Environmental Restoration Division
ORNL Environmental Restoration Program

**Hydrologic Data Summary for the White Oak Creek Watershed
at Oak Ridge National Laboratory, Oak Ridge, Tennessee
(October 1990–December 1991)**

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CONTENTS

FIGURES	v
TABLES	ix
PREFACE	xiii
ACKNOWLEDGMENTS	xv
ABBREVIATIONS	xvii
EXECUTIVE SUMMARY	xix
1. INTRODUCTION	1
1.1 PURPOSE AND SCOPE	1
1.2 SITE DESCRIPTION	3
1.2.1 White Oak Creek	3
1.2.2 White Oak Dam	3
1.2.3 White Oak Creek Embayment	3
1.2.4 Geology	5
1.2.5 Soils	9
1.2.6 Contaminants in WOC Watershed	9
1.3 ENVIRONMENTAL RESTORATION PROGRAM	9
1.3.1 Sediment Monitoring and Modeling Project	12
1.3.2 Station Upgrade and Maintenance	13
1.3.3 Flow Frequency Analyses	19
1.3.4 SWSA 6 ICM Environmental Monitoring Program	26
1.3.5 WAG 2 Remedial Investigation	26
1.3.6 Other WAGS and Contaminant Releases	28
1.4 OTHER PROGRAMS	30
1.4.1 Environmental Surveillance	30
1.4.2 National Pollutant Discharge Elimination System	30
1.4.3 Stormwater Monitoring	31
1.4.4 Active Sites Environmental Monitoring Program	31
1.4.5 Biological Monitoring and Abatement Program	32
2. HYDROLOGIC DATA	35
2.1 CLIMATE	35
2.2 SURFACE WATER	40
2.2.1 Discharge	40
2.2.2 Flow Augmentation in the White Oak Creek Watershed	67
2.2.3 Surface Water Quality	70
2.2.4 Contaminants in Sediments	85
2.2.5 Outfalls to the White Oak Creek Flow System	85
3. DATA PROCESSING AND AVAILABILITY	93

3.1 DATA PROCESSING	93
3.1.1 Stream Discharge Data	93
3.1.2 Precipitation Data	93
3.1.3 Software Systems	94
3.2 DATA AVAILABILITY	94
3.2.1 Environmental Sciences Division	94
3.2.2 U. S. Department of the Interior, Geological Survey	100
3.2.3 Environmental Surveillance and Protection Section	100
3.2.4 Oak Ridge Environmental Information System	100
4. QUALITY ASSURANCE/QUALITY CONTROL	103
5. SUMMARY AND RECOMMENDATIONS	105
5.1 PROGRESS DURING THE PAST YEAR	105
5.2 RECOMMENDED IMPROVEMENTS	105
5.2.1 Issues Within the ERP Hydrologic Monitoring Activity	105
5.2.2 Issues for Upper Level Management Approval	106
REFERENCES	109
APPENDIX A—Descriptions of Waste Area Groupings located in the White Oak Creek Watershed	115
APPENDIX B—Daily Precipitation Totals for Stations in White Oak Creek Watershed	125
APPENDIX C—Daily Streamflow for Monitoring Stations in White Oak Creek Watershed	147
APPENDIX D—Rating Tables for Monitoring Stations in White Oak Creek Watershed	181

FIGURES

		Page
1	Map of the White Oak Creek Watershed with waste area groupings (WAGs) shown	2
2	Water-surface elevation at the mouth of the White Oak Creek embayment on October 11, 1990	6
3	Trends in the water-surface elevation at the mouth of the White Oak Creek embayment in a wet winter month, January 1989	7
4	Schematic of the WOC watershed showing potential area contamination sources	8
5	White Oak Creek watershed soils classified according to hydrologic soil groups (HSGs)	11
6	Comparison of 15-min discharge at Melton Branch (MS4) monitoring station for a storm that occurred on December 22-23, 1990	16
7	Comparison of 15-min discharge at Melton Branch (MS4) monitoring station for a storm that occurred on February 17-20, 1991	17
8	Drowned-flow reduction factor as a function of H_2/H_1 (submergence ratio) for the high-flow control at White Oak Dam (MS5)	18
9	Flow-frequency and flow-volume fraction curves for the White Oak Creek station (MS3), based on 2 years of 15-min discharge data	21
10	Flow-frequency and flow-volume fraction curves for the Melton Branch station (MS4), based on 2 years of 15-min discharge data	22
11	Flow-frequency and flow-volume fraction curves for the White Oak Dam station (MS5), based on 2 years of 15-min discharge data	23
12	Flow-frequency and flow-volume fraction curves for the East Seep station, based on 3 years of 15-min discharge data	24
13	Flow-frequency and flow-volume fraction curves for the West Seep station, based on 3 years of 15-min discharge data	25
14	Meteorological stations in the White Oak Creek watershed for which data are available through the OREIS data base system	38

15	Daily precipitation measured at the ETF rain gage in the White Oak Creek watershed during the period October 1990–December 1991	42
16	Daily precipitation measured at the NOAA/ATDD rain gage in Oak Ridge during the period October 1990–December 1991	43
17	Locations of surface–water monitoring stations in the vicinity of the White Oak Creek watershed	45
18	Daily streamflow at the White Oak Creek station (MS3) for the period October 1990–December 1991	47
19	Daily streamflow at the Melton Branch station (MS4) for the period October 1990–December 1991	48
20	Daily streamflow at the White Oak Dam station (MS5) for the period October 1990–December 1991	49
21	Comparison of monthly mean discharge at USGS monitoring station GS3 and ESD monitoring station MS3	63
22	Comparison of ESD monthly mean discharge at monitoring stations MS3, MS4, and MS5	64
23	Comparison of monthly mean discharge at USGS monitoring station GS6 and ESD monitoring station WOCHW	66
24	Comparison of monthly mean discharge at USGS monitoring stations GS1, GS3, GS4, and GS5	68
25	Comparison of monthly mean discharge at USGS monitoring stations GS5 and GS6	69
26	Surface–water quality monitoring or sampling sites in WOC and its tributaries	71
27	ORNL surface-water and reference sampling locations	77
28	Map of ESP water sampling stations for mercury in the ORNL Melton Valley complex	78
29	Map of ESP water sampling stations for mercury in the ORNL area	79
30	ESP sample locations for PCB and TOC (sediment only) analyses in the ORNL area	80
31	Monthly discharge of ¹³⁷ Cs at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991	81

32	Monthly discharge of ^{60}Co at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991	82
33	Monthly discharge of ^3H at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991	83
34	Monthly discharge of total Sr at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991	84
35	Terrestrial gamma exposure rates derived from the September–October 1986 survey of the White Oak Creek floodplain	86
36	Gamma energy spectra locations derived from the September–October 1986 survey of the White Oak Creek floodplain	87
37	Cesium–137 photopeak count rate isopleths derived from the September–October 1986 survey of the White Oak Creek floodplain	87
38	Cobalt–60 photopeak count rate isopleths derived from the September–October 1986 survey of the White Oak Creek floodplain	88
39	Daily discharge at the White Oak Creek (MS3) monitoring station for the 27-month period October 1989–December 1991	95
40	Daily discharge at the Melton Branch (MS4) monitoring station for the 27-month period October 1989–December 1991	96
41	Daily discharge at the White Oak Dam (MS5) monitoring station for the 27-month period October 1989–December 1991	97
42	Daily precipitation at the ETF rain gage for the 27-month period October 1989–December 1991	98
43	Daily precipitation at the NOAA/ATDD rain gage in Oak Ridge for the 27-month period October 1989–December 1991	99

TABLES

		Page
1	Historical changes in the surface of White Oak Lake and major events associated with significant changes in the lake	4
2	White Oak Creek Watershed hydrologic soil groups	10
3	Sources of data and contaminants known or suspected to have been released from WAGs in the White Oak Creek Watershed	29
4	Meteorological stations in the vicinity of the WOC watershed	36
5	Rainfall vs frequency for areas up to 25.9 km ² (10 miles ²) in Anderson and Knox counties, Tennessee	37
6	Precipitation measurement descriptions for stations located in the WOC watershed and the NOAA/ATDD Oak Ridge station	39
7	Monthly precipitation totals at the WOC watershed and NOAA/ATDD stations during October 1990–December 1991	41
8	Maximum storm event analysis for the ETF station	44
9	Maximum storm event analysis for the First Creek (1ST) station	44
10	Monthly flow and runoff statistics for ESD stations located in the vicinity of WOC watershed	56
11	Monthly flow and runoff statistics for USGS stations located in the vicinity of WOC watershed	59
12	Availability of White Oak Creek watershed environmental monitoring data from the Environmental Surveillance and Protection Section, Information Integration and Analysis Group, Water Year 1991	72
13	Major treated effluent discharges to White Oak Creek from ORNL	90
14	Data product hierarchy for the ESD Surface Water Hydrology Group surface-water monitoring program	103
B.1	Daily precipitation totals at the ETF station for the period October 1, 1990–December 31, 1991	127
B.2	Daily precipitation totals at the First Creek (1ST) station for the period October 1, 1990–December 31, 1991	129

B.3	Daily precipitation totals at the SWSA 7 (SW7) station for the period October 1, 1990–December 31, 1991	131
B.4	Daily precipitation totals at the 49T station for the period October 1, 1990–December 31, 1991	133
B.5	Daily precipitation totals at the SWSA 4 (SW4) station for the period October 1, 1990–December 31, 1991	135
B.6	Daily precipitation totals at the Ish Creek (ISH) station for the period October 1, 1990–December 31, 1991	137
B.7	Daily precipitation totals at the Walker Branch Watershed (RG1) station for the period October 1, 1990–December 31, 1991	139
B.8	Daily precipitation totals at the Walker Branch Watershed (RG3) station for the period October 1, 1990–December 31, 1991	141
B.9	Daily precipitation totals at the Bear Creek Burial Ground (BUR) station for the period October 1, 1990–December 31, 1991	143
B.10	Daily precipitation totals at the NOAA/ATDD station, Oak Ridge, Tennessee for the period October 1, 1990–December 31, 1991	145
C.1	Daily streamflow at the East Seep monitoring station for the period October 1, 1990–December 31, 1991	149
C.2	Daily streamflow at the White Oak Creek (MS3) station for the period October 1, 1990–December 31, 1991	151
C.3	Daily streamflow at the Melton Branch (MS4) monitoring station for the period October 1, 1990–December 31, 1991	153
C.4	Daily streamflow at the White Oak Dam (MS5) monitoring station for the period October 1, 1990–December 31, 1991	155
C.5	Daily streamflow at the Ish Creek monitoring station for the period October 1, 1990–December 31, 1991	157
C.6	Daily streamflow at the Raccoon Creek monitoring station for the period October 1, 1990–December 31, 1991	159
C.7	Daily streamflow at the White Oak Creek Headwaters (WOCHW) monitoring station for the period October 1, 1990–December 31, 1991	161
C.8	Daily streamflow at the West Seep monitoring station for the period October 1, 1990–December 31, 1991	163

