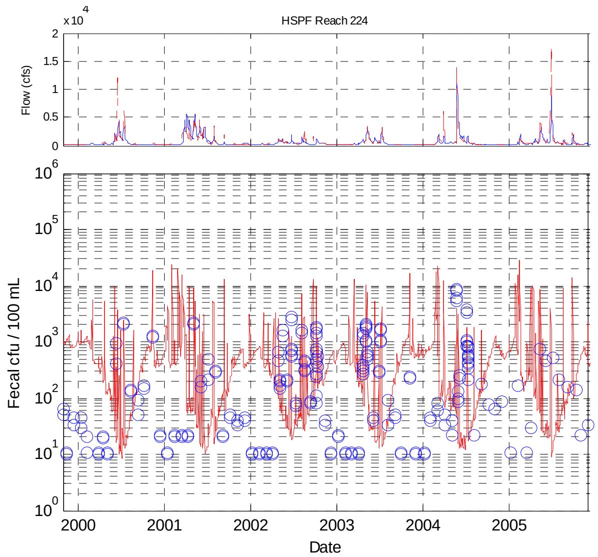

HSPF Reach 202
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

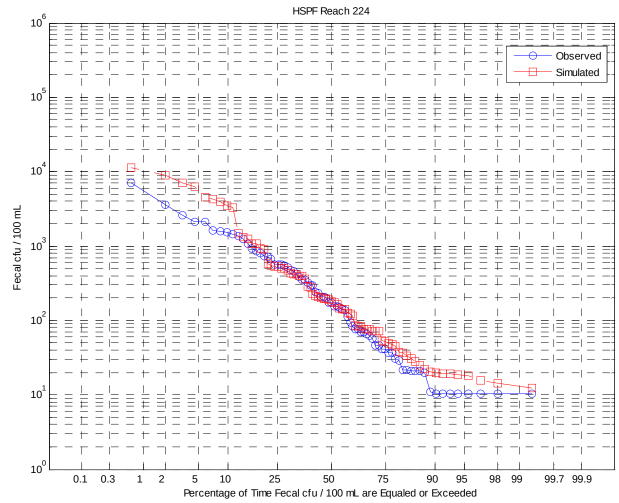

HSPF Reach 205
Flow (cfs)
Fecal cfu / 100 mL
Date

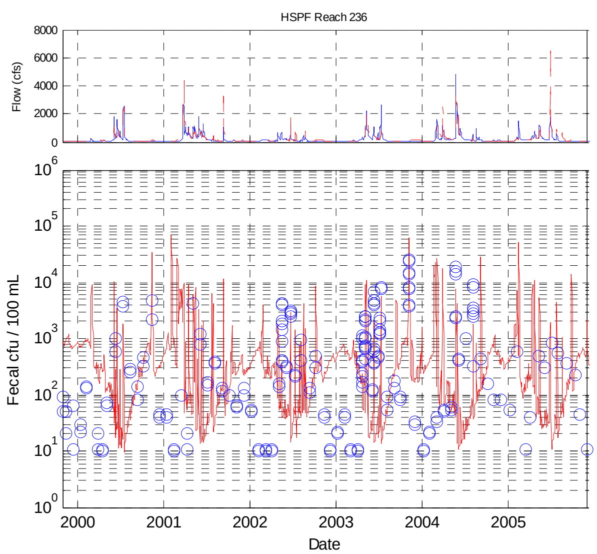

HSPF Reach 205
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

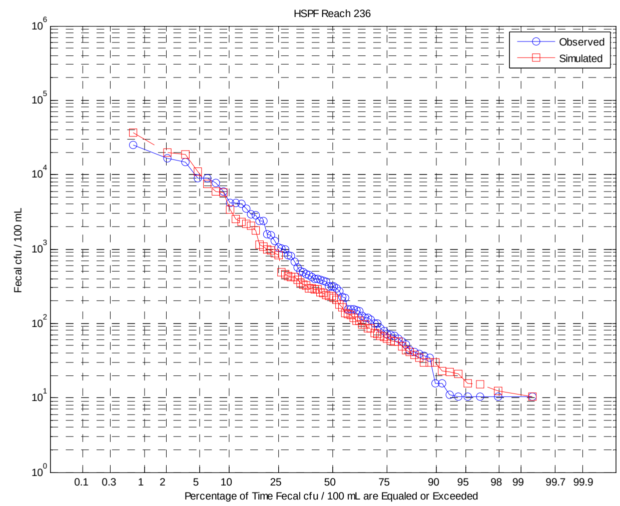

HSPF Reach 212
Flow (cfs)
Fecal cfu / 100 mL
Date

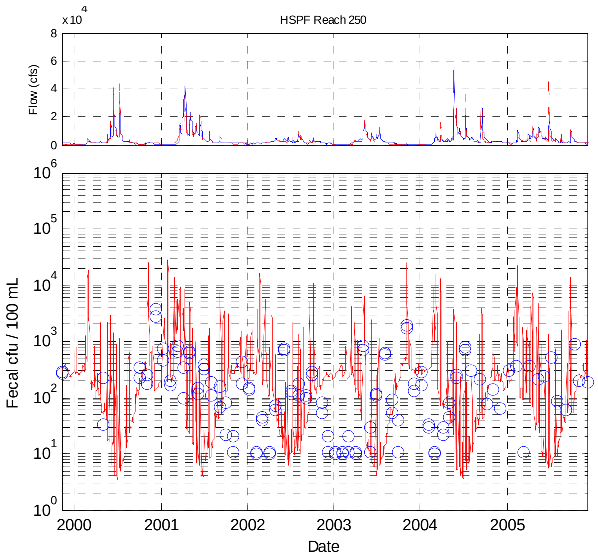

HSPF Reach 212
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

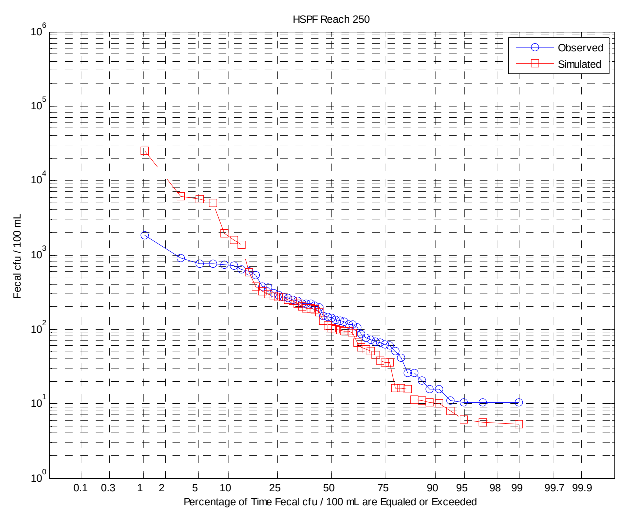

HSPF Reach 224
x10^4
Flow (cfs)
Fecal cfu / 100 mL
Date
2000
2001
2002
2003
2004
2005

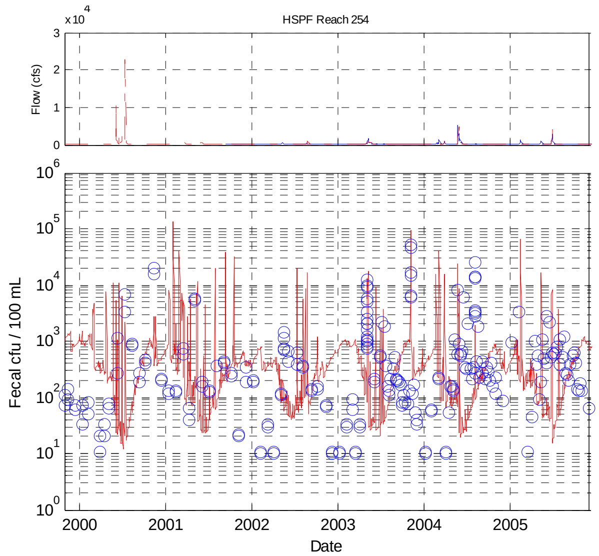

HSPF Reach 224
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

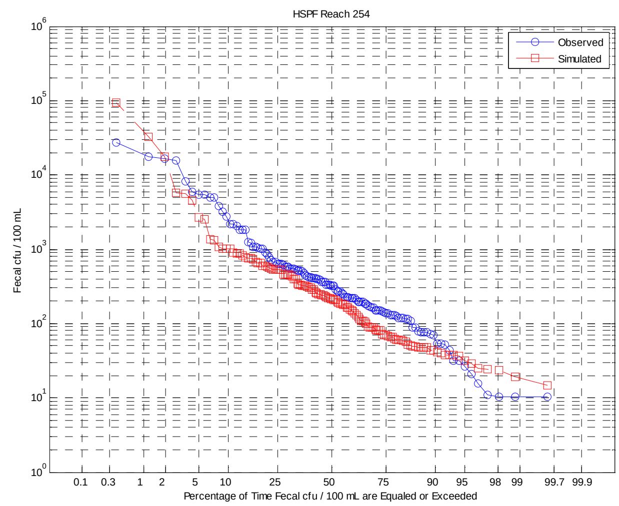

HSPF Reach 236
Flow (cfs)
Fecal cfu / 100 mL
Date
2000
2001
2002
2003
2004
2005

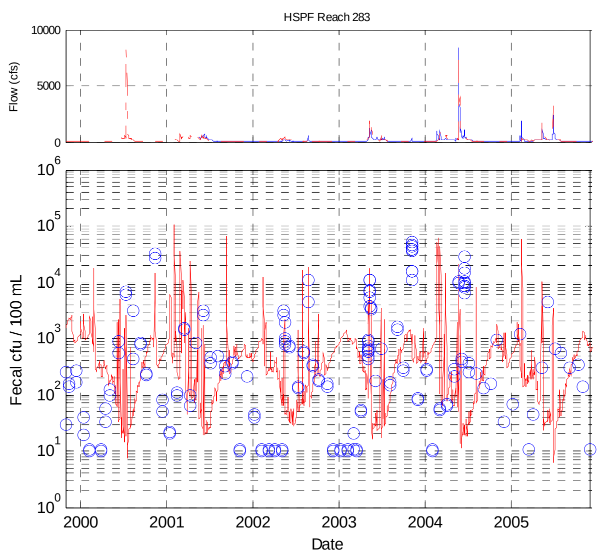

HSPF Reach 236
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

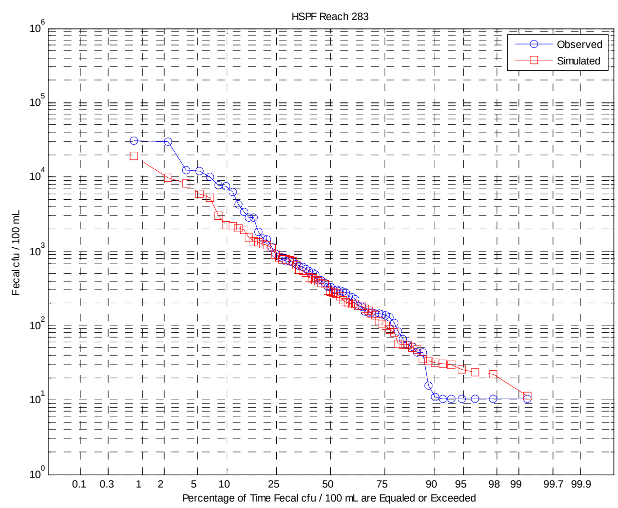

HSPF Reach 250
x10^4
Flow (cfs)
Fecal cfu / 100 mL
Date
2000
2001
2002
2003
2004
2005