C.9	Daily streamflow at monitoring station GS1 (USGS 03536450) for October 1, 1990–December 31, 1991	165
C.10	Daily streamflow at monitoring station GS2 (USGS 03537100) for October 1, 1990–December 31, 1991	167
C.11	Daily streamflow at monitoring station GS3 (USGS 03536550) for October 1, 1990–December 31, 1991	169
C.12	Daily streamflow at monitoring station GS4 (USGS 03536440) for October 1, 1990–December 31, 1991	171
C.13	Daily streamflow at monitoring station GS5 (USGS 03536380) for October 1, 1990–December 31, 1991	173
C.14	Daily streamflow at monitoring station GS6 (USGS 03536320) for October 1, 1990–December 31, 1991	175
C.15	Daily streamflow at monitoring station GS16 (USGS 03537050) for October 1, 1990–December 31, 1991	177
C.16	Daily streamflow at monitoring station GS17 (USGS 03537200) for October 1, 1990–December 31, 1991	179
D.1	Rating table for low flow at White Oak Dam (MS5) station	183
D.2	Rating table for high flow at White Oak Dam (MS5) station	184
D.3	Rating table for low flow at White Oak Creek (MS3) station located above the confluence with Melton Branch	189
D.4	Rating table for high flow at White Oak Creek station (MS3) located above the confluence with Melton Branch	191
D.5	Rating table for low flow for Melton Branch (MS4) station located above the confluence with White Oak Creek	194
D.6	Rating table for White Oak Creek Headwaters station located in the upper reaches of White Oak Creek and upstream of ORNL facility discharges	196
D.7	Rating table for East Seep station located on the east seep tributary to the headwaters of White Oak Lake	198
D.8	Rating table for West Seep Tributary station located in the west seep tributary to the headwaters of White Oak Lake	199
D.9	Rating table for Ish Creek station located upstream from the mouth of the Clinch River at kilometer 30.7 (mile 19.1)	201

D.10	Rating table for Raccoon Creek station	203
D.11	Rating table for T-2A station located on an unnamed tributary to White Oak Creek near the southern boundary of SWSA 4	205
D.12	Rating table for Melton Branch 2 (MB2) upstream from the confluence with the HRT tributary	206
D.13	Rating table for the Palmer Bowlus flume at station on tributary to Melton Branch near the Old Homogeneous Reactor Test Facility (HRTF)	207
D.14	Rating table for Upper White Oak Creek station (GS6, USGS 03536320) east of the East gate of ORNL and near Building 6000	208
D.15	Rating table for White Oak Creek Parshall Flume station (GS5, USGS 03536380)	210
D.16	Rating table for Northwest Tributary (NWT, GS4, USGS 03536440) station located above the confluence with First Creek	214
D.17	Rating table for First Creek station (GS1, USGS 03536450) located on the First Creek tributary to White Oak Creek between Burial Ground Road and the confluence with the Northwest tributary	217
D.18	Rating table for 7500 Bridge station (GS3, USGS 03536550) located on White Oak Creek below Melton Valley Drive	219
D.19	Rating table for East Seven Tributary (GS16, USGS 03537050) station on Melton Branch adjacent to proposed SWSA 7	222
D.20	Rating table for the H-flume at Center Seven station (GS17, USGS 03537200) located on Center 7 Creek, a tributary of Melton Branch ..	224
D.21	Rating table for the V-notch at Center Seven (GS17, USGS 03537200) station located on Center 7 Creek, a tributary of Melton Branch	226
D.22	Rating table for West Seven Tributary station (GS18, USGS 03537300) located on Melton Branch	227

PREFACE

Those readers familiar with our last hydrologic report (Borders et al. 1991) will observe that the name of the watershed, and hence the creek that drains it, formerly referred to as "Whiteoak," appears as two words (White Oak) in this report. It is the opinion of many that since local usage for much of the nearly 50-year history of ORNL has customarily been two words, this is now the proper usage of the name. The authors of this report disagree with this opinion, and we supported our position in last year's annual report (Borders et al. 1991). Briefly, the official federal position on the name of the feature is "Whiteoak Creek." To change it would take a formal decision by the Board on Geographic Names. Our primary motivation is that we would like to see correct and consistent usage of the name by all parties. However, to be consistent with other Environmental Restoration documents, we have agreed to use the two-word form of the name in this report. We strongly suggest that the official one-word usage be followed. If the two-word usage continues to be followed, the Board on Geographic Names should be petitioned to officially change the name to two words. Until such time that the Board on Geographic Names officially changes the name, all other federal agencies (e.g., U.S. Geological Survey, U.S. Environmental Protection Agency, and Tennessee Valley Authority) will correctly continue to represent the name as "Whiteoak."

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ABBREVIATIONS

ASEMP	Active Sites Environmental Monitoring Program
ATDD	Atmospheric Turbulence and Diffusion Division
BMAP	Biological Monitoring and Abatement Program
cfs	cubic feet per second
C7C	Center Seven Creek
CYRTF	Coal Yard Runoff Treatment Facility
DAS	Data Acquisition System
DCP	Data Collection Platform
DOE	Department of Energy
E7C	East Seven Creek
ECE	Environmental Consulting Engineers
ECS	Environmental Compliance Section
EDT	Explosives Detonation Trench
EPA	Environmental Protection Agency
ERMA	Environmental Restoration Monitoring and Assessment
ERP	Environmental Restoration Program
ESD	Environmental Sciences Division
ESP	Environmental Surveillance and Protection Section
ETF	Engineering Test Facility
EWB	Emergency Waste Basin
FFA	Federal Facilities Agreement
FS	Feasibility Study
gpd	gallons per day
GIS	Geographic Information System
GWPP	Groundwater Protection Program
HDPE	High density Polyethylene
HDTF	Hillcut Disposal Test Facility
HFIR	High Flux Isotope Reactor
HRE	Homogenous Reactor Experiment
HRTF	Homogenous Reactor Test Facility
HSG	Hydrologic Soil Group
ICM	Interim Corrective Measures
IEA	Internal Environmental Assessment
IR	Infrared
IWMF	Interim Waste Management Facility
LLW	Low Level Waste
MB	Melton Branch
mgd	million gallons per day
MMES	Martin Marietta Energy Systems
msl	mean sea level
MSRE	Molten Salt Reactor Experiment
MSS	Multispectral
NEPA	National Environmental Policy Act
NHF	New Hydrofracture Facility
NOAA	National Oceanic and Atmospheric Administration
NPDES	National Pollutant Discharge Elimination System

NRWTF	Non-Radiological Wastewater Treatment Facility
NSPP	Nuclear Safety Pilot Plant
NWT	Northwest Tributary
OECD	Office of Environmental Compliance and Documentation
OEHP	Office of Environmental and Health Protection
OHF	Old Hydrofracture Facility
OREIS	Oak Ridge Environmental Information System
ORNL	Oak Ridge National Laboratory
ORR	Oak Ridge Reservation
PCB	Polychlorinated Biphenyl
PWTP	Process Waste Treatment Plant
QA	Quality Assurance
QC	Quality Control
RA	Remedial Action
RAP	Remedial Action Program
RCRA	Resource Conservation and Recovery Act
RFA	RCRA Facilities Assessment
RFI	RCRA Facility Investigation
RI	Remedial Investigation
RI/FS	Remedial Investigation/Feasibility Study
S&A	Sampling and Analysis
SAS	Statistical Analysis System
SCS	Soil Conservation Service
SI	Site Investigation
STP	Sewage Treatment Plant
SWMU	Solid Waste Management Unit
SWSA	Solid Waste Storage Area
TDEC	Tennessee Department of Environment and Conservation
TEHM	Terrestrial Ecology and Hydrology Model
TRC	Total Residual Chlorine
TRU	Transuranics or Transuranium Processing Facility
TVA	Tennessee Valley Authority
USGS	United States Geological Survey
WAG	Waste Area Grouping
WOC	White Oak Creek
WOCE	White Oak Creek Embayment
WOCHW	White Oak Creek Headwater
WOD	White Oak Dam
WOL	White Oak Lake
WPCP	Water Pollution Control Program

EXECUTIVE SUMMARY

This report summarizes for the 15-month period October 1990–December 1991 the available dynamic hydrologic data collected, primarily on the White Oak Creek (WOC) watershed, along with information collected on the surface flow systems that affect the quality or quantity of surface water. The collection of hydrologic data is one component of numerous, ongoing Oak Ridge National Laboratory (ORNL) environmental studies and monitoring programs and is intended to

1. characterize the quantity and quality of water in the flow system,
2. assist with the planning and assessment of remedial action activities, and
3. provide long-term availability of data and quality assurance.

Characterization of the hydrology of the WOC watershed is critical for understanding the processes that drive contaminant transport in the watershed. Identification of spatial and temporal trends in hydrologic parameters and mechanisms that affect the movement of contaminants supports the development of interim corrective measures and remedial restoration alternatives. In addition, hydrologic monitoring supports long-term assessment of the effectiveness of remedial actions in limiting the transport of contaminants across Waste Area Grouping (WAG) boundaries and ultimately to the off-site environment. For these reasons, it is of paramount importance to the Environmental Restoration Program (ERP) to collect and report hydrologic data activities that contribute to the Site Investigations component of the ERP.

Principally, this report describes and provides sources of hydrologic data for Environmental Restoration activities that use monitoring data to quantify and assess the impact from releases of contaminants from ORNL WAGs. Also, it briefly summarizes and describes specific components of the ERP and tasks providing hydrologic and contaminant flux data. In addition, this report reviews existing programs outside of ERP that provide hydrologic data that could be of benefit to the ERP goals.

The majority of the data summarized in this report are available from the Oak Ridge Environmental Information System (OREIS). Surface-water data available within the WOC flow system include discharge and runoff, surface-water quality, radiological and chemical contamination of sediments, and descriptions of the outfalls to the WOC flow system. Climatological information available for the Oak Ridge area includes precipitation, temperature, relative humidity, wind speed, wind direction, and pan evaporation data. Information on groundwater levels, aquifer characteristics, and groundwater quality is presented in the Environmental Monitoring and Assessment Report (ERMA) which will be published in September 1992. Anomalies in the data and problems with monitoring and accuracy are discussed. Appendices contain daily precipitation measurements, daily discharge at surface-water monitoring stations, and rating curves for most hydraulic control structures described in this report.

1. INTRODUCTION

This report, prepared as part of the Environmental Restoration Program (ERP) at Oak Ridge National Laboratory (ORNL), is the fourth in a series of reports that summarize the hydrologic data collected on and in the vicinity of the White Oak Creek (WOC) watershed (Fig. 1). White Oak Creek drains the watershed in which ORNL is located and receives radioactive and nonradioactive effluents (treated and untreated) from Laboratory activities as well as leachates from subsurface waste storage areas in use since the early 1940s. In 1986, Sherwood and Loar summarized the available information on hydrogeological and ecological characteristics of the WOC flow system and the nature and quantity of contaminants released into and from the system. Annual summaries of hydrologic data (Borders et al. 1989, 1991) were prepared in response to Sherwood and Loar's recommendation that the hydrology of the WOC watershed be characterized in order to better understand trends in both temporal and spatial patterns of the watershed.

The collection of hydrologic data is an integral component of numerous ongoing ORNL environmental studies and monitoring programs and is designed to help (1) characterize the quantity and quality of water in the flow system, (2) plan and assess remedial action activities, (3) provide long-term data availability and quality assurance, and (4) support long-term measures of contaminant fluxes at a spatial scale to provide a comprehensive picture of watershed performance that is commensurate with future remedial actions. This report continues the characterization and provides the sources of data needed for long-term assessment of the effectiveness of remedial restoration activities.

1.1 PURPOSE AND SCOPE

This report documents hydrologic data collected in the WOC watershed for October 1, 1990-December 31, 1991. Previous reports have covered standard or nonstandard "water years" that differ from the calendar year (January to December). The reasons for reporting data for this 15-month period are twofold: (1) for the ERP, important information on contaminant fluxes is typically quantified on a calendar year basis (calendar year 1991 is covered in full, and future reports will henceforth be on a calendar year basis); and (2) reporting data through December 1991 enabled a more timely dissemination of the data and their analyses and interpretations.

Available dynamic hydrologic data collected during the 15-month period, along with information collected on the surface flow systems that affect the quantity or quality of surface water, are summarized. A number of relevant ORNL programs and ERP projects that produce information on hydrologic characterization or related data are also described. In addition to presenting data collected during the past 15 months, we have attempted to summarize data collected over several years to show trends in both spatial and temporal scales.

Fig. 1. Map of the White Oak Creek Watershed with waste area groupings (WAGs) shown

1.2 SITE DESCRIPTION

The WOC watershed is located primarily in the Roane County portion of the Oak Ridge Reservation (ORR). The headwaters region of WOC, making up the northeast corner of the watershed, lies partially in Anderson County. The WOC watershed is bounded by Copper Ridge to the south, White Wing Road (State Highway 95) to the west, Chestnut Ridge to the north, and approximately the Roane/Anderson County boundary to the east. The majority of ORNL facilities, active and inactive waste management areas, and potential sources of contaminants lie within the watershed boundaries. Therefore, most waste effluents produced as a result of ORNL operations are released into the WOC system.

White Oak Lake (WOL) was created in 1943. Since then a number of studies have been undertaken to determine contaminant sources, quantities of contaminants released into and retained in the lake, and the geology and hydrogeology of WOC/WOL. Table 1 summarizes some of the more important studies conducted since 1945. In some instances, the studies referenced in Table 1 represent summaries of the information developed; individual investigators have reported in greater detail their efforts in other reports and papers.

1.2.1 White Oak Creek

The WOC rises from springs on the southern slopes of Chestnut Ridge and, with its tributaries, drains much of Bethel and Melton Valleys (which include ORNL) to the Clinch River (Fig. 1). The waters of WOC are impounded by White Oak Dam (WOD), constructed 1.0 km (0.6 miles) upstream from the Clinch River in 1943 to form WOL, which serves as a holding pond for ORNL waste effluents. The drainage areas upstream from the Clinch River and WOD are approximately 16.8 km² (6.5 miles²) and 16.0 km² (6.15 miles²), respectively (Martin Marietta Energy Systems, Inc. 1985). Elevations in the watershed range from 226 m (741 ft) above mean sea level (msl) at the mouth of WOC to 413 m (1355 ft) above msl at the top of Melton Hill, the highest point on the ORR (McMaster and Waller 1965; McMaster 1967).

1.2.2 White Oak Dam

White Oak Dam is a low-head structure with a normal lake elevation of 227.1 m (745 ft). The reservoir is only 0.9 m (3 ft) above full-pool elevation in the Clinch River, which is 226.6 m (742 ft). Recent work by Cox et al. (1991) indicates that the volume of WOL at normal pool level was approximately 43,890 m³ (1,546,330 ft³) in the summer of 1988. Flow from WOL discharges through a weir and concrete-box culvert to the lower reach of WOC. In 1983, the flow system at the dam was modified to increase flood discharge capacity to approximately 56.6 m³/s (2000 ft³/s). Tschantz (1987) estimated the 100-year flood peak discharge to be approximately 44.6 m³/s (1574 ft³/s).

1.2.3 White Oak Creek Embayment

Until recently, only when the Watts Bar Reservoir was near full pool level (approximately April to October), backwater from the Clinch River created an embayment in WOC below

Table 1. Historical changes in the surface of White Oak Lake and major events associated with significant changes in the lake

DATE	SURFACE AREA (ha)	EVENTS	REFERENCES
1941	NA	Highway fill and culvert installed by TVA	Smith (1945) as in Krumholz (1954a)
1943	14.5	(a) Sheet piling dam installed with spillway with vertical sliding gate; (b) Generation of radioactive waste at ORNL began and lake served as final settling basin (750 ft MSL)	(a) Krumholz (1954b,c); (b) Clinch River Study Steering Committee (1967)
1944	NA	Dikes at WOC km 3.3 and 3.9 washed out (7.75 in., 26 h, 3.5 in. runoff)	Setter and Kochitsky (1950)
1945	12.2	Investigation of structural strength of dam (746.5 ft)	Oakes et al. (1982)
1948	10.3	Lake lowered to 745.5 ft to facilitate sediment sampling, normal operation from 1948 to 1955 varied from 747-749 ft)	Oakes et al. (1982)
1953	NA	Lake partially drained during rotenone survey of fish populations	Oakes et al. (1982)
1955	2.8	Lake drained; radionuclides in lake sediment and water believed to be in equilibrium so lake served no useful function in retaining radioactivity but could function as an emergency storage basin.	Clinch River Study Steering Committee (1967)
1956	0.4	Significant releases of ¹³⁷ Cs probably from erosion of freshly exposed sediment after lake was drained.	Lackey (1957)
1959	NA	Gate structure renovated to prevent inflow of backwaters from Clinch River	Clinch River Study Steering Committee (1967)
1960	3.2	Dam closed, surface level raised	Kolehmainen and Nelson (1969)
1963	6.0	Completion of Melton Hill Dam	Kolehmainen and Nelson (1969)
1967	8.1	None reported	McMaster (1967)
1969	10.5	None reported	Kolehmainen and Nelson (1969)
1979	4.6	Lake level gradually dropped from 745 to 742 ft due to potential instability of the dam	Oakes et al. (1982)
1980	6.9	Construction of a berm to stabilize dam was completed	Boyle et al. (1982)
1983	6.9	Discharge channel and weir constructed, roadbed rerouted	
1988	6.9	Estimate of surface area and volume (43,900m ³) at lake level of 745 ft	Cox et al. (1991)

WOD. The WOC Embayment (WOCE) extends 1 km (0.6 mile) downstream from WOD to its mouth at Clinch River kilometer 33.5 (Clinch River mile 20.8). Water levels and flow in the WOCE were largely controlled by the operation of Melton Hill Dam [3.7 km (2.3 miles) upstream on the Clinch River] and summer and winter pool levels on Watts Bar Reservoir, formed by Watts Bar Dam [94 km (58.8 miles) downstream on the Tennessee River]. When the generators at Melton Hill Dam are operating, the release of water from the dam can increase the depth of water at the mouth of the embayment by over 0.3 m (1 ft) in 2 minutes (Fig. 2). When the generators shut down, the water level drops almost as quickly. This rapid change in water level and pulsing of flow caused by daily peaking operations at Melton Hill Dam were, until recently, contributing to the erosion of sediments from the embayment. Figure 3 shows the trend in water levels at the mouth of the embayment during a wet winter month. Water levels typically vary by ~0.6-1.2 m (2-4 ft) per day, with monthly water levels ranging up to 2.5 m (8 ft) or more.

A sediment retention structure has been constructed (completed mid-April 1992) at the mouth of WOC on the Clinch River. It was constructed to reduce the scour of contaminated sediments in WOCE. The spillway of the retention structure consists of sheet pile coffer cells constructed to an elevation of 224.9 m (738 ft) above msl with gabions constructed on top of the cells to elevation 226.5 m (743 ft) msl. This structure limits the winter drawdown in the embayment to an elevation of > 224.9 m (> 738 ft) msl, resulting in a year-round embayment below WOD. The gabions are intended to attenuate the rapid rise and drawdown, causing scouring of sediments, resulting from the diurnal pulsing of Melton Hill Dam.

1.2.4 Geology

Four major geologic units underlie the WOC drainage basin. All formations strike northeast at about 56° and dip southeast at angles commonly between 30° and 40°. The Knox Group (Cambrian and Ordovician Age) underlies Chestnut and Copper Ridges, which bound the WOC drainage basin to the north and south. The Knox Group, mostly composed of cherty dolomite in which sinkholes and caverns have developed, is the principal water-bearing formation in the watershed. The springs along the southern slopes of Chestnut Ridge are the principal sources of the base flow of WOC's upper portion (McMaster and Waller 1965).

The Chickamauga Group (Ordovician Age) underlies Bethel Valley, which includes the ORNL Main Plant area, and Solid Waste Storage Areas (SWSAs) 1, 2, and 3 (Fig. 4). This formation is mostly limestone, although shales, siltstones, and bedded chert compose a significant part of the formation. Generally, the strata are thin- to medium-bedded. Solution openings and fractures occur in the Chickamauga, but the openings are smaller than in the Knox Group.

The Conasauga Group (Cambrian Age) underlies Melton Valley, including SWSAs 4, 5, and 6, and the pits and trenches area (Fig. 4). The general sequence through the Conasauga formation is gradational, from shale at its base to bedded limestone at the top. WOL and the lower part of WOC rest on limestone or shaley limestone of the Conasauga Group.

The Rome Formation (Cambrian Age) is exposed along Haw Ridge. In general, the formation consists of sandstone, shale, siltstone and, locally, dolomite.

WOC Embayment Water Surface Elevation

October 11, 1990 (Friday)

Fig. 2. Water-surface elevation at the mouth of the White Oak Creek embayment on October 11, 1990

Fig. 3. Trends in the water-surface elevation at the mouth of the White Oak Creek embayment in a wet winter month, January 1989

Approximate Location of Waste Disposal Areas and Sampling Stations at ORNL.

Fig. 4. Schematic of the WOC watershed showing potential area contamination sources

The Knox Group and the underlying Maynardville Limestone of the Conasauga Group form the Knox aquifer (Solomon et al. 1992), which is the source of most natural base flow in streams in the WOC basin. The Rome Formation, the Conasauga Group, and the Chickamauga Group discharge smaller quantities of water to the streams. Water is found in weathered rock of all units near land surface.

1.2.5 Soils

The soils of Roane County were mapped in the 1930s, and the results were published in 1942 (Swann et al. 1942). Tschantz and Rghebi (1989) analyzed soil survey maps of Roane and Anderson Counties and identified ~40 different soil groups in the WOC watershed (Table 2). The soils, most of silty or very fine loam texture, fall into three major hydrologic soil groups (HSGs): B, C, and D, and range from moderate, slow, to very slow infiltration rates, respectively.

Soils in the watershed are clustered into six broad bands running east to west (ORNL grid) as shown in Fig. 5. Soils are distributed in the watershed as follows: 54.1% of the watershed area is HSG B, 20.0% is HSG C, and 25.9% is HSG D. Therefore, the natural soils of the watershed, in both Bethel and Melton Valleys, have relatively slow infiltration rates and tend to yield relatively high runoff.

1.2.6 Contaminants in WOC Watershed

Water in WOL contains measurable quantities of dissolved ^3H and ^{90}Sr , which are released through the monitoring station at WOD. Controlled releases of ORNL treated and untreated effluents to WOC include those from the Process Waste Treatment Plant (PWTP), the Sewage Treatment Plant (STP), and a variety of process waste holding ponds scattered throughout the ORNL complex. The WOC flow system also receives effluent through both surface and groundwater flow from nonpoint sources, the SWSAs, and low-level waste (LLW) pits and trenches (Fig. 4). Sediments within the WOC flow system have sorbed chemical and radioactive contaminants and have accumulated in the WOC floodplain and WOL. Oakes et al. (1982) estimated that $\sim 5 \times 10^6 \text{ ft}^3$ of contaminated sediment had collected in the lake bed since 1943. The sediment in the lake bed contains an estimated 650 Ci of radioactive isotopes, primarily ^{137}Cs , ^{60}Co , and ^{90}Sr . During periods of heavy runoff, both dissolved radionuclides and resuspended contaminated sediment (see Sects. 2.2.3 and 2.2.4) are released from the lake into the Clinch River.