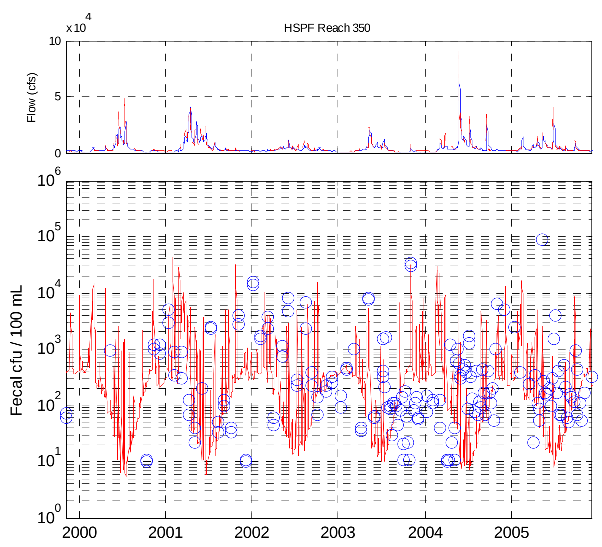

HSPF Reach 250
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

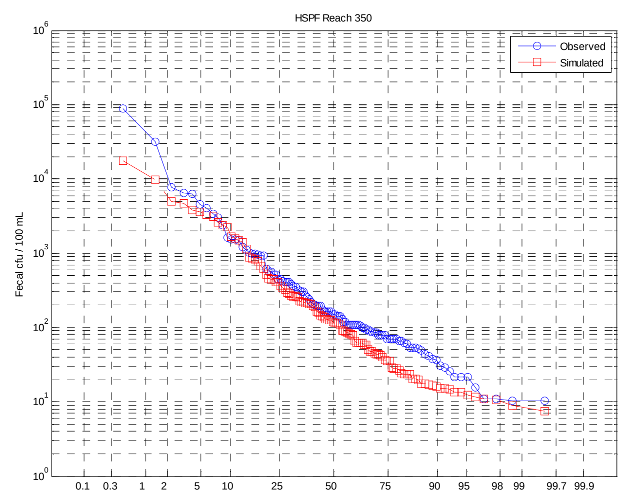

HSPF Reach 254
Flow (cfs)
Fecal cfu / 100 mL
Date

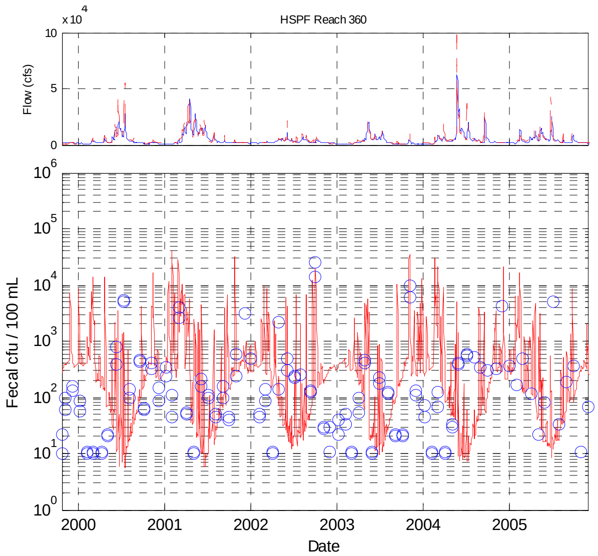

HSPF Reach 254
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

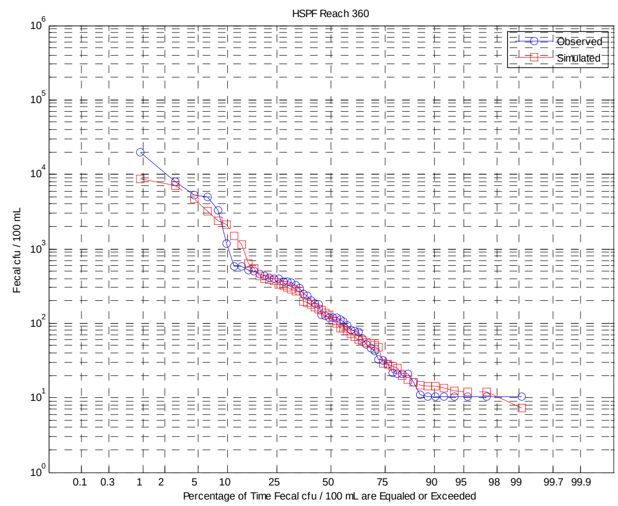

HSPF Reach 283
Flow (cfs)
Fecal cfu / 100 mL
Date

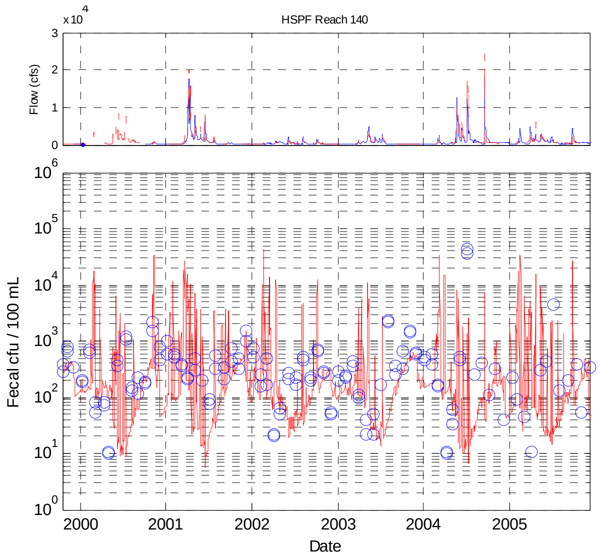

HSPF Reach 283
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

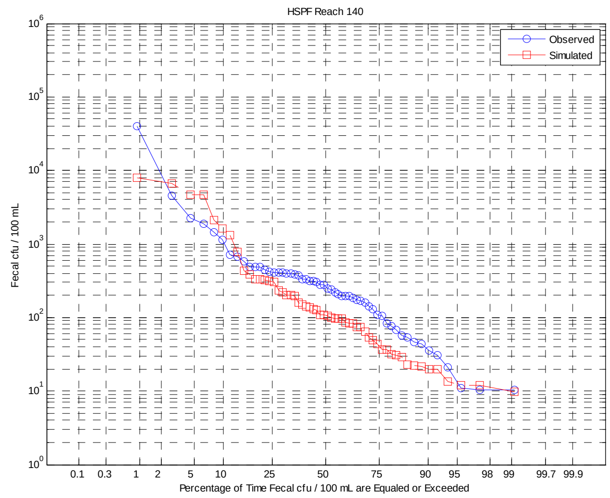

HSPF Reach 350
Flow (cfs)
Fecal cfu / 100 mL
Date

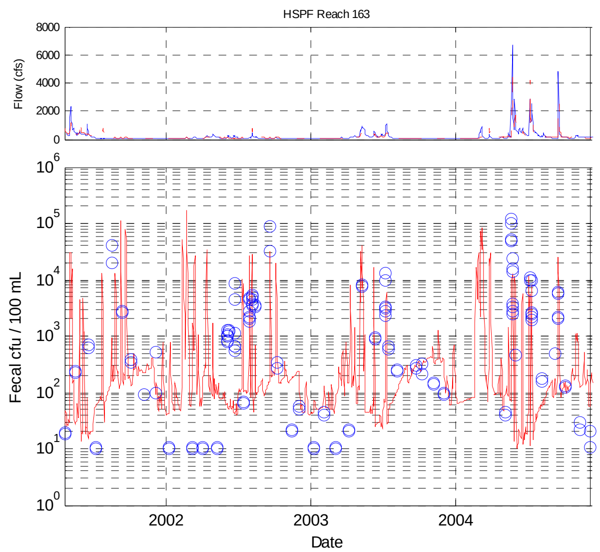

HSPF Reach 350
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

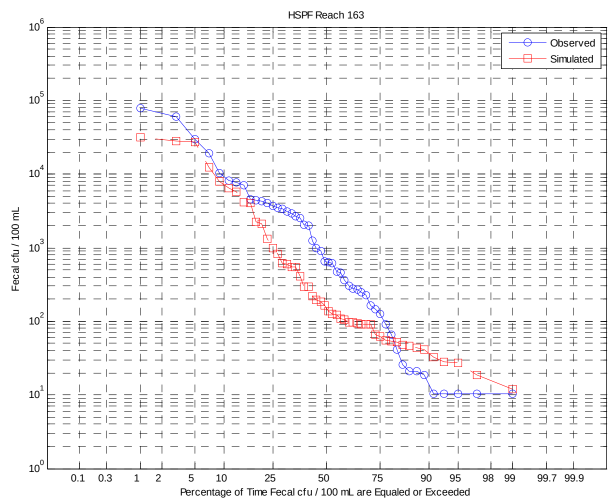

HSPF Reach 360
Flow (cfs)
x 10^4
Fecal cfu / 100 mL
Date
2000
2001
2002
2003
2004
2005

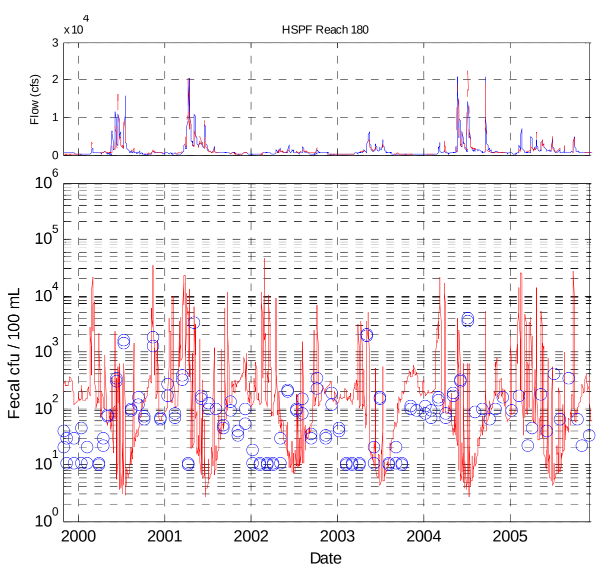

HSPF Reach 360
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

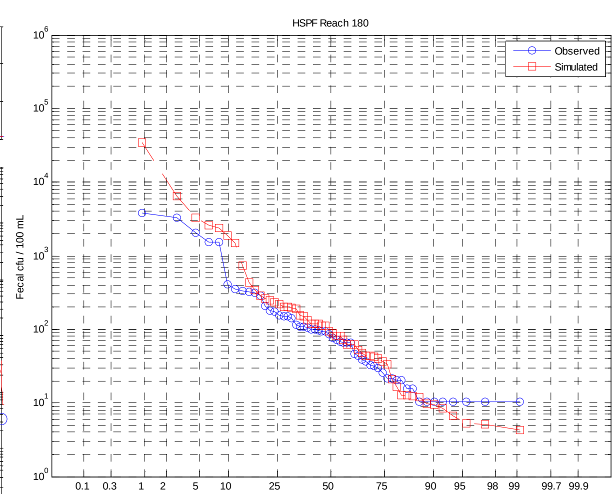

HSPF Reach 140
x 10^4
Flow (cfs)
Fecal cfu / 100 mL
2000
2001
2002
2003
2004
2005
Date