1.3 ENVIRONMENTAL RESTORATION PROGRAM

The ERP was established in 1985 to provide comprehensive environmental management of areas where research, development, and waste management activities have resulted in residual contamination of facilities or the environment. The ERP at ORNL remediates sites contaminated by spills or past waste disposal practices. The remediation efforts are intended to protect human health and the environment off-site, both during and after ORNL facility operations, and on-site after institutional control ceases. In March 1987, a listing of known active and inactive waste management areas, contaminated facilities, and potential sources of continuing releases to the environment was prepared for the ORNL Resource Conservation and Recovery Act (RCRA) Facilities Assessment (RFA). The RFA identified about 250 sites

Table 2. White Oak Creek Watershed hydrologic soil groups

COUNTY	SOIL GROUP DESCRIPTION	HSG CODE	COUNTY	SOIL GROUP DESCRIPTION	HSG CODE
Roane	Armuchee silt loam	D	Roane	Lindside silt loam	C
	Pope very fine sandy loam	B		Colbert silt loam	D
	Pinlo very fine sandy loam	B		Fullerton cherty silt loam	B
	Colbert silty clay loam	D		Melvin silt loam	D
	Apison very fine sandy loam	B		Fullerton cherty silt loam	B
	Pope gravelly fine sandy loam	B		Talbott silty clay loam	C
	Lehew stony fine sandy loam	C		Talbott stony material	C
	Gullied land-Apison soil	B		Fullerton-rough gullies ²	B
	Colbert silt loam	D		Roane gravelly loam	B
	Clarksville cherty silt loam	B		Dewey silty clay loam	B
	Fullerton cherty silt loam	B		Dewey silt loam	B
	Fullerton cherty silt loam	B		Dewey silty clay loam	B
	Fullerton cherty silt loam	B		Fullerton cherty silt loam	B
	Upshur silty clay loam	C		Dewey silty clay loam	B
	Stony land-Colbert/Talbott	D/C	Anderson	Fullerton cherty silt loam	B
	Talbott silty clay loam	C		Minvale cherty silt loam	B
	Clarksville cherty silt loam	B		Bodine cherty silt loam	B
	Clarksville cherty silt loam	B		Fullerton cherty silt loam	B
	Apison very fine sandy loam	B		Greendale silt loam	B
				Fullerton cherty silt loam	B

OFNL DWG 91M-16668

[Solid Waste Management Units (SWMUs)] to be considered for possible remediation. Since that time, the number of SWMUs has grown to approximately 400. Because of the large number of SWMUs, ORNL proposed that they be combined into 20 Waste Area Groupings (WAGs). Each WAG was selected to contain sites with geographical proximity and common hydrological characteristics. Eleven of these WAGs lie at least partially within the WOC watershed and have the potential for impact on the environment of, and effluents from, the watershed.

Site investigation activities for environmental restoration are being conducted in order to reduce the uncertainties associated with the characterization of ORNL WAGs to acceptable levels for remedial planning. These uncertainties are related to lack of information about the type and quantities of waste disposed of at ORNL and to the complexity of the hydrologic regime on the ORR. The primary uncertainties associated with characterizing ORNL WAGs are: (1) the source term (i.e., the available contaminated waste that currently supplies, or has the potential to supply, a source of contaminant flux, hydrologically transported, from one or more ORNL WAGs), (2) secondary sources (contamination in the soil matrix), (3) hydrologic transport mechanisms, and (4) near-term and long-term risks based on sources and transport mechanisms. A brief description of various special studies that have provided, or will provide, pertinent hydrologic data or descriptions of hydrologic transport mechanisms follows.

1.3.1 Sediment Monitoring and Modeling Project

Contaminants of key concern in the WOC watershed, particularly ^{137}Cs and ^{60}Co , are particle-reactive and accumulate in and move with aquatic and floodplain sediments. In order to determine potential off-site radiation exposures, it is critically important to characterize the nature and extent of contamination, monitor sediment movement within and out of the watershed, and develop the capability to predict contaminant transport under a range of conditions, including land-use scenarios imposed by future remediation and erosion and resuspension of contaminated sediment as a result of moderate to extreme floods (Fontaine, 1991).

The transport of contaminated sediment in WOC will be measured at eight monitoring stations. Five primary stations are located at the confluence of the WOCE and the Clinch River, WOD monitoring station 5 (MS5), WOC monitoring station (MS3), Melton Branch (MB) monitoring station (MS4), and several hundred meters downstream from the main plant area on WOC. Three secondary stations will be established alternately for 6 to 12 months at five or more locations on WOC. The primary stations will remain in place for the duration of the monitoring and modeling program. Each secondary station, located to develop an estimate of sediment and contaminant contributions from minor catchments, will remain to monitor several storm events and will then be relocated. Secondary stations are currently located at MS1 on the tributary draining WAG 4 to the south, on the Northwest Tributary, and on WOC upstream from the main plant area.

At each station, samples of suspended sediment and bedload will be collected. Suspended sediment will be collected by automatic and manual sampling methods. Automatic samples were collected at two field-test sites in WOC during the period March to September 1991. Through March 1992, data were collected for one storm event by manual and

automatic methods at MS3 and MS4 and manually at MS5. In addition, two low-flow events have been sampled at seven stations (primary and secondary) (T. A. Fontaine, Oak Ridge National Laboratory, personal communication to D. M. Borders, The University of Tennessee, April 1992).

Sediment samples will be analyzed to determine the flux of sediments and particle-reactive contaminants. Particle-size distribution, specific weight, sediment concentration, and screening for contaminants (primarily ^{137}Cs) and chemical characteristics will be determined from samples taken at approximately ten points in time during each flood. These samples will be distributed over the storm hydrograph to adequately characterize the sediment and contaminant transport characteristics of the storm.

The development of a computer program for simulating the transport of contaminated sediment in WOC will provide a method of (1) predicting contaminant transport during moderate to extreme floods, (2) developing long-term control measures and remediation solutions, and (3) predicting the impact of future land-use changes on the transport of contaminated sediment. The computer model, once adequately calibrated and verified, will simulate the transport of sediment-bound contaminants within and out of the WOC watershed during floods up to the 100-year event. Calibration and verification of the sediment transport model are critically dependent on immediate access to precipitation, pan evaporation, and streamflow data collected in the WOC watershed. In addition, errors in streamflow data (see Sect. 1.3.2) are a major limitation to the accuracy of model results. Ultimately, the results of the monitoring and modeling project will be utilized to evaluate the potential for off-site contaminant transport, design alternatives for the control of sediment transport, and the effectiveness of completed control measures. Fontaine (1991) contains a complete description of the sediment monitoring and modeling project.

1.3.2 Station Upgrade and Maintenance

The integrity of the system that monitors surface-water discharge on the WOC watershed has been deteriorating for several years because of the unmitigated deposition of sediments in stilling pools, inadequate design and lack of calibration of engineered flow measurement devices, and general lack of a consistent and comprehensive monitoring station and channel maintenance program. In addition, the limited length and continuity of stream discharge records hinders the performance of streamflow analyses (e.g., duration and frequency analyses) and the ability to use hydrologic models. This section addresses the problems encountered in monitoring surface-water discharge and collecting data at sites in the WOC watershed and vicinity. Accurate, continuous discharge measurements are critical to the ERP. Without accurate discharge data, the following tasks are impossible: (1) accurate measurement of existing movement and release (flux) of contaminants, (2) development of an accurate understanding of hydrology and transport mechanisms, (3) development of accurate hydrologic and transport models for prediction and design, and (4) verification of the effectiveness of future remedial efforts.

In the early 1980s, the primary surface-water monitoring stations on WOC and MB, above their confluence and at WOD were upgraded (redesigned) for improved discharge measurements and water quality sampling. At each site, the engineered hydraulic control (i.e., flow-measurement structure) consists of separate low-flow and high-flow devices (i.e., weirs)

for measuring discharge. The low-flow weirs were designed to accurately measure a range of flows from the minimum expected to occur at the respective site to a given flow rate considerably higher (by a factor of 2 or more) than wet-season base flow rates. The high-flow weirs were designed to measure flows in a range from slightly less than the maximum low-flow weir discharge to maximum discharges associated with a moderate to extreme flood event of ~ 25- to 100-year return periods. Instrumentation at these sites was designed to detect (but not record) stages (water levels) above the weir crests and convert the stages to discharge values. During significant storm events, when streamflow increases and the low-flow stage exceeds the maximum design value (corresponding to the capacity of the weir), the instrumentation automatically switches over to the high-flow weir to measure discharge until streamflow decreases to the point where the capacity of the low-flow weir is no longer exceeded. At this point, the instrumentation automatically switches back to the low-flow device.

The original stage-discharge relationships for these three monitoring stations were developed from scale model tests. In 1984-85, the low-flow control devices (sharp-crested V-notch weirs on WOC and MB and a sharp-crested trapezoidal weir at WOD) were field-rated by volumetric measurements made over a range of flows. These field ratings, incorporated into the instrumentation to provide more accurate discharge data, indicated that the original model calibrations were significantly in error. The high-flow control devices (broad-crested weirs) have never been field-rated to verify or adjust the stage-discharge relationships for determining discharge. However, standard theoretical derivations for each site indicate that high-flow stage-discharge relationships significantly disagree with the original relationships still being used. For example, the maximum discharge at WOD, for a stage of 2.74 m (9 ft), calculated by the original scale model relationship and the theoretical relationship, is 2005 and 1860 cfs, respectively. This suggests a 7.8% overestimation of the capacity of WOD. However, unknown factors, which can be accounted for only by field calibration and potentially increasing this error in calculation, coupled with the inherent errors and uncertainties in stage measurement, may cause current errors in discharge measurement at WOD in excess of 10%. This error would exceed regulatory guidelines for National Pollutant Discharge Elimination System (NPDES) discharge measurement.

Similar conditions exist at the WOC and MB monitoring stations. However, at the MB station, much greater errors in discharge measurement occur under high-flow conditions because of submergence (drowning out) of the broad-crested weir. This error in measurement is caused by channel constriction downstream from the monitoring station. At high flows, the tailwater, unable to flow freely because of inadequate channel capacity, backs up and rises above the crest of the weir, drowning out the structure. At some critical degree of submergence (the ratio between the depth of water above the weir crest on the downstream side to the depth of water above the weir crest on the upstream side), the broad-crested weir no longer performs as designed. Above this critical degree of submergence, generally accepted to be about 70% for rectangular broad-crested weirs, the upstream stage (head) over the weir begins to rise disproportionately to the discharge and the stage sensor detects an elevated stage for a given flow rate. Therefore, the monitoring station instrumentation calculates a higher flow rate than is actually occurring.

A theoretical rating has been developed at the MB monitoring station (MS4) that uses the low-flow control with an extended rating for stages above the wall (weir sill) containing

the sharp-crested weir. The method used for developing this extended rating is consistent with that used by the U.S. Geological Survey (USGS) in the past. The Environmental Sciences Division (ESD) Surface Water Hydrology Group uses this extended rating to calculate flows at the MB monitoring station for flows that exceed the capacity of the low-flow weir (34.7 cfs). Figures 6 and 7 show the comparison of discharge measurements for two storms in December 1990 and February 1991. For each event, the standard rating overestimated the peak instantaneous flow rate for a major storm by approximately 200%. Previously, the two methods of discharge calculation gave comparable results at flows below approximately 50 cfs. Currently, however, only those flows within the low-flow range (up to 34.7 cfs) are comparable by the two methods. This situation indicates that the factors contributing to submergence are worsening. For a discussion on model simulations conducted to examine the effects of possible tailwater channel improvements on mitigating the submergence problems at this site, refer to Borders et al. (1991). Results indicate that channel improvements could provide only marginal relief.

The theoretical extended rating at MS4 is a short-term solution, considered to be much more accurate than uncorrected measurements made at the primary high-flow control device. However, it must be verified and/or adjusted according to in-field discharge measurements made to establish a stage-discharge relationship at the extended control (i.e., the weir sill containing the sharp-crested weir). In addition, alternative measures (e.g., engineered solutions) should ultimately be considered in the near future in order to establish improved capabilities to measure peak flows during extreme events. The MS4 monitoring station was originally designed to measure peak flows on the order of 650 cfs or greater. The extended rating, however, will likely be applicable only up to flows in the range of 400-500 cfs. This is because the extended hydraulic control, acting as a broad-crested weir, will ultimately suffer submergence problems similar to the primary high-flow broad-crested weir. Therefore, peak flows for extreme events (e.g., 25-year, 50-year, etc.) may not be within the applicable range of the extended control and would have to be estimated by inexact methods, with a resulting loss in accuracy.

Periodic submergence of the outlet structure also occurs at WOD because of backwater from elevated stage in the Clinch River. This condition, if unaccounted for, can cause significant errors in discharge measurement. For example, on December 23, 1990, the high-flow control device was submerged by backwater from the Clinch River by as much as 97% [i.e., tailwater measured relative to the crest of the high-flow control reached a depth of 97% of the stage (head) over the high-flow control]. According to Bos (1990), the high-flow control (triangular broad-crested weir) can sustain submergence of 80% without suffering a significant reduction in flow. However, above 80%, the reduction due to submergence increases geometrically (Fig. 8). At 97% submergence, the flow reduction is on the order of 50%. That is, to calculate flow under submergence of 80% or more, the standard stage-discharge relationship at WOD must be corrected by multiplying by the drowned-flow reduction factor. On December 23, 1990, the weir at WOD was submerged greater than 80% for ~10 h. Application of the drowned-flow reduction factor results in a maximum instantaneous correction of 50.5% and a daily correction (for December 23) of approximately 7.5%. In addition, since this flow correction (reduction) is applied to a period of high flow, it has a disproportionate effect on the monthly flow rate, resulting in a correction (reduction) of approximately 2% for the month of December 1990.

ORNL DWG 92M-8370

Melton Branch Monitoring Station (MS4) 15 Minute Discharge (December 22-24, 1990)

Fig. 6. Comparison of 15-minute discharge at Melton Branch (MS4) monitoring station for a storm that occurred on December 22-23, 1990

ORNL DWG 92M-8371

Melton Branch Monitoring Station (MS4)

15 Minute Discharge (February 16-23, 1991)

Fig. 7. Comparison of 15-minute discharge at Melton Branch (MS4) monitoring station for a storm that occurred on February 17-20, 1991

ORNL DWG 92M-8324

Fig. 8. Drowned flow reduction factor as a function of H_2/H_1 (submergence ratio) for the high-flow control at White Oak Dam (MS5)

Errors in streamflow data are a critical concern to ERP projects that monitor and model contaminant transport. This is especially true during high flows. Rare larger floods account for a disproportionate percentage of the contaminants transported within the WOC watershed and to the off-site environment. A few high-flow events account for the majority of contaminants leaving the ORNL site each year. In FY 1992, the high-flow control devices on WOC and MB will be field-rated by USGS Water Resources Division staff for verification and development of stage-discharge relationships. In-stream discharge measurements will be collected over at least a 2-year period. After the initial 2 years, if inadequate coverage of storm events has resulted in an incomplete rating, the focus will be shifted to measuring larger floods until enough data have been collected to extend the rating over the full range of high flows for each station. The resulting relationships will be incorporated into the data processing procedures for discharge calculations. The USGS will evaluate methods for rating the high-flow control at WOD and will submit a proposal in FY 1992 or FY 1993. Field rating of the high-flow control at WOD could begin as early as FY 1993.

The accuracy of discharge measurements at surface-water monitoring stations in the WOC watershed is also being degraded because of deposition of sediment and debris during high flow events resulting from heavy rainfalls. Flow-measurement devices (i.e., weirs and flumes), stilling well intakes, and approach and tailwater sections in stream channels are being fouled by fine sediments, sand, rock and organic material (leaves, logs, etc.). In addition, during the growing season, aquatic plants flourish in and around these areas, often obstructing flow and further deteriorating the quality of discharge measurements. A complicating factor that must be considered in any mitigative effort is the presence of contaminants in the sediments. At the primary monitoring stations on WOC and particularly on MB, these contaminated sediments have essentially filled the stilling pools. There is a critical need to remove the contaminated sediments that are clogging stilling pools and gages above weirs.

Routine maintenance is necessary at all hydraulic control structures in order to collect accurate discharge measurements. A routine maintenance program was initially developed in cooperation with ESP, and an Internal Environmental Assessment (IEA) was initiated for National Environmental Policy Act (NEPA) compliance. This maintenance program was intended to alleviate certain aspects of the sediment problem and to prevent worsening of conditions; however, in order to restore adequate conditions for accurate flow measurement at surface-water monitoring stations in the WOC system, the geometry of approach and tailwater channels must be restored and maintained. The Environmental Surveillance and Protection Section (ESP) of the Office of Environmental and Health Protection (OEHP) is now responsible for the removal of deposited sediments at major surface-water monitoring stations at ORNL. ESP is working closely with the ERP to meet the needs of both groups and restore the sites to conditions conducive to accurate discharge measurement. Contaminated sediments will be removed through the cooperative efforts of the aforementioned groups, and a maintenance program will be developed to prevent the recurrence of the problem. The IEA will be modified to incorporate the removal of deposited sediments from the stilling pools.

1.3.3 Flow-Frequency Analyses

Whereas the emphasis for most compliance monitoring is to document and compare contaminant concentrations relative to concentration limits set forth in regulations, for the

ERP the important information is contaminant flux, typically quantified over a period of 12 months. An appropriate measure of success for remedial actions is the reduction of this annual flux measured at key points in the hydrologic system. Measurement of the long-term contaminant flux is important because an increase in it leads to the assessment of potential health risks to individuals downstream of the Laboratory.

To generate a record of the annual flux, it is necessary to have complete and accurate flow measurements and flow-proportional water quality samples. In some instances where contaminant concentrations are correlated to flow, it is possible to intensively sample water during storms and use these data, together with a correlation model and the annual streamflow hydrograph, to estimate annual fluxes. In all cases, reliable flow data are needed throughout the entire year.

Flow-frequency analyses are a standard method for evaluating the flow regime. These analyses indicate the magnitude and frequency of flows expected. However, the emphasis on monitoring is on measuring the total amount of contaminant discharged (product of flow rate, time, and concentration). High flows carry a disproportionate amount of contaminants in these streams and tributaries. Therefore, it is important to measure the flow over a large fraction of total flow volume rather than over a large fraction of the elapsed time. Volume-frequency analyses allow this approach. Design flow ranges may be determined from a combination of these analyses to meet the DOE regulation requiring the monitoring of contaminant releases in stream water.

Flow-frequency and volume-frequency analyses were performed on continuous instantaneous data sets for five surface-water monitoring stations on the WOC watershed: WOC (MS3), MB (MS4), WOD (MS5), and the East Seep and West Seep monitoring stations. East Seep and West Seep each had ~3 years (1989-1991) of continuous data available for analysis, while each of the other three had 2 years (1990 and 1991) of continuous data (Figures 9-13). Figure 13, for West Seep, shows the flow-frequency curve (flow vs frequency) and the flow-volume fraction curve (flow vs volume fraction) for the 3-year data set. The data show that discharge was between 0.1 and 1.0 cfs approximately 50% of the time, with discharge seldom falling below 0.01 cfs (< 5% of the time) and seldom exceeding 10 cfs (<< 5%). This period of record is not enough to analyze frequency to accurately determine the discharge associated with infrequent return periods. However, the data should be fairly adequate to bracket the 95th percentile. That is, discharge at West Seep is between 0.01 and 5.0 cfs approximately 95% of the time. However, volumetrically, 95% of the flow occurs between 0.1 and 40 cfs. This is because a disproportionately high percentage of total flow passes a point on a stream during a few major storms, whereas a small percentage of total flow passes under normal flow conditions. For example, flows of 0.1 cfs and less occur approximately 35% of the time, yet volumetrically account for less than 5% of the total flow. Conversely, flows of 1.0 cfs and greater occur less than 15% of the time, yet volumetrically account for nearly 70% of the total flow. Likewise, flows of 10.0 cfs and greater occur only about 1% of the time, yet volumetrically account for approximately 20% of the total flow. This emphasizes the need to consider the discharge volumetrically because the percentage of contaminants passing a point in a stream more closely parallels flow volume.

ORNL DWG 92M-2093

White Oak Creek Monitoring Station (MS3)

Fig. 9. Flow-frequency and flow-volume fraction curves for the White Oak Creek station (MS3), based on two years of 15-minute discharge data

Fig. 10. Flow-frequency and flow-volume fraction curves for the Melton Branch station (MS4), based on two years of 15-minute discharge data

Fig. 11. Flow-frequency and flow-volume fraction curves for the White Oak Dam station (MS5), based on two years of 15-minute discharge data

ORNL DWG 92M-2090

East Seep Monitoring Station

Fig. 12. Flow-frequency and flow-volume fraction curves for the East Seep station, based on three years of 15-minute discharge data

West Seep Monitoring Station

Fig. 13. Flow-frequency and flow-volume fraction curves for the West Seep station, based on three years of 15-minute discharge data

1.3.4 SWSA 6 ICM Environmental Monitoring Program

In 1988, interim corrective measures (ICMs) were implemented at SWSA 6 (Clapp and Marshall 1992). The ICMs consist of eight large impermeable polyethylene sheets placed as temporary caps to cover trenches containing RCRA-regulated materials. The purpose of the ICMs is to reduce or eliminate infiltration of rainwater into the wastes and subsequent leaching and transport of contaminants from the trenches.

An ICM environmental monitoring program was implemented to evaluate the effectiveness of the caps. Environmental monitoring during FY 1991 consisted of collecting water levels at 13 groundwater wells outside the capped areas and 44 wells in or near the capped areas. The data were used to identify significant loss, if any, of hydrologic isolation of wastes. No water quality sampling was done in FY 1991. Water levels measured in drive point wells located in the old trenches show that hydrologic isolation of buried waste cannot be ensured unless the entire area of recharge is covered. Perched water in trenches is probably due to lateral subsurface flow above the water table; for the low-lying trenches, the water is derived from the water table aquifer. Beneath cap 8, adjacent to WOL, water levels in the trenches are related to lake level.

Environmental monitoring is being expanded in FY 1992 to include surface-water discharge monitoring and sampling of surface water and suspended sediment during baseflow and storm conditions. The purpose of the expanded study is to further evaluate the effectiveness of the caps at reducing or eliminating the transport of contaminants from waste trenches and to document baseline contaminant discharge levels to evaluate the effectiveness of the final remediation of SWSA 6 (WAG 6).

1.3.5 WAG 2 Remedial Investigation

The WAG 2 RI Plan (ORNL 1990) provides a brief history of the site, a characterization of the environmental setting, descriptions of the existing monitoring programs at ORNL and in the WOC system that contribute to WAG 2, existing information for contaminant inputs into the WOC system, and information for contaminants in and contaminant releases from WAG 2.

The ORNL WAG 2 is located in the WOC drainage downstream of ORNL discharge points and includes the associated floodplain and subsurface environments of WOL, WOC, MB, and their major tributaries, and the WOCE between WOD and the sediment retention structure at the mouth of WOC on the Clinch River. In addition, WAG 2 is downgradient from numerous contaminated areas (WAGs) in the WOC watershed. WAG 2 is unique in that essentially all contaminants residing in, and therefore being released from, WAG 2 came from these upgradient WAGs. Remedial investigations (RIs) are under way or planned for these WAGs; therefore, contaminant inputs to WAG 2 will change as individual upgradient areas are remediated. For this reason, WAG 2 will be remediated only after the upgradient WAGs have been remediated. However, because the WOC system acts as a conduit and a sink for contaminants from upgradient areas, the WAG 2 RI is already commencing.

Because hydrologic fluxes through WAG 2 link contaminant sources in the WOC watershed with off-site areas, a quantitative understanding of where contaminants enter

WAG 2 is needed. In addition, an inventory of contaminants in the system and a detailed characterization of the transport mechanisms that move them into, through, and out of the system are needed in order to define the temporal and spatial mass balance of contaminants in WAG 2. Since such information does not currently exist, nor is it likely to become available through efforts in other WAGs, the WAG 2 RI Plan (ORNL 1990) addresses the need to (1) take immediate steps to protect the public and the environment, (2) monitor contaminant releases from ORNL WAGs, and (3) form a foundation for eventual remedial actions in WAG 2. The RI Plan calls for a phased effort to characterize, monitor, assess risk, and identify remedial needs and alternatives.