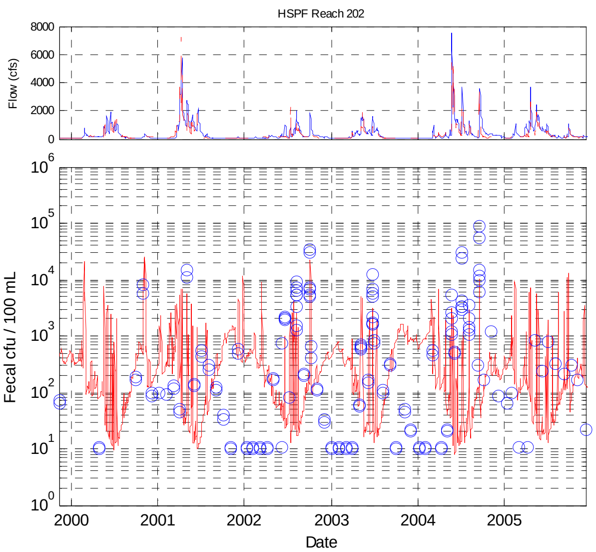

HSPF Reach 140
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

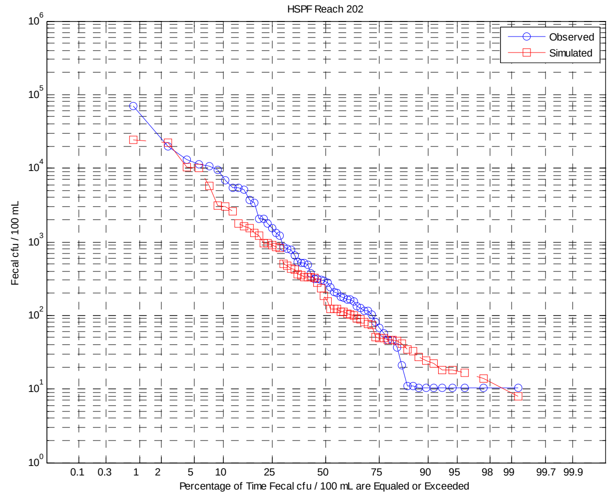

HSPF Reach 163
Flow (cfs)
Fecal cfu / 100 mL
2002
2003
2004
Date

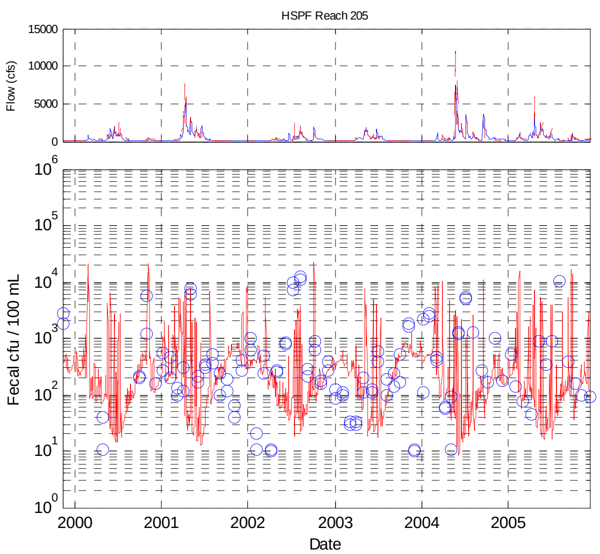

HSPF Reach 163
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

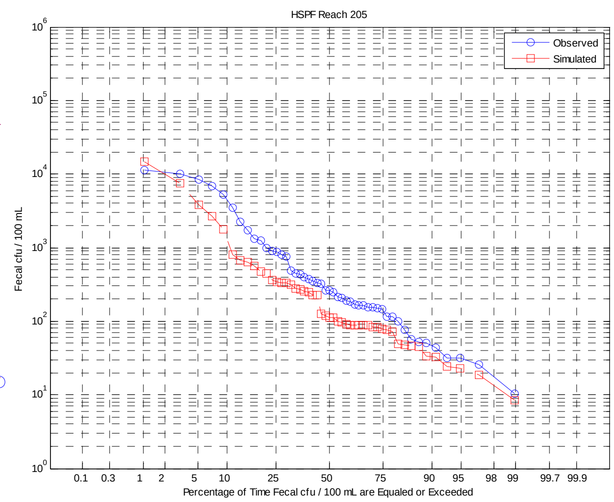

HSPF Reach 180
x 10^4
Flow (cfs)
Fecal cfu / 100 mL
2000
2001
2002
2003
2004
2005
Date