A field sampling and analysis (S&A) plan (Boston et al. 1992) has been developed as part of the Department of Energy (DOE) RI of WAG 2 at ORNL in support of the RI Plan for WAG 2 (ORNL 1990). The long-term S&A strategy takes advantage of WAG 2's role as an integrator of contaminant fluxes from other ORNL WAGs and focuses on four key goals:

- (1) implement, in concert with other programs, long-term monitoring and tracking of contaminants leaving other WAGs, entering WAG 2, and being transported off-site;
- (2) provide a conceptual framework to integrate and develop information at the watershed-level for pathways and processes that are key to contaminant movement and support remedial efforts at ORNL;
- (3) provide periodic updates of estimates of potential human health and ecological risk associated with contaminants accumulating in and moving through WAG 2 to off-site areas; and
- (4) support the ER prioritization and evaluation of remedial actions through long-term monitoring and risk assessments.

The general objectives of this long-term S&A plan are to support a multimedia environmental monitoring and characterization program to (1) define and monitor contaminant inputs from adjacent (upgradient) WAGs, (2) support a mass balance approach to determining sources, sinks, and transport of contaminants based on hydrologic processes, (3) document trends in contaminant inventories and fluxes, and (4) develop predictive models that simulate contaminant transport under future land-use and remediation scenarios.

Preliminary efforts of the S&A plan are aimed at (1) developing long-term sampling and monitoring programs based on a statistical approach, (2) selecting appropriate sampling sites and implementing monitoring and tracking efforts, and (3) updating evaluations of human health and ecological risk by concentrating on the collection of pertinent information and contaminant data.

Much of the initial effort of the S&A plan will focus on sediments, seeps, and tributaries. Sediments are the primary pool for most contaminants of concern (with the exception of ^3H) in WAG 2. The primary mechanisms for the transport of contaminants off-site are a relatively few high-flow discharge events per year. Data from environmental monitoring efforts will be used to evaluate groundwater contamination, pathways of groundwater transport, and groundwater flow from adjacent WAGs to discharge in local streams. Data

provided by the seep sampling program will also support groundwater efforts and link them with surface transport studies.

Work to be conducted in the initial stages of the WAG 2 RI includes: (1) continued synthesis of existing information and preliminary contaminant screening; (2) formulation and implementation of the initial sampling and analysis plan; (3) sampling of areas (e.g., new groundwater wells and floodplain soils) for which no data are available, and which are suspected to be contaminated, to identify hot spots and operable units, (4) upgrade of discharge monitoring facilities (see Sect. 1.3.2) to improve the hydrologic budget and to identify contaminant inputs; and (5) surveys of WOC sediments and floodplain soils, work on sediment transport models, and sampling of WOL bottom sediments.

All efforts on WAG 2 will be coordinated with upgradient WAGs, the Clinch River RCRA Facility Investigation (RFI), existing monitoring programs, the Technical Integration Committee, and the ERP. Remedial investigations in adjacent WAGs will provide short-term information on contaminant releases and potential releases, based on inventory records, from those WAGs.

1.3.6 Other WAGS and Contaminant Releases

The RFA identified all sites, grouped into 20 WAGs on the basis of hydrogeological and functional parameters based on proximity, considered to be potential RCRA 3004(u) SWMUs. With the possible exception of the WOCE below WOD, contamination in the WOC system is a result of releases from active and inactive waste sites in 11 WAGs located within the WOC watershed.

Information available on known releases from WAGs into the WOC/WOL drainage is highly variable from one WAG to another. There are not enough data to fully characterize either the historical or continuing releases from any WAG. Table 3 summarizes primary sources of data and contaminants released for each WAG. These existing reports typically provide information on waste inventories within the WAG, limited data on known releases, and results of various characterization studies. Although available information does not allow releases from each WAG to be fully characterized, the waste inventory and known release data can be used to identify key radioisotopes and, to a lesser extent, elements that may potentially be released from a WAG (Table 3). Data on organic contamination are limited to a very few sites. This summary of key potential contaminants can be used to guide further monitoring and characterization efforts.

Appendix A contains descriptions of each of the 11 WAGs located at least partially within the WOC watershed and provides existing data on releases from each. It also summarizes available information about contaminant releases, both historical and continuing, from each WAG (except WAG 2) in the WOC watershed. It provides information from a number of sources (ORNL 1990), detailing additional data needs for adequate characterization of the sources (historical and continuing) of contamination to the WOC/WOL system. Further information will be obtained through programmatic linkages with ongoing and planned Remedial Investigation/Feasibility Study (RI/FS) activities in these WAGs and through further review of existing monitoring and characterization data.

Table 3. Sources of data and contaminants known or suspected to have been released from WAGs in the White Oak Creek Watershed

WAG	NAME	CONTAMINANTS ^a	DATA PACKAGE ^b	R/RFI PLAN ^c
1	ORNL Main Plant Area	⁶⁰ Co, ⁸⁵ Sr, ¹³⁷ Cs, ¹⁵² Eu, ²³² Th, ²³⁵ U, ²³⁸ Pu, ²⁴¹ Am, ²⁴⁴ Cm, other radionuclides, Cd, Cr, Cu, Hg, Mo, Ni, Pb, Zn, TRE, PCBs, Chlorodane	1987	BNI
3	Solid Waste Storage Area 3	³ H, ⁹⁰ Sr, ¹³⁷ Cs, TRE	1987	BNI
4	Solid Waste Storage Area 4	³ H, ⁶⁰ Co, ⁸⁵ Sr, ¹³⁷ Cs, ²³⁸ Pu, other radionuclides, TRE	E. C. Davis & R. R. Shoun 1986	BNI
5	Solid Waste Storage Area 5	³ H, ⁶⁰ Co, ⁸⁵ Sr, ¹³⁷ Cs, ²³⁸ Pu, ²⁴¹ Am, ²⁴⁴ Cm, other radionuclides, Cr, Hg, Ni, Pb, Zn, PCBs	1987	BNI
6	Solid Waste Storage Area 6	³ H, ¹⁴ C, ⁶⁰ Co, ¹³⁷ Cs, ¹⁵² Eu, ²³⁵ U, Cr, Cu, Hg, Mo, Ni, Pb, Zn, VOCs, nitrates	W. J. Boegly et al. 1984	BNI
7	LLW Pits & Trenches Area	³ H, ⁶⁰ Co, ⁸⁵ Sr, ⁹⁹ Tc, ¹⁰⁶ Ru, ¹³⁷ Cs, ²³⁵ U, Cr, Ni, Zn, nitrates	1987	BNI
8	Melton Valley Area	⁶⁰ Co, ⁸⁵ Sr, ¹³⁷ Cs, Cr, Cu, Zn	1987	BNI
9	Homogeneous Reactor Experiment (HRE) Area	⁶⁰ Co, ⁸⁵ Sr, ¹³⁷ Cs, Cr, Zn	R. G. Stanfield & C. W. Francis 1986	BNI
10	Hydrofracture Injection Wells & Grout Sheets	⁹⁰ Sr, ¹³⁷ Cs, ²⁴⁴ Cm, TRU isotopes		BNI
13	Environmental Research Areas	¹³⁷ Cs	1988	
17	ORNL Services Area	¹³⁷ Cs, Cd, Cr, Cu, Zn, fuel-derived hydrocarbons, & solvents	1988	BNI

^aBased primarily on data in ORNL RCRA Facility Investigation (unpublished) and environmental data packages for each WAG. ¹⁰⁶Ru and TRE have short half-lives (e.g. ~1 year) and should have decayed to insignificant levels by this time.

^bData Packages were produced for WAGs for which a date only appears; however, these reports are not cleared for distribution. Includes site characterization report for WAG 10 for which no environmental data package was prepared.

^cR1=Remedial Investigation, RFI=RCRA Facility Investigation, BNI=Bechtel National, Inc.

1.4 OTHER PROGRAMS

1.4.1 Environmental Surveillance

To meet regulatory requirements and DOE directives and to provide continuity of data on environmental media at unregulated locations, ESP conducts a comprehensive environmental surveillance monitoring program to determine contaminant releases from ORNL facilities, from the Laboratory site, and, with the support of the other Energy Systems facilities, from the ORR (Energy Systems 1990).

Environmental monitoring consists of two major activities: (1) effluent monitoring — collecting and analyzing samples or measurements of liquid and gaseous effluents; and (2) environmental surveillance — collecting and analyzing samples, or direct measurements of air, water, soil, biota, and other media from DOE sites and their environs.

Monthly or quarterly samples for each of the media sampled are presented in quarterly environmental surveillance reports (Energy Systems 1990). Summary tables are included, which give the number of samples collected during the period and mean, maximum, minimum, and standard error of the mean values for some parameters. Maps are provided to identify sampling locations for most parameters. In addition, mean values of some parameters are compared to applicable guidelines, criteria, and standards to evaluate the impact of effluent releases or environmental concentrations. A description of the types of data available from ESP's environmental surveillance program is presented in Sect. 2.2.2.

1.4.2 National Pollutant Discharge Elimination System

The ORNL NPDES permit (TN0002941) expired March 31, 1991. This permit had authorized ORNL to discharge to receiving waters of WOC, Northwest Tributary (NWT), MB, Fifth Creek, and First Creek on the WOC watershed in compliance with the Clean Water Act and in accordance with effluent limitations, monitoring requirements, and other conditions set forth in the permit. A permit renewal application was submitted in September 1990 (DOE 1990). The renewal application was filed more than 180 days prior to the expiration of the existing permit. According to regulations, ORNL, having met that filing condition, is qualified to operate under the guidelines of the old permit until the regulatory agency, Environmental Protection Agency (EPA), acts on the new application (C. K. Valentine, Oak Ridge National Laboratory, personal communication to D. M. Borders, The University of Tennessee, August 1991). When this report went to press, EPA had not acted on the approval of the permit renewal application; therefore, ORNL continues to operate under the old permit.

Water-quality analyses have been conducted to monitor the effluent quality of discharges from ORNL operations. Permit limitations were based on various state and federal guidelines determined to be applicable to the ORNL facility. Available data collected under the terms of the expired permit, optimization studies, current toxicity information, and review of current state and federal guidelines have been considered in the development of proposed limitations for the permit renewal. These limitations are being considered for all discharges at ORNL, and special conditions for the permit application have been developed. These include mercury, PCB, and Radiological Monitoring Plans, which have been evaluated for

modification and submitted as addendums to the permit application. Best Management Practices have also been submitted.

1.4.3 Stormwater Monitoring

A new provision to the NPDES regulations was promulgated after ORNL submitted the application for permit renewal. The EPA and the Tennessee Department of Environment and Conservation (TDEC) stormwater monitoring regulations, which were effective November 16, 1990, require ORNL to submit stormwater permit applications by October 1, 1992 (extended from the previous deadline of November 17, 1991), for new and/or previously unpermitted stormwater outfalls associated with industrial activity (C. K. Valentine, Oak Ridge National Laboratory, personal communication to D. M. Borders, The University of Tennessee, April 1992). The regulations specifically require permit applications for industrial facilities that are subject to stormwater effluent limitations guidelines, sites used for treatment, storage, or disposal of hazardous waste; landfills, land application sites and open dumps that have received any industrial waste; and areas where industrial activity has taken place in the past and significant materials remain exposed to stormwater, among other elements. Because of the diversity of research activities, waste-generating operations (including radioisotope production, experimental reactors, hot cells, and pilot plants), and the legacy of environmental waste sites requiring remediation in the future, ORNL falls under most of the categories of industrial activity that require submission of a stormwater application. By interpretation, all of the WAGs must be sampled to meet ORNL's obligation under EPA's new stormwater regulation.