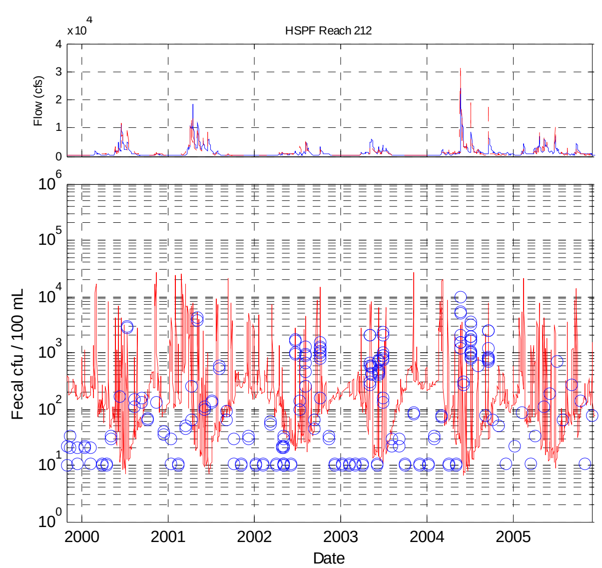

HSPF Reach 180
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

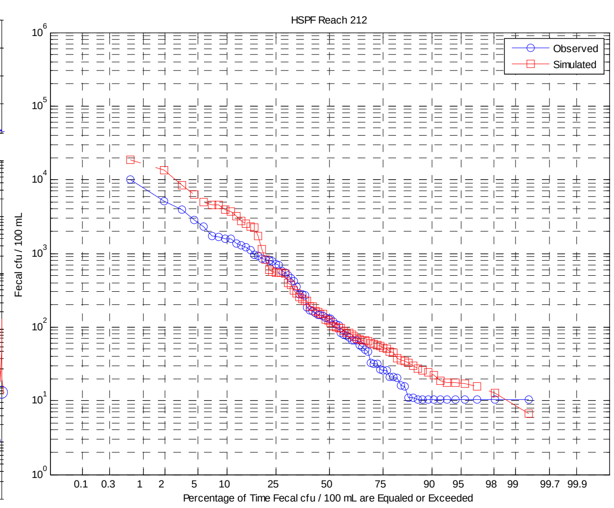

HSPF Reach 202
Flow (cfs)
Fecal cfu / 100 mL
Date

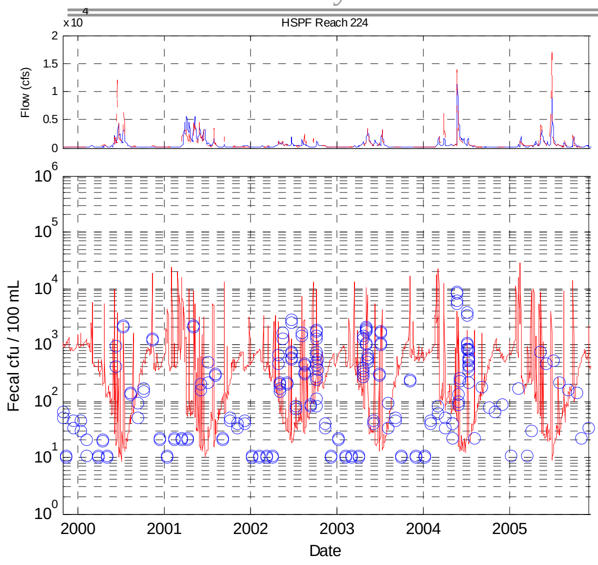

HSPF Reach 202
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

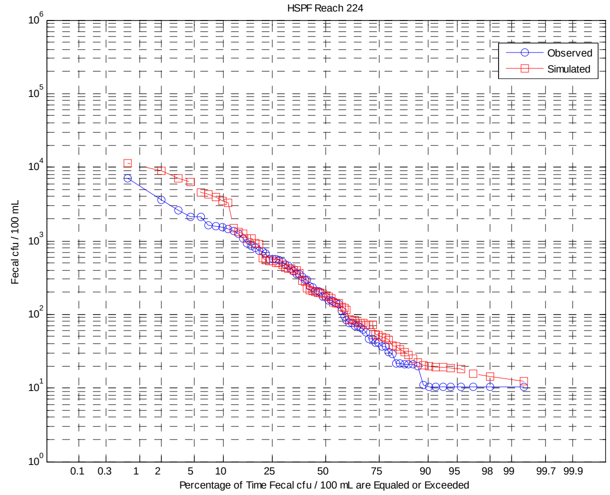

HSPF Reach 205
Flow (cfs)
Fecal cfu / 100 mL
Date

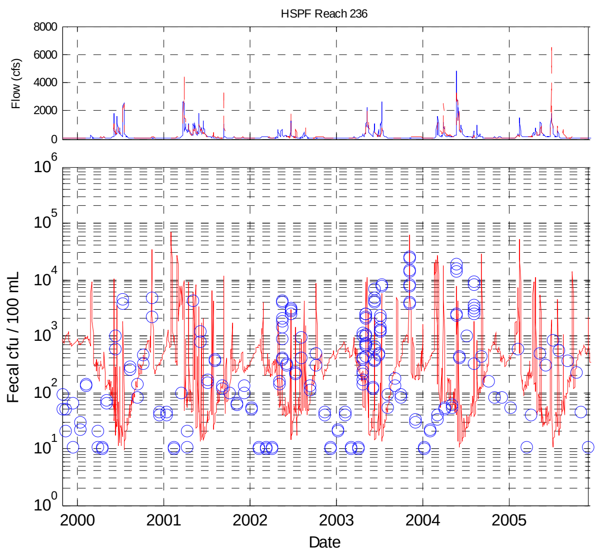

HSPF Reach 205
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

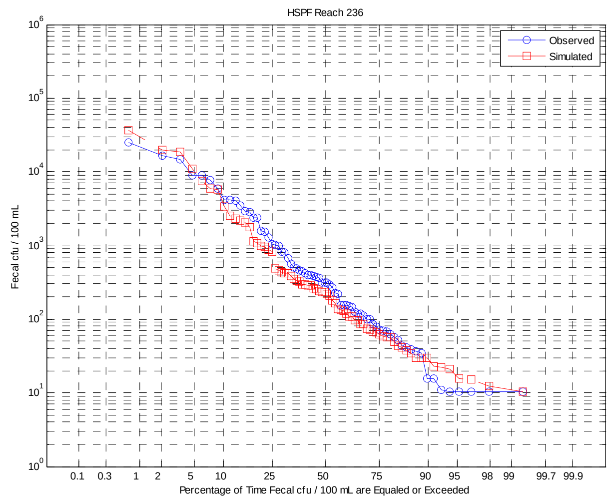

HSPF Reach 212
Flow (cfs)
Fecal cfu / 100 mL
Date

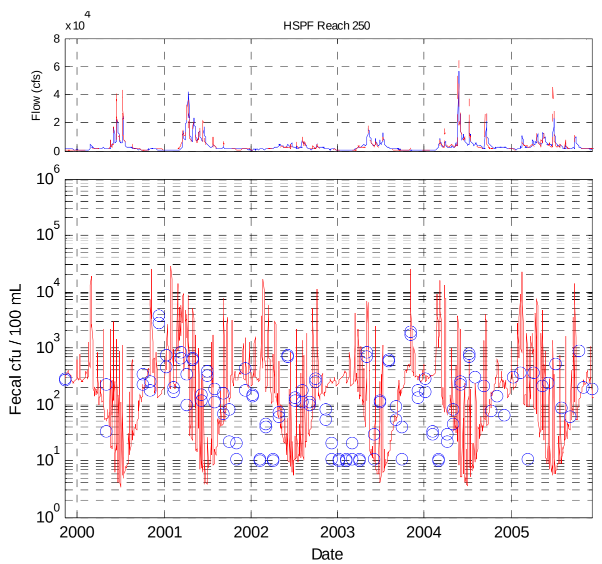

HSPF Reach 212
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

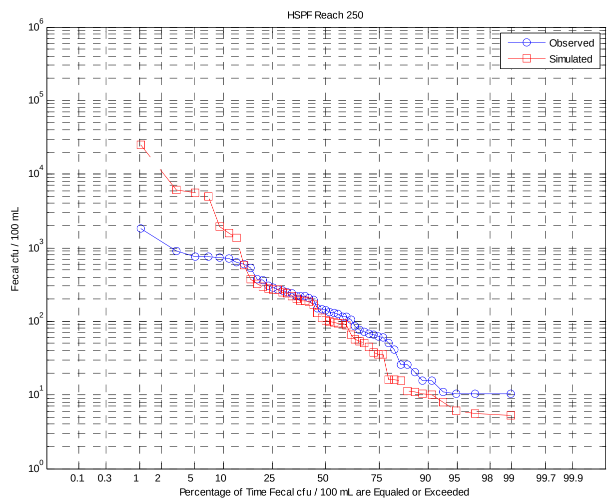

HSPF Reach 224
Flow (cfs)
Fecal cfu / 100 mL
Date

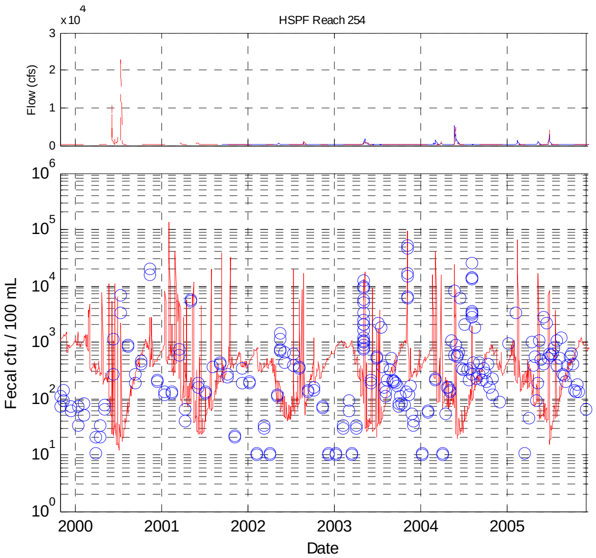

HSPF Reach 224
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

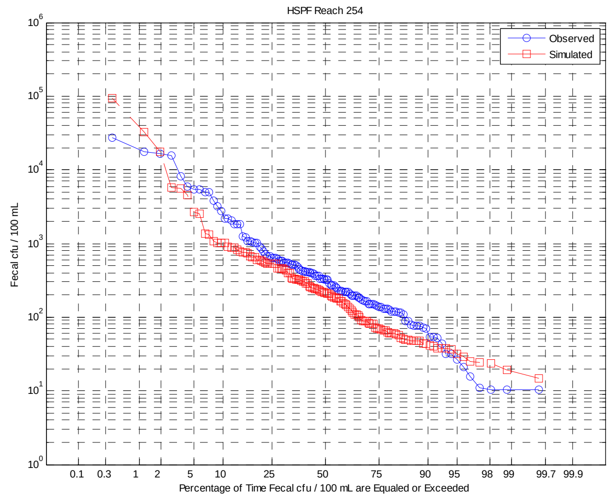

HSPF Reach 236
Flow (cfs)
Fecal cfu / 100 mL
Date

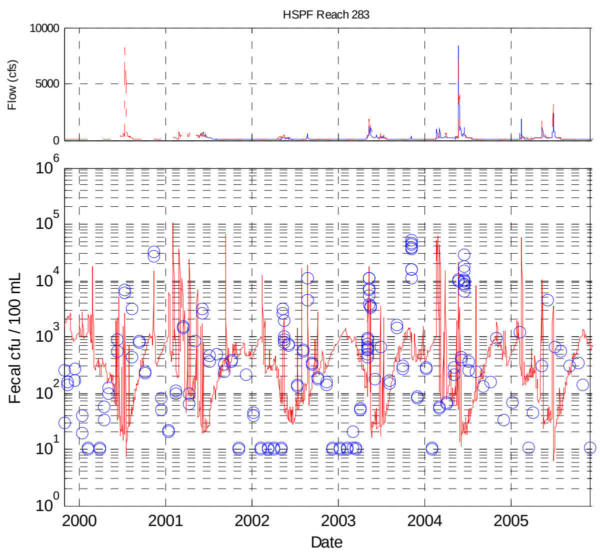

HSPF Reach 236
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

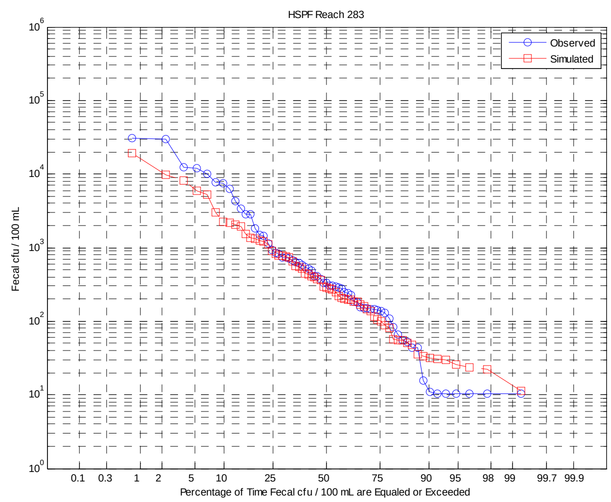

HSPF Reach 250
Flow (cfs)
Fecal cfu / 100 mL
Date

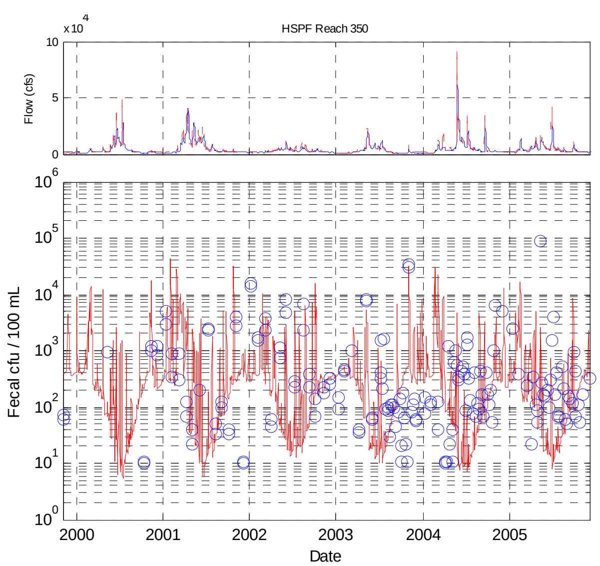

HSPF Reach 250
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

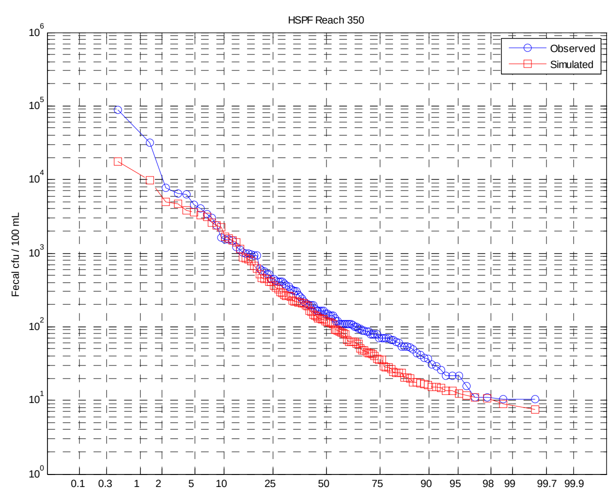

HSPF Reach 254
Flow (cfs)
Fecal cfu / 100 mL
Date

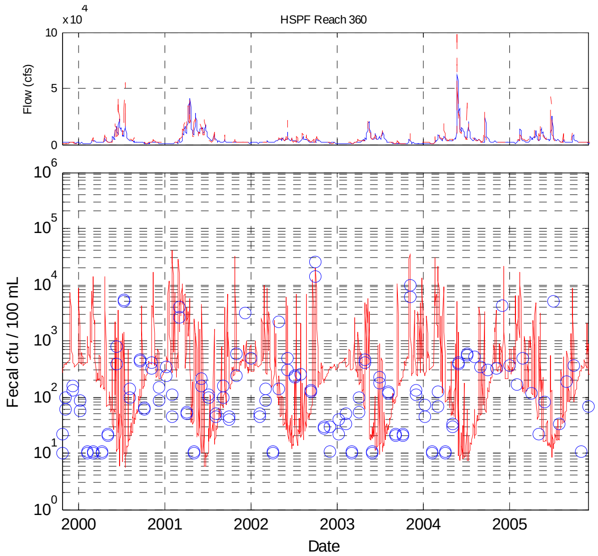

HSPF Reach 254
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

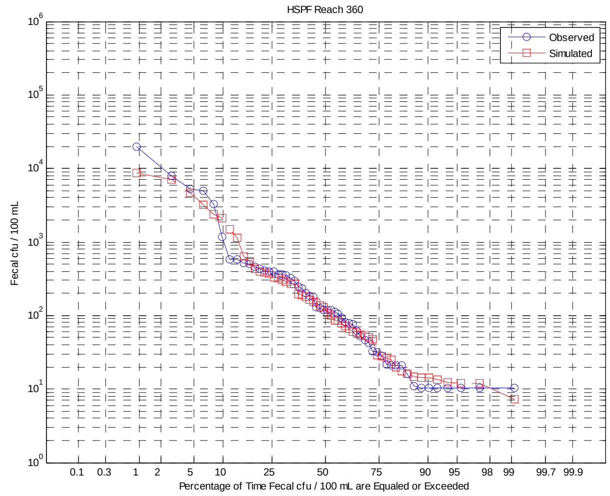

HSPF Reach 283
Flow (cfs)
Fecal cfu / 100 mL
Date


HSPF Reach 283
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded


HSPF Reach 350
Flow (cfs)
Fecal cfu / 100 mL
Date


HSPF Reach 350
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded


HSPF Reach 360
x 10^4
Flow (cfs)
Fecal cfu / 100 mL
Date
2000
2001
2002
2003
2004
2005


HSPF Reach 360
Observed
Simulated
Fecal cfu / 100 mL
Percentage of Time Fecal cfu / 100 mL are Equaled or Exceeded

Appendix F — HSPF Perennial Stream Analysis

Table F-1. All Flows—Base Conditions (Page 1 of 4)

Reach	25th Percentile	50th Percentile	75th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
10	133	256	585	53%	90%
21	141	254	453	54%	91%
22	154	279	498	58%	94%
23	69	125	227	24%	47%
24	139	256	470	54%	83%
20	124	234	471	50%	88%
31	210	384	710	71%	99%
30	124	231	463	49%	86%
41	209	386	716	71%	99%
42	139	249	449	53%	88%
43	137	247	449	52%	87%
44	136	241	438	51%	87%
40	120	218	417	47%	84%
51	32	55	110	14%	19%
52	42	69	132	14%	27%
50	93	168	332	36%	75%
61	118	210	379	44%	82%
60	91	170	338	37%	75%
71	42	74	140	12%	26%
72	59	105	192	19%	43%
70	74	147	301	33%	68%
81	69	123	231	25%	62%
80	81	162	326	36%	72%
91	90	164	306	35%	76%
92	163	299	514	62%	98%
90	89	181	355	39%	75%
101	13	26	74	12%	6%
102	62	120	255	28%	55%
100	69	143	300	32%	68%
110	56	126	294	30%	63%
121	33	63	111	12%	25%
122	66	117	214	23%	66%

Table F-1. All Flows—Base Conditions (Page 2 of 4)