The Environmental Compliance Section (ECS) of the Office of Environmental Compliance and Documentation (OECD) has developed a Stormwater Monitoring Compliance Plan for inclusion in the Stormwater Application. The ECS plans to sample stormwater at 36 sites in the 20 ORNL WAGs, excluding WAGs 10, 11, 15, 18, and 20. WAGs 15 and 20 will be the responsibility of the Y-12 Plant. Eleven sites in WAG 1 will have the lowest priority because stormwater runoff has been sampled in the main plant area for several years and the information has been submitted to the TDEC. Samples will be collected for wet and dry conditions (where dry weather flow occurs).

The stormwater regulations are aimed at characterizing the first discharge associated with the storm event (grab sample within the first 30 min of runoff) and characterizing the runoff over the course of the storm (composite sample collected over at least 3 h during the storm). Staff members in ERP and ESD have helped to identify existing stream monitoring stations, select sampling sites, and disseminate pertinent information, including Environmental Restoration activities and monitoring plans. The ERP has an interest in storm sampling at many of the same locations. Therefore, efforts have been coordinated, where practical, to avoid duplication of effort and to satisfy the requirements of ORNL and ERP.

1.4.4 Active Sites Environmental Monitoring Program

The Active Sites Environmental Monitoring Program (ASEMP) (Ashwood et al. 1992a), established in 1989 by Solid Waste Operations and conducted by ESD in accordance with chapters II and III of DOE Order 5820.2A, provides for early detection and performance monitoring at active LLW disposal sites and Transuranic (TRU) waste storage sites at ORNL.

The scope of this program includes all ORNL waste disposal sites that were active on, or after September 1988, the date the order was issued. These active sites include the high-activity and low-activity silos, high-range wells, fissile wells, asbestos silos, the suspect waste landfill, the Tumulus Disposal Demonstration Project (Tumulus I), Tumulus II, the Interim Waste Management Facility (IWMF) in SWSA 6, and the TRU waste storage sites in SWSA 5 North. In addition, the program addresses monitoring activities associated with the Hillcut Disposal Test Facility (HDTF). The objective of the ASEMP is to provide for early detection of radionuclides leaking from storage or disposal facilities before the releases pose a threat to public health or the environment (Ashwood and Ashwood 1991).

SWSA 6 is currently the only LLW disposal facility on the ORR. Monitoring activities associated with SWSA 6 facilities are divided into three major areas: Tumulus/IWMF, subsurface areas, and HDTF. Tumulus monitoring activities include monitoring pad runoff, water in the underpad area, and water in groundwater below the pad.

Monitoring and sampling of surface runoff from both Tumulus I and Tumulus II pads changed in FY 1991. Because of concerns over the release of water with high pH and tritium and gross beta activity, all accumulated water is now collected and transported to the PWTP after sampling. Therefore, the majority of samples collected are taken by direct sampling of water on the pads. The IWMF began operation in December 1991. Approximately 3 years of groundwater elevation, pad runoff flow rate and volume, relative humidity, solar radiation, and temperature data have been collected and archived (Ashwood et al. 1992b).

The ORNL ASEMP plan has been implemented by ESD staff with key interfaces with Solid Waste Operations and the ICM Program, among others. However, sampling of surface drainages in SWSA 6, to identify changes in contaminant levels due to the ICM capped areas, and monitoring of water levels in piezometers and wells installed in trenches under the ICM capped areas are activities no longer conducted by the ASEMP.

1.4.5 Biological Monitoring and Abatement Program

The Biological Monitoring and Abatement Program (BMAP) was developed in response to a requirement of the NPDES permit issued to ORNL on April 1, 1986. Part III, Special Conditions, of the NPDES permit calls for a plan for biological monitoring of the Clinch River, White Oak Creek, Northwest Tributary, Fifth Creek, First Creek, and Melton Branch. The BMAP consists of six major tasks that address radiological and nonradiological contaminants in the aquatic and terrestrial environs: (1) toxicity monitoring, (2) bioaccumulation monitoring of nonradiological contaminants in aquatic biota, (3) biological indicator studies, (4) instream ecological monitoring, (5) assessment of contaminants in the terrestrial environment, and (6) radioecology of WOC and WOL (Loar 1991, Loar 1992).

The BMAP (Loar 1991, Loar 1992) was developed to meet three objectives:

1. Sufficient data are to be provided to determine whether the effluent limits established for ORNL protect and maintain the classified uses of WOC and its major tributaries. These streams have been classified by the TDEC for growth and propagation of fish and aquatic life, irrigation, and livestock watering and wildlife.

2. The BMAP provides ecological characterizations of WOC and its tributaries and of WOL to document ecological impacts of past and current operations and to identify contaminant sources that adversely affect stream biota. This information has helped to develop RI/FS plans and to assess remedial action alternatives within the ORNL ERP.
3. The BMAP evaluates remedial actions taken by the ERP and the Water Pollution Control Program (WPCP) by documenting the effects of those actions on stream biota. The long-term nature of the BMAP ensures that the effectiveness of remedial measures will be properly evaluated.

Water samples have been collected for chemical analyses under a component of the BMAP known as the Toxicity Monitoring Studies. Through 1991, 15 sites on 5 streams had been evaluated for toxicity at least 39 times (Loar 1992). The 15 sites used for these ambient studies were initially selected to encompass both point and nonpoint source contributions to toxicity in receiving streams. Four of the 15 sites (upstream on First Creek, Fifth Creek, WOC, and MB) have no contaminants in toxic concentrations and are used as reference sites. Samples collected for ambient toxicity tests on water are analyzed for conductivity, alkalinity, hardness, and pH. Most samples are analyzed for free and total residual chlorine (TRC). Toxicity monitoring studies provide an understanding of ambient toxicity patterns in streams at ORNL and provide evidence of environmental degradation.

BMAP radioecology studies in WOL have been conducted to provide information on concentrations of radionuclides in soil core samples from the WOL floodplain. These studies have provided preliminary data necessary to design a sampling plan to determine the inventory of contaminants in the floodplain. Soil cores have been collected and analyzed for ^{137}Cs and ^{60}Co to determine profiles of concentration vs depth. A composite sample, taken from ten cores for ^{90}Sr analysis, showed that ^{137}Cs and ^{60}Co were the most abundant gamma-emitting radionuclides. In addition to providing preliminary data for an inventory of contaminants, the BMAP radioecology studies will assess the potential ecological and human health risk from exposure to radiation.

2. HYDROLOGIC DATA

The collection of hydrologic data in the WOC watershed began with facility planning studies in the early 1940s. Collection of these data has developed into a long-term program of environmental research studies and monitoring activities required to cope with the Laboratory's unique waste management needs.

The hydrologic data available for the report period were derived largely from ongoing studies of the ORNL ERP and, to a lesser extent, from the continuing effluent and environmental surveillance monitoring conducted by the ORNL ESP Section of the Office of Environmental and Health Protection (OEHP). Much of ESP's monitoring is associated with the NPDES permit for ORNL operations (EPA 1986). The following sections provide information on hydrologic data available in the Oak Ridge Environmental Information System (OREIS) data and information system, and elsewhere, and data summaries for selected stations. Climate data (precipitation, temperature, etc.) are presented first, followed by surface-water data (discharge and quality).

2.1 CLIMATE

Precipitation, temperature, humidity, wind speed, and wind direction data are available for several stations in the vicinity of the WOC watershed (Table 4). The period of record varies from station to station. The National Oceanic and Atmospheric Administration Atmospheric Turbulence and Diffusion Laboratory (NOAA/ATDD) monitoring station, located in Oak Ridge about 15.4 km (9.6 miles) north of the center of the watershed, is the closest long-term meteorological station, with records dating from 1947.

Precipitation is probably the most important climatic factor in hydrologic studies, since it establishes quantity and variations in runoff and streamflow. It also replenishes groundwater. Maximum, mean, and minimum annual precipitation for stations near ORNL during the period 1954-1983 was 190.0, 132.6, and 89.7 cm (74.8, 52.2, and 35.3 in.), respectively (Webster and Bradley 1987). Monthly precipitation at the NOAA/ATDD station generally ranges from 13.46-15.75 cm (5.3-6.2 in.) during the wettest months (January-March), and from 7.37-9.65 cm (2.9-3.8 in.) during the driest months (August-October) (NOAA 1974). The normal (mean) precipitation for the NOAA/ATDD station, based on the 30-year (1951-1980) period of record, is 133.6 cm (52.6 in.). Table 5 shows the frequency of occurrence for precipitation at various intensities over periods of 5 min to 24 h (Huff and Frederick 1984). The mean annual runoff for streams in the ORNL area is 56.6 cm (22.3 in.) (McMaster 1967). The remainder of the mean annual precipitation, about 76.2 cm (30 in.), is consumed by evapotranspiration.

Figure 14 shows meteorological stations for which data are available in the Remedial Action Program (RAP) data base management system, and Table 6 contains information on precipitation data collection methodology.

Table 4. Meteorological stations in the vicinity of the WOC watershed^a
(adapted from Boegley et al. 1985)

STATION DESCRIPTION	LOCATION	PERIOD OF RECORD	MEASUREMENTS
Knoxville (TYS) ^b	McGhee Tyson Airport	1942-Present	Precipitation, wind, temperature, temperature gradient, and humidity
Oak Ridge (ATDD)	City	(a) 1947-Present (b) 1947-1979	(a) Precipitation, temperature, and temperature gradient; (b) wind
First Creek (1st CR)	ORNL	1987-Present	Precipitation ^c
USGS 7500 Bridge (7500B) ^d	7500 Bridge	1987-Present	Precipitation ^c
ETF	SWSA 6	1980-Present	Precipitation ^c
SW4	SWSA 4	1986-Present	Precipitation ^c , temperature, wind speed and direction, solar radiation, relative humidity, and pan evaporation ^e
ISH	Ish Creek	1982-Present	Precipitation ^c
RG1	Walker Branch	1982-Present	Precipitation ^c
RG3	Walker Branch	1982-Present	Precipitation ^c
BUR	Bear Creek Burial Ground	1985-Present	Precipitation ^c
49T	SWSA 6	1986-Present	Precipitation ^c
SW7	SWSA 7	1984-Present	Precipitation ^c

^aMeteorological measurements have been made at various times at the Y-12 Plant, the K-25 site, an early ORNL station, and the Tower Shielding Facility.

^bMeasurements also exist for the period 1871, until the station was moved to McGhee Tyson Airport.

^cPrecipitation gages are not equipped to measure snowfall.

^dRain gage at this site has not been calibrated. Data are not reported for this station.

^eRecords are discontinuous for all parameters collected at this site.

Table 5. Rainfall vs frequency for areas up to 25.9 km² (10 miles²) in Anderson and Knox counties, Tennessee
(adapted from Huff and Frederick 1984)
Units=mm

DURATION FREQUENCY (years)	MINUTES ^b						HOURS ^c					
	5	10	15	30	60	2	3	6	12	24		
2	10.9	16.5	20.3	29.0	38.1	45.7	50.8	61.0	71.1	83.8		
5	12.7	19.8	24.9	35.3	47.3	61.0	63.5	76.2	91.4	106.7		
10	14.2	22.6	28.5	41.9	55.9	68.6	73.7	88.9	104.1	121.9		
25	16.3	26.2	33.0	48.0	63.5	76.2	86.4	99.1	119.4	139.7		
50	18.0	29.2	36.8	53.6	71.1	86.4	94.0	119.4	134.6	154.9		
100	19.6	32.0	40.6	59.9	78.7	96.5	101.6	124.5	144.8	167.6		
Probable maximum, 6-h duration: 723.9												

^a1 mm = 0.04 in.