Reach	25th Percentile	50th Percentile	75th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
120	45	109	273	28%	55%
130	37	97	262	27%	48%
140	42	106	276	28%	50%
150	36	98	260	27%	47%
161	58	110	207	21%	51%
162	89	160	282	32%	78%
163	65	129	316	29%	68%
164	58	119	294	29%	62%
160	24	81	254	26%	43%
170	20	74	236	25%	42%
181	77	167	368	40%	60%
180	21	80	245	26%	43%
191	21	33	68	11%	7%
192	16	30	65	13%	11%
193	16	30	73	13%	12%
194	21	44	153	20%	20%
195	15	30	87	15%	14%
196	16	38	134	18%	22%
197	21	41	139	20%	19%
198	15	35	132	19%	18%
199	13	37	137	19%	21%
190	20	77	236	25%	42%
201	191	407	893	69%	96%
202	38	104	317	29%	46%
203	35	93	299	29%	44%
204	13	42	164	20%	18%
205	51	105	279	28%	50%
206	37	86	247	26%	42%
207	31	77	230	25%	37%
208	33	66	176	20%	31%
209	18	41	116	17%	18%
211	29	67	182	21%	32%
212	34	82	247	26%	40%
213	38	90	262	27%	43%
214	107	268	625	54%	77%
215	71	179	459	43%	67%

Table F-1. All Flows—Base Conditions (Page 3 of 4)

Reach	25th Percentile	50th Percentile	75th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
216	69	187	506	44%	67%
217	164	405	1,075	64%	90%
218	101	306	858	56%	75%
219	21	50	145	18%	22%
221	25	58	168	20%	27%
222	54	120	271	29%	45%
223	60	186	539	45%	64%
224	47	161	474	42%	58%
200	32	112	322	31%	48%
231	21	48	144	19%	22%
232	73	188	469	43%	70%
233	104	264	665	53%	76%
234	31	113	323	32%	52%
235	36	133	363	35%	55%
236	45	149	370	38%	58%
237	46	147	369	37%	59%
230	33	119	333	32%	49%
241	64	126	215	23%	60%
251	116	294	607	56%	82%
252	79	196	446	44%	68%
253	79	217	464	47%	71%
254	68	187	405	43%	68%
255	92	219	425	47%	74%
240	34	118	329	32%	49%
250	36	121	325	33%	50%
260	32	113	316	32%	49%
270	29	111	308	31%	48%
281	96	261	607	53%	75%
282	79	225	506	49%	71%
283	62	189	443	44%	66%
284	208	474	940	71%	95%
280	37	125	350	34%	52%
290	29	115	338	33%	50%
300	30	120	341	33%	50%
311	214	524	1,074	72%	95%
310	27	116	334	33%	50%

Table F-1. All Flows—Base Conditions (Page 4 of 4)

Reach	25th Percentile	50th Percentile	75th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
321	90	256	558	52%	73%
322	60	134	279	30%	64%
320	29	122	374	35%	52%
331	97	209	356	44%	69%
330	29	122	368	35%	51%
341	136	307	815	58%	84%
342	72	221	606	49%	70%
343	50	195	574	46%	64%
340	31	130	396	36%	53%
351	36	92	287	30%	51%
350	34	133	399	36%	54%
361	68	155	366	37%	69%
360	34	130	398	36%	55%
370	32	129	393	36%	54%
380	28	123	380	35%	52%
391	59	156	438	40%	61%
390	26	121	379	35%	51%
401	106	277	655	54%	76%
402	296	666	1,350	81%	99%
400	29	133	421	38%	54%
411	19	50	155	19%	33%
410	27	136	443	38%	54%

Table F-2. All Flows—Scenario 1 (Page 1 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
10	49	133	256	585	2,583	53%	90%
21	58	141	254	453	1,035	54%	91%
22	65	154	279	498	1,124	58%	94%
23	32	69	125	227	476	24%	47%
24	55	139	256	470	959	54%	83%
20	51	124	234	471	2,585	50%	88%
31	91	210	384	710	3,569	71%	99%
30	51	124	231	463	2,444	49%	86%
41	90	209	386	716	1,671	71%	99%
42	61	139	249	449	996	53%	88%
43	61	137	247	449	988	52%	87%
44	60	136	241	438	988	51%	87%
40	50	120	218	417	2,083	47%	84%
51	15	32	55	110	2,171	14%	19%
52	19	42	69	132	1,948	14%	27%
50	39	93	168	332	2,409	36%	75%
61	52	118	210	379	1,569	44%	82%
60	37	91	170	338	2,675	37%	75%
71	21	42	74	140	964	12%	26%
72	28	59	105	192	936	19%	43%
70	30	74	147	301	2,129	33%	68%
81	32	69	123	231	4,486	25%	62%
80	3	9	18	35	92	3%	0%
91	41	90	164	306	3,825	35%	76%
92	37	99	187	328	888	40%	74%
90	9	27	53	100	285	6%	11%
101	6	13	26	74	1,096	12%	6%
102	25	62	120	255	2,748	28%	55%
100	12	30	55	104	886	8%	12%
110	12	29	54	110	3,895	13%	18%
121	16	33	63	111	4,820	12%	25%
122	29	66	117	214	10,259	23%	66%
120	12	27	52	109	3,578	13%	18%
130	9	22	48	110	2,889	15%	18%
140	9	21	45	106	2,436	14%	17%
150	7	19	42	101	2,239	14%	16%
161	23	55	103	182	2,719	17%	47%
162	23	56	103	182	10,065	17%	54%
163	19	50	95	200	11,032	23%	52%
164	17	45	89	194	9,266	23%	48%
160	5	16	41	118	3,000	17%	20%
170	4	14	38	114	2,655	17%	19%
181	3	8	21	56	264	6%	1%

Table F-2. All Flows—Scenario 1 (Page 2 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
180	3	12	37	109	2,365	16%	18%
191	12	21	33	68	2,530	11%	7%
192	4	8	14	29	2,510	10%	3%
193	5	10	18	39	2,767	12%	5%
194	10	21	44	153	2,184	20%	20%
195	5	12	22	61	2,665	14%	8%
196	6	13	26	78	2,937	16%	11%
197	10	21	41	139	2,989	20%	19%
198	4	8	16	54	1,580	11%	5%
199	4	10	24	88	1,856	14%	12%
190	3	12	36	108	2,400	16%	18%
201	11	23	45	133	1,879	18%	18%
202	6	16	35	131	1,763	17%	17%
203	7	17	36	134	2,136	17%	17%
204	5	13	42	164	2,354	20%	18%
205	14	34	65	175	2,137	20%	28%
206	11	26	53	154	1,822	18%	23%
207	7	19	40	127	2,032	18%	18%
208	15	30	57	106	990	13%	15%
209	7	17	36	101	2,800	16%	15%
211	11	29	67	182	3,611	21%	32%
212	10	24	51	161	2,970	21%	23%
213	8	22	47	152	2,870	20%	22%
214	12	28	61	138	1,416	14%	25%
215	10	23	51	144	3,162	18%	26%
216	14	34	72	174	3,457	19%	31%
217	15	33	80	207	3,646	22%	38%
218	12	28	68	181	3,321	20%	33%
219	9	21	50	145	2,600	18%	22%
221	11	25	58	168	2,696	20%	27%
222	23	54	120	271	1,535	29%	45%
223	10	26	63	204	3,395	22%	33%
224	9	25	62	192	3,266	21%	33%
200	6	18	49	170	2,953	21%	25%
231	8	21	48	144	4,091	19%	22%
232	10	29	66	188	5,516	21%	33%
233	14	35	89	208	3,644	22%	42%
234	7	21	60	171	4,168	20%	30%
235	7	22	60	165	4,495	21%	28%
236	6	19	52	157	3,714	19%	25%
237	7	22	55	160	3,748	19%	26%
230	6	19	52	187	2,987	22%	27%
241	31	62	120	210	1,179	22%	57%

Table F-2. All Flows—Scenario 1 (Page 3 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
251	20	48	110	242	2,581	26%	49%
252	9	22	52	131	1,356	14%	20%
253	12	33	76	175	3,450	19%	34%
254	13	34	78	171	3,645	18%	34%
255	20	53	117	236	3,052	25%	52%
240	7	21	56	184	2,932	22%	30%
250	7	21	57	176	2,680	21%	30%
260	6	20	53	170	2,695	21%	29%
270	6	19	52	165	2,610	20%	28%
281	11	29	69	160	2,466	16%	31%
282	11	30	74	167	2,973	18%	34%
283	10	29	74	165	2,683	18%	33%
284	32	72	182	380	2,412	43%	66%
280	7	20	55	184	2,799	22%	31%
290	5	17	51	177	3,027	22%	30%
300	4	14	47	168	2,873	21%	28%
311	12	30	66	134	9,369	17%	33%
310	4	13	46	163	2,919	21%	28%
321	7	20	46	109	4,994	16%	24%
322	24	60	134	279	5,652	30%	64%
320	4	14	49	197	2,898	23%	29%
331	37	97	209	356	658	44%	69%
330	4	15	50	193	2,857	23%	29%
341	7	19	45	164	4,607	20%	29%
342	7	22	54	177	5,780	21%	34%
343	5	19	57	224	5,724	24%	35%
340	4	15	53	222	2,969	24%	32%
351	12	34	79	247	8,852	26%	46%
350	6	19	60	249	3,117	25%	36%
361	24	64	135	274	7,029	30%	65%
360	7	21	60	253	3,620	26%	37%
370	7	20	60	254	3,544	26%	36%
380	5	18	58	246	3,419	25%	34%
391	6	18	45	185	9,086	22%	32%
390	5	17	57	254	3,391	26%	34%
401	4	13	33	98	5,212	18%	24%
402	10	25	51	124	6,517	16%	28%
400	4	16	58	282	3,740	27%	35%
411	7	19	45	122	7,283	19%	29%
410	4	16	60	310	3,973	28%	36%

Table F-3. All Flows—Scenario 2 (Page 1 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
10	43	118	216	470	1,380	47%	74%
21	56	133	239	420	832	51%	82%
22	60	144	264	462	896	55%	86%
23	32	69	125	227	476	24%	47%
24	55	139	256	470	959	54%	83%
20	44	109	199	371	871	43%	72%
31	75	180	333	599	1,168	65%	92%
30	42	104	195	364	832	42%	70%
41	77	183	348	639	1,271	67%	93%
42	54	126	228	408	813	49%	80%
43	55	126	226	404	816	48%	79%
44	54	123	222	395	802	47%	79%
40	42	100	187	339	707	40%	69%
51	14	30	48	84	255	6%	6%
52	18	39	63	107	271	6%	12%
50	34	77	136	253	525	27%	55%
61	47	104	188	332	678	39%	72%
60	32	75	137	253	536	27%	56%
71	21	40	69	124	310	8%	19%
72	27	55	98	175	373	15%	33%
70	24	61	119	225	492	24%	49%
81	29	60	107	194	419	18%	42%
80	2	8	17	31	69	0%	0%
91	37	79	144	261	545	28%	60%
92	34	89	164	294	521	36%	60%
90	8	24	48	87	167	2%	9%
101	6	12	23	52	212	4%	4%
102	23	52	98	195	423	19%	37%
100	11	26	47	85	157	1%	6%
110	10	25	45	81	169	3%	4%
121	16	31	58	97	306	6%	9%
122	25	55	100	166	385	12%	40%
120	10	23	43	78	180	3%	4%
130	9	19	38	72	181	3%	3%
140	8	18	36	70	175	3%	3%
150	7	16	34	67	178	3%	3%
161	22	49	90	157	359	10%	32%
162	20	48	89	145	275	7%	30%
163	16	41	76	124	275	7%	20%
164	14	38	71	119	267	7%	18%
160	4	12	29	66	191	4%	4%
170	4	11	27	64	191	4%	4%
181	3	8	21	56	264	6%	1%

Table F-3 All Flows—Scenario 2 (Page 2 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
180	3	9	26	64	201	4%	4%
191	12	21	32	59	230	5%	1%
192	4	8	13	23	99	2%	0%
193	5	10	16	29	113	2%	0%
194	9	19	36	84	413	10%	11%
195	5	11	19	37	135	2%	0%
196	5	11	21	43	150	2%	0%
197	10	19	34	72	397	10%	11%
198	4	8	14	33	157	3%	2%
199	4	9	19	46	193	3%	3%
190	3	9	25	63	197	4%	3%
201	11	21	38	81	335	9%	10%
202	6	14	27	61	232	5%	5%
203	6	14	28	64	232	5%	5%
204	5	12	33	104	366	11%	9%
205	13	29	50	99	256	7%	10%
206	10	22	41	84	250	6%	8%
207	7	16	30	63	199	4%	4%
208	15	29	53	90	353	8%	9%
209	7	15	29	59	276	6%	3%
211	11	25	50	109	384	10%	18%
212	9	20	37	74	239	5%	5%
213	8	18	34	71	235	5%	4%
214	12	24	50	105	241	5%	13%
215	9	20	41	91	282	7%	11%
216	13	29	56	114	284	8%	15%
217	14	30	64	141	377	13%	22%
218	11	25	54	120	340	9%	17%
219	9	19	41	98	364	10%	11%
221	10	22	48	107	357	10%	13%
222	21	47	99	210	726	22%	37%
223	9	21	48	108	327	9%	14%
224	8	20	46	102	303	8%	13%
200	5	13	31	70	244	5%	4%
231	8	19	41	97	431	11%	13%
232	9	24	50	113	380	10%	15%
233	13	30	71	163	490	14%	27%
234	6	17	44	99	356	9%	12%
235	7	18	43	96	343	9%	11%
236	5	15	38	86	303	7%	8%
237	6	18	41	88	292	7%	9%
230	5	13	31	71	255	5%	5%
241	29	57	111	183	421	16%	41%

Table F-3. All Flows—Scenario 2 (Page 3 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
251	18	42	87	191	382	18%	33%
252	9	21	45	104	291	7%	14%
253	12	29	60	132	294	10%	20%
254	12	30	61	128	285	9%	20%
255	19	46	95	181	345	16%	33%
240	6	16	35	78	259	6%	6%
250	6	15	35	79	242	5%	7%
260	6	14	33	78	238	5%	6%
270	5	13	32	77	236	5%	6%
281	11	26	56	127	297	8%	21%
282	10	24	54	120	280	8%	19%
283	9	24	53	119	279	8%	19%
284	26	56	136	299	561	33%	49%
280	5	15	34	79	248	5%	7%
290	4	12	30	76	243	5%	6%
300	3	9	26	72	225	5%	6%
311	12	26	55	96	278	7%	7%
310	3	9	26	69	225	5%	6%
321	7	17	37	71	259	5%	6%
322	20	51	100	197	407	18%	37%
320	3	10	27	71	246	5%	6%
331	37	97	209	356	658	44%	69%
330	3	10	27	72	243	5%	6%
341	7	16	35	89	348	10%	14%
342	7	18	38	94	307	8%	14%
343	5	15	38	100	355	9%	12%
340	3	10	28	75	252	5%	7%
351	11	28	61	121	364	11%	14%
350	5	14	34	80	257	5%	8%
361	21	53	101	190	392	17%	37%
360	6	16	35	81	264	6%	8%
370	5	14	34	80	264	6%	8%
380	5	12	32	77	260	6%	7%
391	6	15	33	72	310	7%	8%
390	4	11	31	75	263	6%	7%
401	4	11	25	56	258	5%	3%
402	9	22	43	83	262	6%	7%
400	4	10	30	75	270	6%	7%
411	7	17	35	76	282	6%	5%
410	3	10	30	74	279	6%	7%

Table F-4. All Flows—Scenario 3 (Page 1 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
10	40	113	208	450	1,365	46%	71%
21	52	128	234	412	787	50%	80%
22	56	140	258	452	854	54%	83%
23	29	66	122	219	452	22%	44%
24	52	136	253	464	930	53%	82%
20	41	104	192	356	805	41%	69%
31	73	175	324	579	1,133	64%	91%
30	40	101	189	349	781	41%	67%
41	73	177	338	621	1,215	66%	91%
42	51	122	221	393	760	47%	78%
43	51	121	221	391	763	47%	77%
44	51	119	217	381	755	46%	77%
40	40	98	180	325	668	39%	65%
51	14	29	47	79	192	4%	4%
52	17	38	62	101	221	4%	10%
50	32	74	132	236	494	25%	51%
61	45	101	183	319	637	38%	69%
60	30	72	132	239	508	26%	52%
71	19	38	66	120	265	7%	17%
72	24	54	96	169	346	14%	31%
70	23	59	115	214	471	22%	44%
81	27	58	104	187	393	17%	38%
80	2	8	16	31	68	0%	0%
91	34	77	139	252	507	27%	56%
92	32	86	161	287	503	34%	58%
90	8	24	47	86	166	2%	9%
101	5	12	22	48	181	3%	3%
102	21	49	95	188	386	17%	35%
100	10	25	46	81	150	1%	6%
110	10	24	43	77	154	2%	3%
121	15	30	57	94	229	5%	7%
122	24	53	97	157	311	9%	36%
120	9	22	41	75	164	2%	3%
130	8	18	36	68	161	2%	2%
140	8	17	35	66	161	2%	2%
150	7	16	33	64	159	2%	2%
161	21	47	89	149	301	9%	28%
162	19	46	87	140	239	5%	27%
163	16	39	73	118	246	6%	16%
164	13	36	68	114	242	5%	15%
160	4	12	28	61	163	3%	2%
170	3	10	26	60	159	3%	1%
181	3	7	20	52	208	4%	0%

Table F-4. All Flows—Scenario 3 (Page 2 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
180	3	9	25	58	162	3%	1%
191	11	20	31	57	191	4%	0%
192	4	8	12	22	75	1%	0%
193	5	9	16	28	89	1%	0%
194	9	18	35	77	389	9%	11%
195	5	10	18	35	109	1%	0%
196	5	11	20	40	121	2%	0%
197	9	18	32	64	369	9%	10%
198	4	7	13	30	136	2%	2%
199	4	8	18	41	164	2%	3%
190	3	9	24	57	162	3%	1%
201	10	20	37	76	306	8%	10%
202	6	13	25	54	203	4%	5%
203	6	14	26	57	205	4%	5%
204	5	12	31	98	350	10%	8%
205	12	27	48	91	245	6%	10%
206	9	22	40	78	233	5%	8%
207	6	15	28	59	175	3%	3%
208	13	28	51	84	257	5%	6%
209	6	15	28	54	198	4%	1%
211	10	23	48	100	330	8%	15%
212	8	19	35	68	191	4%	3%
213	7	17	32	65	189	4%	3%
214	11	24	48	100	219	4%	11%
215	8	19	40	86	244	5%	10%
216	12	27	54	107	258	6%	14%
217	13	29	60	132	345	11%	20%
218	10	24	51	110	305	8%	15%
219	8	18	39	92	331	8%	11%
221	9	21	45	98	312	8%	12%
222	19	45	93	200	667	20%	35%
223	9	20	44	99	282	7%	12%
224	8	19	42	93	261	6%	11%
200	5	13	29	64	191	3%	2%
231	7	18	39	89	351	9%	11%
232	9	23	48	105	323	8%	13%
233	12	28	68	152	399	12%	26%
234	6	16	41	90	276	7%	10%
235	6	17	41	88	278	7%	9%
236	5	15	36	78	244	5%	7%
237	6	17	38	82	241	5%	7%
230	5	13	29	66	196	4%	2%
241	28	57	109	180	405	16%	40%

Table F-4. All Flows—Scenario 3 (Page 3 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
251	17	41	84	182	365	17%	32%
252	8	20	43	100	260	6%	13%
253	11	28	57	126	276	8%	19%
254	12	29	59	124	267	8%	19%
255	18	45	93	175	331	15%	32%
240	6	16	33	71	201	4%	3%
250	6	14	33	73	195	4%	3%
260	5	14	32	72	189	4%	3%
270	5	13	31	70	189	4%	3%
281	10	25	54	123	265	7%	20%
282	9	23	52	114	262	6%	17%
283	9	23	51	113	261	7%	17%
284	24	54	131	292	544	32%	47%
280	5	14	32	71	192	4%	4%
290	4	11	29	68	188	4%	3%
300	3	9	25	64	184	3%	3%
311	11	25	53	93	242	5%	5%
310	3	9	24	63	177	3%	3%
321	6	16	35	66	200	4%	4%
322	20	49	96	189	368	16%	35%
320	3	10	26	64	184	3%	3%
331	37	97	209	356	658	44%	69%
330	3	10	26	65	184	3%	3%
341	6	15	33	80	296	8%	12%
342	6	17	36	85	248	6%	12%
343	4	14	36	91	290	7%	10%
340	3	10	27	67	191	4%	4%
351	10	27	59	116	330	10%	12%
350	5	13	32	73	194	4%	5%
361	21	51	96	182	355	15%	35%
360	6	15	33	73	195	4%	5%
370	5	14	33	73	196	4%	5%
380	4	12	30	70	196	4%	5%
391	5	15	31	64	257	6%	7%
390	4	11	29	69	197	4%	4%
401	4	11	23	50	174	4%	2%
402	9	22	41	79	215	4%	5%
400	3	10	29	69	197	4%	4%
411	6	16	33	71	204	4%	3%
410	3	9	28	68	204	4%	4%

Table F-4. All Flows—Scenario 4 (Page 1 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
10	23	68	130	283	830	30%	46%
21	31	78	146	255	508	29%	53%
22	34	86	159	279	551	33%	59%
23	14	37	73	133	294	9%	18%
24	30	83	160	286	603	33%	59%
20	24	65	121	228	531	24%	45%
31	45	112	204	365	719	44%	73%
30	24	64	120	225	521	24%	44%
41	45	111	210	383	772	45%	73%
42	31	75	140	247	494	27%	54%
43	31	76	139	249	500	27%	54%
44	30	75	137	245	497	27%	53%
40	24	62	116	211	442	21%	42%
51	7	15	25	46	162	3%	1%
52	8	21	36	64	187	4%	1%
50	19	47	85	154	326	12%	26%
61	27	63	114	201	422	19%	43%
60	18	46	84	155	330	12%	26%
71	9	20	39	72	213	4%	2%
72	12	30	57	102	243	5%	13%
70	14	37	71	138	307	10%	21%
81	15	34	62	111	255	6%	15%
80	1	5	10	19	42	0%	0%
91	20	45	85	153	323	12%	26%
92	19	53	99	178	318	12%	36%
90	5	15	29	53	102	1%	0%
101	1	3	7	22	118	2%	0%
102	11	28	56	116	250	6%	17%
100	6	15	28	51	97	1%	0%
110	6	15	27	50	106	2%	0%
121	6	14	28	50	199	4%	1%
122	13	31	56	95	248	5%	6%
120	6	13	26	47	110	2%	0%
130	5	11	23	44	119	2%	0%
140	5	11	22	44	121	2%	0%
150	4	10	20	42	121	2%	0%
161	12	27	53	90	256	6%	6%
162	11	28	52	85	176	3%	2%
163	9	24	44	73	177	3%	2%
164	8	21	41	71	172	3%	2%
160	3	7	18	40	133	2%	0%
170	2	7	17	40	133	2%	0%
181	1	2	8	39	197	4%	0%

Table F-4. All Flows—Scenario 4 (Page 1 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
180	2	6	16	39	139	3%	0%
191	6	10	15	37	176	3%	0%
192	2	4	6	12	68	1%	0%
193	2	5	8	16	80	1%	0%
194	3	8	18	51	215	4%	5%
195	2	5	9	20	94	1%	0%
196	3	5	10	25	103	2%	0%
197	3	8	15	37	179	3%	3%
198	1	2	5	14	86	1%	0%
199	2	4	9	25	110	1%	0%
190	2	6	16	39	136	3%	0%
201	6	12	22	50	188	3%	5%
202	3	7	14	36	140	2%	1%
203	3	7	14	39	148	3%	1%
204	1	2	11	70	283	7%	1%
205	8	19	34	70	189	3%	5%
206	6	14	27	59	187	3%	4%
207	4	9	18	40	148	2%	1%
208	6	14	26	49	220	5%	0%
209	3	6	12	31	177	4%	1%
211	5	12	28	60	222	4%	5%
212	5	12	21	45	169	3%	0%
213	4	10	20	42	166	3%	0%
214	8	17	35	72	178	3%	6%
215	5	11	25	57	196	4%	4%
216	8	17	35	72	193	3%	6%
217	7	16	36	83	242	5%	7%
218	6	13	30	69	219	4%	4%
219	3	8	19	50	217	4%	2%
221	4	11	24	57	222	5%	3%
222	11	26	58	120	397	11%	20%
223	5	12	28	64	208	4%	6%
224	5	12	26	60	203	4%	4%
200	3	8	18	42	166	3%	0%
231	3	7	18	50	265	6%	2%
232	5	12	26	62	250	5%	4%
233	6	16	39	90	318	7%	7%
234	3	9	23	54	217	4%	3%
235	3	9	22	52	229	5%	3%
236	3	8	20	47	203	4%	2%
237	3	9	22	49	201	4%	2%
230	3	8	18	43	171	3%	0%
241	13	32	63	127	378	12%	8%

Table F-4. All Flows—Scenario 4 (Page 3 of 3)

Reach	5th Percentile	25th Percentile	50th Percentile	75th Percentile	95th Percentile	% Exceed Max-Standard	% Exceed Geom-Standard
251	10	24	53	116	249	6%	16%
252	3	8	20	52	181	3%	0%
253	6	15	34	75	188	3%	3%
254	7	16	36	77	195	3%	3%
255	10	26	56	112	250	6%	12%
240	4	10	22	49	182	3%	0%
250	4	11	24	53	174	3%	0%
260	4	10	22	51	167	3%	0%
270	3	9	21	51	165	3%	0%
281	5	12	29	62	176	3%	1%
282	5	12	29	65	182	3%	1%
283	5	12	29	66	180	3%	2%
284	14	34	81	180	346	16%	34%
280	4	10	22	51	173	3%	1%
290	3	8	19	48	166	3%	1%
300	2	6	17	46	157	3%	0%
311	5	13	29	57	216	4%	0%
310	2	6	16	45	155	3%	0%
321	3	9	20	40	179	3%	1%
322	11	29	61	119	269	7%	17%
320	2	7	17	46	168	3%	1%
331	15	52	126	268	562	29%	44%
330	2	7	18	47	166	3%	1%
341	4	8	19	53	214	4%	3%
342	4	10	21	55	204	4%	2%
343	2	7	22	68	270	6%	4%
340	2	7	19	49	172	3%	1%
351	5	14	35	90	307	8%	5%
350	4	10	24	56	175	3%	2%
361	12	30	59	114	247	6%	17%
360	4	11	24	56	177	4%	2%
370	4	10	24	55	177	4%	2%
380	3	9	22	53	179	4%	2%
391	3	8	18	42	188	4%	1%
390	3	8	21	52	180	4%	2%
401	2	5	12	31	165	4%	1%
402	5	13	26	56	193	4%	1%
400	2	7	21	51	182	4%	2%
411	3	9	19	45	189	4%	1%
410	2	7	21	51	189	4%	2%

Appendix G — Supplemental Implementation Plan

This implementation plan is not a requirement of the Federal Clean Water Act. However, the contractor included it as part of the TMDL preparation. U. S. EPA recognizes that technical guidance and support are critical to determining the feasibility of and achieving the goals outlined in this TMDL. Therefore, this informational plan is included to be used by local professionals, watershed managers and citizens for decision-making support and planning purposes. It should not be considered to be a part of the established Cedar River Watershed TMDL.

Currently, this plan focuses on estimating the current condition of all perennial streams and the feasibility of BMPs achieving water-quality standards throughout the watershed.

G.1. Rationale for Watershed wide Implementation Plan

Although this document only provides TMDLs for the nine currently listed impaired river segments, it is clear from the available data that bacteria pollution is a watershed wide problem. Moreover, with the change in Iowa's water-quality standards for indicator bacteria such that all perennial rivers and streams are subject to Class A standards, it is highly likely TMDLs will soon be required for a prohibitively large number of segments. Thus it makes sense to develop implementation plans that address the watershed as a whole and not just for the currently listed nine segments. Thinking proactively and holistically in this initial watershed wide implementation plan will potentially eliminate the need for additional TMDLs in the Iowa portion of the watershed.

The HSPF application developed for this TMDL provides the ideal framework to evaluate existing conditions in the perennial streams and to evaluate the impact various implementation plans have in achieving water-quality standards in these streams.

G.2. Perennial Stream Analysis for Existing Conditions

The HSPF model application represented the perennial streams within the subbasin as 126 reach segments ranging in size from less than 1 mile to 35 miles, with an average stream length of 14 miles. The model was calibrated for the time period of 1995 to 2005. Over this time period, the model provides predictions at an hourly interval for all state variables; e.g., *E. coli* concentration at each of the 126 reach endpoints. These results were averaged at a daily interval and analyzed to determine the percent of time a particular concentration and/or exceedances occurred for each reach. Figure G-1 presents the percent of time exceedances of the maximum concentration standard occurred for each of the 126 reaches within the watershed. All 126 reaches were predicted to have exceedances occurring more than 10 percent of the time. The Iowa portion of the watershed has 105 reaches, of which 91 had exceedances occurring more than 20 percent of the time. These results are within reason based on the fact that the median exceedance rate for the 57 stations analyzed within the watershed was 56 percent. The combination of the model results and available data clearly indicate that *E. coli* pollution is a watershed wide problem. Appendix F contains a tabular summary of the percentile concentrations and percent exceedance rate for each of the 126 reaches.

RSI-1748-08-080

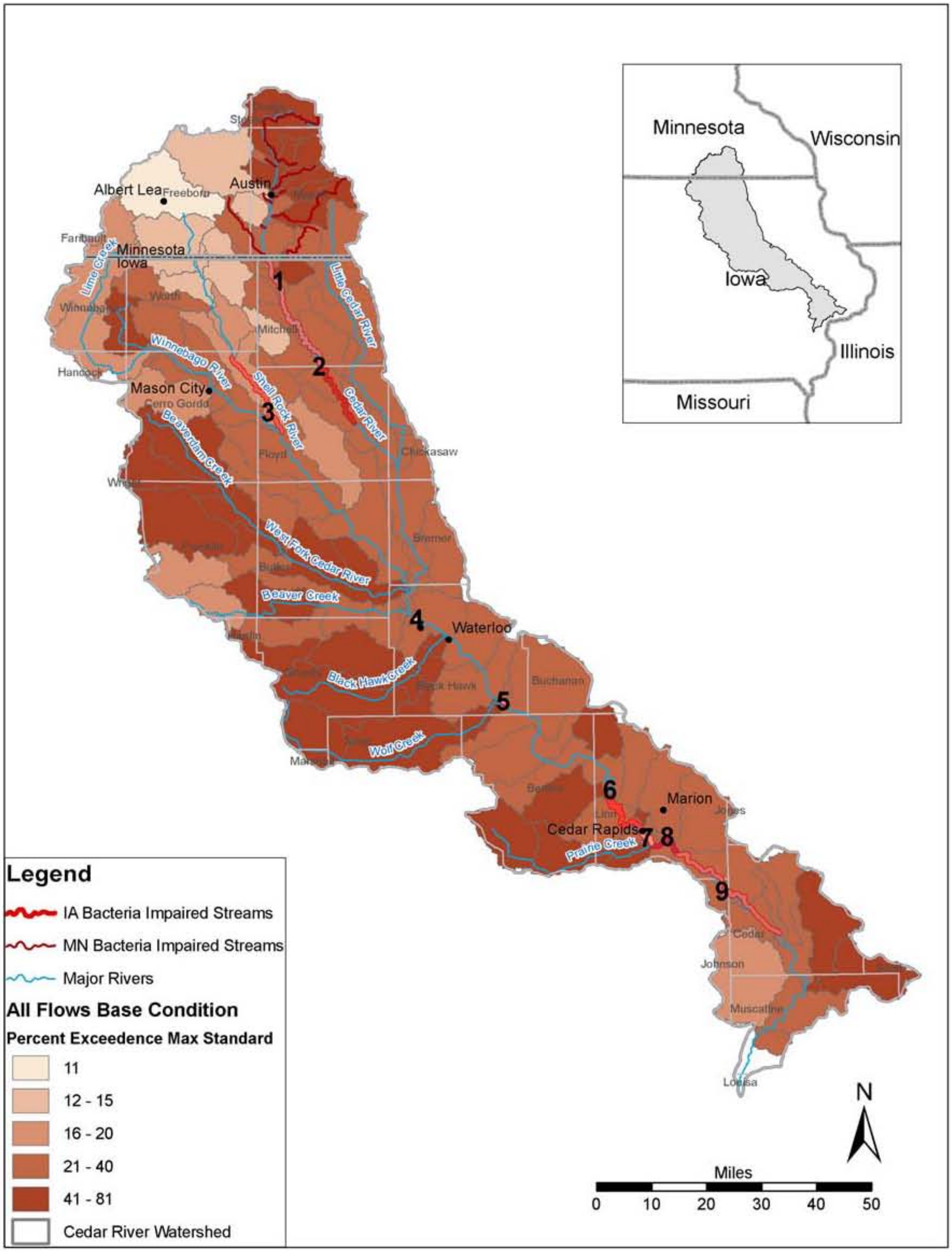


Figure G-1. Percent of Time Exceedances Occur for Existing Conditions.

G.3. Watershed Scale Load Reduction Scenarios

The BMPs listed below represents four management practices that would be highly effective at improving the water-quality conditions within the Cedar River Watershed and achieving the TMDLs stated in this document.

1. **All WWTP effluent and rivers entering Iowa will have bacteria concentrations less than or equal to the water-quality standard.** This scenario was represented by reconfiguring the base model to restrict concentrations entering the state from Minnesota rivers and WWTPs at 235 *E. coli* cfu/100 ml.
2. **Unpermitted feedlots will control/capture the first one-half inch of rain.** The average storm event in this part of the country is typically between 0.5 and 0.6 inch. Controlling runoff from the average storm can easily equate to capturing 70-90 percent of the *E. coli* loading. The model was configured to capture the first one-half inch of rain falling on all open feedlots to test the potential benefits of this scenario.
3. **Cropland bacteria loading will be reduced by 40 percent through proper timing and application techniques.** This scenario was represented by reconfiguring the base model to use a 0.60 multiplier on all cropland-generated loadings. Although simplistic, this is an effective way of quickly looking at the potential water-quality improvement through better watershed wide manure management.
4. **Cattle in stream will be reduced by 40 percent and leaking septic systems will be eliminated.** This scenario was represented by reducing the base scenario loads from direct defecation by cattle by 40 percent.

Each one of these scenarios was successively added to the base management scenario, simulated by the model and cumulative reductions calculated for each of the perennial reaches represented in the model. Appendix F contains a tabular summary of the percentile concentrations and percent exceedance rate for each of 105 reaches in Iowa under each of the scenarios. Table G-1 presents the results for the nine TMDL reach endpoints. Refer to Table 1-1 for correspondence between Reach Figure ID and Waterbody IDs.

It is clear from Table G-1 that significant reductions are achieved through implementation of Scenarios 1 and 2. Scenario 1 represents control of indirect sources of pollution entering the state and direct sources from WWTPs in Iowa not currently using disinfection. The reductions achieved are significant, especially for reaches close to the Minnesota/Iowa state line. Scenario 2 focuses on control/capture of the first one-half inch of rain from open feedlots. Capturing the first one-half inch would relate to capturing the average storm for the region and the first flush from larger storms. Open feedlots were consistently the largest stressor for each of these reaches. Not surprisingly, the model predictions show that significant reductions in the upper percentile concentrations, those associated primarily with high flows, resulted from the implementation of Scenario 2. It would seem that the cost-versus-benefit gained from implementation of a form of Scenarios 1 and 2 would be a logical first step to achieve water-quality standards in this watershed. Scenarios 3 and 4 do provide extra benefit to this watershed but the reductions are not as significant.

Table G-1. Scenario concentrations and percent exceedance rates for nine TMDL reaches (Page 1 of 2).

HSPF reach/ reach figure ID	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	% Exceed max-standard	% Exceed geom-standard
Base Conditions							
110/1	22	56	126	294	6,278	30%	63%
130/2	12	37	97	262	4,179	27%	48%
196/3	6	16	38	134	3,494	18%	22%
230/4	9	33	119	333	3,430	32%	49%
270/5	9	29	111	308	3,015	31%	48%
320/6	10	29	122	374	3,259	35%	52%
340/7	9	31	130	396	3,299	36%	53%
350/8	11	34	133	399	3,549	36%	54%
370/9	10	32	129	393	3,831	36%	54%
Scenario 1							
110/1	12	29	54	110	3,895	13%	18%
130/2	9	22	48	110	2,889	15%	18%
196/3	6	13	26	78	2,937	16%	11%
230/4	6	19	52	187	2,987	22%	27%
270/5	6	19	52	165	2,610	20%	28%
320/6	4	14	49	197	2,898	23%	29%
340/7	4	15	53	222	2,969	24%	32%
350/8	6	19	60	249	3,117	25%	36%
370/9	7	20	60	254	3,544	26%	36%
Scenario 2							
110/1	10	25	45	81	169	3%	4%
130/2	9	19	38	72	181	3%	3%
196/3	5	11	21	43	150	2%	0%
230/4	5	13	31	71	255	5%	5%
270/5	5	13	32	77	236	5%	6%
320/6	3	10	27	71	246	5%	6%
340/ 7	3	10	28	75	252	5%	7%
350/8	5	14	34	80	257	5%	8%
370/9	5	14	34	80	264	6%	8%
Scenario 3							
110/1	10	24	43	77	154	2%	3%
130/2	8	18	36	68	161	2%	2%
196/3	5	11	20	40	121	2%	0%
230/4	5	13	29	66	196	4%	2%
270/5	5	13	31	70	189	4%	3%
320/6	3	10	26	64	184	3%	3%
340/7	3	10	27	67	191	4%	4%
350/8	5	13	32	73	194	4%	5%
370/9	5	14	33	73	196	4%	5%

Table G-1. Scenario concentrations and percent exceedance rates for nine TMDL reaches (Page 2 of 2).

HSPF reach/ reach figure ID	5th percentile	25th percentile	50th percentile	75th percentile	95th percentile	% Exceed max-standard	% Exceed geom-standard
Scenario 4							
110/1	6	15	27	50	106	2%	0%
130/2	5	11	23	44	119	2%	0%
196/3	3	5	10	25	103	2%	0%
230/4	3	8	18	43	171	3%	0%
270/5	3	9	21	51	165	3%	0%
320/6	2	7	17	46	168	3%	1%
340/7	2	7	19	49	172	3%	1%
350/8	4	10	24	56	175	3%	2%
370/9	4	10	24	55	177	4%	2%

Implementation of all four scenarios is predicted to reduce the percentage of model reaches in Iowa exceeding the 235 *E. coli* cfu/100 ml 10 percent of the time to approximately 5 percent (6/105 reaches). Similarly, the number of reaches with greater than 20 percent exceedances is predicted to be less than 1 percent (1/105 reaches). Figure G-2 shows the percent of time exceedances are predicted after implementation of all four BMP scenarios within Iowa.

It is clear from the model predictions that the TMDLs established in this document are feasible and water-quality conditions throughout the watershed can come into compliance through technically feasible BMPs. Additional cost benefit analysis and review of the model results will allow the development of a more focused and phased implementation plan.

RSI-1748-08-081

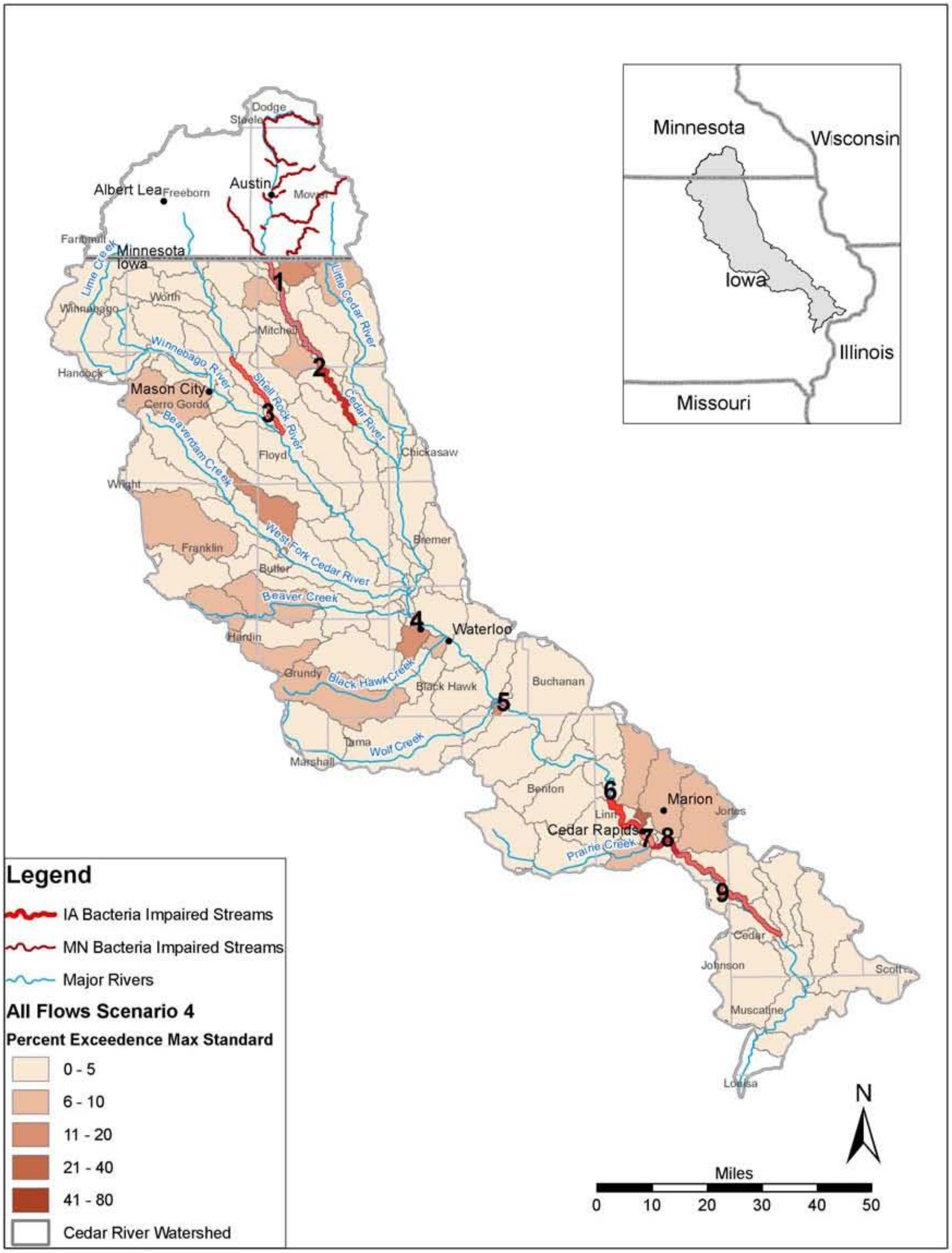


Figure G-2. Percent of Time Exceedances Predicted to Occur After Implementing All Four BMP Scenarios.

CEDAR RIVER – *E. Coli*
SUMMARY OF COMMENTS AND RESPONSES
Prepared by the Environmental Protection Agency, Region 7
Water, Wetlands and Pesticides Division
February 2010

COMMENTOR(S):

Brad Jesse, Resident, LaPorte City, Iowa
Barry Jesse, Resident, LaPorte City, Iowa
Tracy Meise, Planning & Project Superintendent, Charles City, Iowa
Rick Robinson, Iowa Farm Bureau, West Des Moines, Iowa
Kent Shultz, Resident, Osage, Iowa

INTRODUCTION

The Cedar River Total Maximum Daily Load (TMDL) for *E. Coli* was public noticed from December 29, 2009 to February 10, 2010. This document summarizes public comments and United States Environmental Protection Agency (EPA) responses. Any changes to the final TMDL are explained in the Summary of Changes to the Final TMDL. Similar comments on a single topic are summarized as one comment, but each commentor is referenced. If no change is noted in the response, then no change is made in the final TMDL.

Comment 1:
Commentors expressed concerns over: the requirement to keep cattle out of the river and the resulting financial impact, and the contribution of *E. coli* from livestock lots, manure spreading, and wastewater treatment plants on the Cedar River watershed. A concern was also expressed about the runoff of pesticides, herbicides, and oil from cities into the creeks and rivers. Suggestions for improving water quality were also provided, including filter strips and sand filtration. Commentors: Kent Shultz, resident, Osage, Iowa, January 25, 2010; Brad Jesse, resident, LaPorte City, Iowa, January 25, 2010; and Barry Jesse, resident, LaPorte, Iowa, February 5, 2010.

Response 1:
Thanked commentors for their comments and suggestions on reductions of contamination, provided a link to the Cedar River TMDL on EPA's website http://www.epa.gov/region07/water/tmdl to assist with information on location of pollution by mile markers, maps, and pollution data. Also emphasized that EPA is sensitive to the concerns of the agricultural community and will continue to seek feedback from agricultural stakeholders as TMDLs are developed and public noticed.

Comment 2:
Commenter requested clarification of the Dam location included in the Cedar River TMDL. The river segment is listed as IA 02-CED-0110_2; Charles City Dam, number 2, to confluence with Rock Creek. Legal description is: NW 1/4, NE 1/4, S12, T95N, R16W. There are two dams

located within 200 feet of each other in Charles City, Iowa. One is referred to as the Main Street Dam (upper dam) the other is Beauty Dam (lower dam). Planned improvement projects need to apply the TMDL to the correct dam. Commentor: Tracy Meise, Planning & Project Superintendent, Charles City, Iowa, initial comment January 7, 2010, subsequent discussions related to same dam identification issues took place on January 11, 2010, and January 13, 2010.

Response 2:
The northern-most dam (of the two) is the Dam number 2 referred to in the TMDL.

Comment 3:
The commentor asked questions on the process for establishing the Cedar River TMDL, and when it will be final. Questions included why Iowa did not develop and submit the TMDL for approval to the EPA, when will the TMDL be finalized, and what is the public notice process. Commentor: Rick Robinson, Iowa Farm Bureau, January 14, 2010.

Response 3:
The TMDL needed to be completed this year to meet EPA lawsuit deadlines. Iowa requested that EPA establish the TMDL. After public notice ends, comments will be reviewed and appropriate edits will be made to the TMDL. The TMDL will be finalized this month.

Summary of Changes to the Final TMDL
Appendix D-1 has been updated for the City of Cedar Rapids permit flow type and language has been added to page 61 for clarity.