^b2-, 100-year and 5-, 15-, and 60-min data are from maps in NWS HYDRO-35 (Frederick et al. 1977). All other "minute" data are calculated using appropriate equations from the same publication. These equations are:

10 min: (0.59)(15 min) + (0.41)(5 min)

30 min: (0.49)(60 min) + (0.51)(15 min)

5 year: (0.278)(100 year) + (0.674)(2 year)

10 year: (0.449)(100 year) + (0.496)(2 year)

25 year: (0.669)(100 year) + (0.293)(2 year)

50 year: (0.835)(100 year) + (0.146)(2 year)

^cInterpolated from maps in USWB TP 40 (Hershfield 1961).

ORNL-DWG 92M-2097

Fig. 14. Meteorological stations in the White Oak Creek watershed for which data are available through the OREIS data base system

Table 6. Precipitation measurement descriptions for stations located in the WOC watershed and the NOAA/ATDD Oak Ridge station

STATION DESCRIPTION	TYPE OF GAGE	FREQUENCY OF DATA COLLECTION	SMALLEST UNIT OF MEASURE FOR GAGE (in)
Oak Ridge (ATDD)	Belfort Weight & Stick	Hourly	0.01
First Creek (1st CR)	Belfort Weighing	Hourly	0.01
USGS 7500 Bridge (7500E) ¹	Electric Tipping Bucket	15-min	0.01
ETF	Belfort Weighing	Hourly	0.01
SW4	Belfort Weighing	Hourly	0.01
ISH	Belfort Weighing	Hourly	0.01
RG1	Belfort Weighing	Hourly	0.01
RG3	Belfort Weighing	Hourly	0.01
BUR	Belfort Weighing	Hourly	0.01
49T	Belfort Weighing	Hourly	0.01
SW7	Belfort Weighing	Hourly	0.01

¹Rain gage has not been calibrated. Data are not reported for this station.

Table 7 displays monthly precipitation for the period October 1990–December 1991 at sites in the vicinity of the WOC watershed and at the NOAA/ATDD station in Oak Ridge. Daily precipitation at these sites is shown in Appendix B.

The current reporting period (October 1990–December 1991) is the third year (plus) of a period of recovery (above-normal precipitation) following the previous 4-year drought. The 4-year drought period (~1985–1988) saw a cumulative precipitation deficit of approximately 90.9 cm (35.78 in.). In 1985, annual (calendar year) precipitation measured at the NOAA/ATDD station was 118.2 cm (46.54 in.), 88% of normal for the 30-year period of record. In 1986, annual precipitation was 98.6 cm (38.82 in.), 74% of normal. In 1987, annual precipitation at the station was 102.4 cm (40.31 in.), 77% of normal, while annual precipitation in 1988 was 124.3 cm (48.95 in.), 93% of normal. Conversely, in 1989, there was 167.7 cm (66.01 in.), 125% of normal; in 1990 there was 151.8 cm (59.78 in.), 114% of normal; and in 1991 there was 164.5 cm (64.78 in.), 123% of normal precipitation. Table 7 shows that precipitation at the NOAA/ATDD station was below average for 6 months and above average for 9 months of the current reporting period, resulting in an above-normal period with a surplus of ~48.7 cm (19.2 in.) for the 15-month period. The three calendar years 1989–1991 saw a surplus of 83.2 cm (32.77 in.) at the NOAA/ATDD station, thereby nearly making up the deficit (91.6%) of the 4-year drought. Figures 15–16 compare the annual plots (hyetographs) of daily precipitation at the Engineering Test Facility (ETF) rain gage in the WOC watershed with the NOAA/ATDD station in Oak Ridge for the 15-month reporting period.

Tables 8 and 9 display maximum storm event analyses for stations ETF and 1ST (First Creek) for the cumulative period of calendar years 1990 and 1991. Analyses were performed at each site to determine the maximum total rainfall recorded for durations of 1, 2, 3, 6, 12, 24, 48, and 72 h over the 2-year period. It is interesting to note that the maximum storms of short duration and high intensity, commonly associated with convective thunderstorm events, occur during the spring and summer months, while the maximum storms of long duration occur in the late fall and winter months. At both stations, storms of 1- to 6-h duration occurred in May and/or July, while storms of 24- to 72-h duration occurred in late November and early December.

2.2 SURFACE WATER

Data on surface-water discharge and quality are collected at several sites in the WOC flow system: (1) from numerous studies conducted by the ERP, (2) as part of the ESP monitoring and compliance program associated with the NPDES permit, (3) from numerous ESD research projects, (4) from evaluations by the Interim Waste Operations group, and (5) as independent research. Some water quality data are also collected periodically as part of the BMAP, which is required by the NPDES permit (Loar et al. 1991).

2.2.1 Discharge

Data on streamflow in the vicinity of the WOC watershed are collected by ESD, USGS, and ESP. Historic daily streamflow data collected at 18 sites (Fig. 17) in the WOC system are available in the OREIS consolidated data base. Three sites, WOD (MS5), WOC (MS3),

Table 7. Monthly precipitation totals at the WOC watershed and NOAA/ATDD stations
for the period October 1990-December 1991
Units=mm

DATE	1ST CR	EIF	SW7	49T	SW4	ISH	RG1	RG3	BUR	ATDD Actual	ATDD Normal
October 1990	107.9	104.5	101.3	109.7	102.0	100.3	97.5	99.8	102.0	103.6	69.1
November 1990	60.8	60.3	58.5	64.9	60.8	59.5	55.7	57.8	60.6	61.1	102.9
December 1990	301.3	292.1	290.1	292.9	295.7	301.8	305.9	306.4	322.7	321.6	136.1
January 1991	64.6	57.8	66.4	64.6	57.5	72.0	69.5	68.7	69.2	75.6	133.4
February 1991	205.3	197.0	204.6	203.3	203.3	211.5	204.1	199.5	214.0	202.0	133.1
March 1991	186.0	174.8	186.8	185.8	189.1	183.7	166.7	167.7	177.6	189.3	138.4
April 1991	75.8	64.9	87.3	72.8	73.8	69.2	74.8	78.4	87.0	97.7	106.9
May 1991	103.1	77.9	119.6	87.0	103.3	68.7	109.2	110.7	102.5	64.9	89.4
June 1991	130.0	150.1	181.7	153.2	132.1	132.1	202.0	193.6	211.7	179.4	100.1
July 1991	79.4	102.3	58.0	105.3	82.2	102.0	85.2	92.9	110.7	103.3	144.0
August 1991	85.0	110.7	79.6	104.6	91.1	85.2	65.4	75.1	55.7	117.6	97.8
September 1991	47.6	53.7	67.2	47.6	45.3	42.8	67.7	66.4	65.7	72.8	84.8
October 1991	40.5	38.9	35.9	37.7	35.4	40.7	43.0	40.7	44.5	44.8	69.1
November 1991	111.2	125.2	112.0	111.2	107.6	114.3	109.7	113.0	115.3	105.6	102.9
December 1991	284.2	293.1	276.1	277.4	280.1	274.6	275.3	270.5	291.4	277.9	136.1
WY ¹ Total (mm)	1446.8	1445.9	1501.0	1491.6	1436.1	1428.8	1503.6	1516.8	1579.4	1588.8	1336.1
CY ² Total (mm)	1412.7	1446.3	1475.1	1450.4	1401.0	1396.7	1472.5	1477.1	1545.3	1530.8	1336.1

¹WY - Water Year (October 1990-September 1991).

²CY - Calendar Year.

ETF Raingage

Fig. 15. Daily precipitation measured at the ETF rain gage in the White Oak Creek watershed during the period October 1990—December 1991

ORNL DWG 92M-2087

NOAA/ATDD Raingage Oak Ridge, TN

Fig. 16. Daily precipitation measured at the NOAA/ATDD rain gage in Oak Ridge during the period October 1990—December 1991

Table 8. Maximum storm event analysis for the ETF station

RECORD BEGINS on January 1, 1990 at 00:00 Hours			
RECORD ENDS on January 1, 1992 at 00:00 Hours			
DURATION (h)	DATE	START TIME (h)	RAINFALL (in.)
1.00	May 1, 1990	14.55	1.59
2.00	May 1, 1990	14.55	2.21
3.00	May 1, 1990	14.55	2.22
6.00	May 1, 1990	14.55	2.25
12.00	May 1, 1990	11.20	2.25
24.00	December 22, 1990	5.44	4.26
48.00	November 30, 1991	16.83	6.26
72.00	November 30, 1991	8.23	7.30

Table 9. Maximum storm event analysis for the First Creek (1ST) station

RECORD BEGINS on January 1, 1990 at 00:00 Hours			
RECORD ENDS on January 1, 1992 at 00:00 Hours			
DURATION (h)	DATE	START TIME (h)	RAINFALL (in.)
1.00	May 1, 1990	15.31	2.02
2.00	May 1, 1990	15.31	2.04
3.00	May 1, 1990	15.31	2.07
6.00	July 1, 1990	19.21	2.12
12.00	December 22, 1990	6.77	2.28
24.00	November 30, 1991	18.50	3.99
48.00	November 30, 1991	18.50	6.05
72.00	November 30, 1991	10.02	7.01

Fig. 17. Locations of surface-water monitoring stations in the vicinity of the White Oak Creek watershed

and MB (MS4), are operated by ESP as part of the NPDES permit requirements, and 6 sites are currently operated by the USGS as a component of ERP studies to isolate individual contributions from upstream hydrologic units and for application in modeling studies. An additional ESP site (WOC headwaters monitoring station) has been established on WOC, upstream of all ORNL facility effluents and Bethel Valley Road, to monitor background water quality and flow in the headwaters area. Data collection activities at this site began in November 1988.

Stream discharge data are also being collected by ESD's Surface Water Hydrology Group at 10 sites. These sites are monitored simultaneously at the four ESP stations (above) and at the USGS station (no longer operated by the USGS) on Center Seven Creek (C7C) (which includes an independent low-flow control and sensor for better resolution of dry-weather base flows), and discharge at five additional surface-water monitoring stations are monitored independently. These include two sites (East and West Seeps) on tributaries that drain the pits and trenches area (WAG 7) northeast of WOL, one site (MS1) that drains SWSA 4 to the south into WOC, and two sites (Ish and Raccoon Creeks) outside the WOC watershed, west of State Highway 95. Stage data (only) are currently collected at MS1 and C7C and archived. No discharge data are processed from these stage measurements. Figures 18-20 show discharge hydrographs for the three major monitoring stations on WOC (MS3), MB (MS4), and WOD (MS5) for the 15-month reporting period.

In the current reporting period, streamflow data were collected at 15 monitoring stations near the WOC watershed (Fig. 17). In the WOC watershed, there are at least 11 more streamflow monitoring stations outfitted with at least a hydraulic control device. These devices are in various states of repair, but each could be upgraded and instrumented to collect streamflow data.

Physical descriptions and monitoring status information on both operating and non-operating stations have been summarized below. The increasing emphasis on characterizing and quantifying discharge from contaminated areas could affect decisions on upgrading the nonoperating stations.

1. White Oak Dam (WOD, X15, MS5)

Physical description: Station is at the outfall of WOL where WOC flows under State Highway 95, 1 km (0.6 mile) above the confluence with the Clinch River. Waters impounded by WOD flow through two 5.5-m (18-ft) sluice gates, through a 12.2-m (40-ft) wide channel; across a triangular, concrete, broad-crested weir (high-flow control); and finally, across a stainless steel, sharp-crested Cipoletti (trapezoidal) weir (low-flow control) before spilling into the WOC embayment (WOCE). The notch (crest) elevations on the broad- and sharp-crested weirs are about 226.8 m (744.0 ft) and 226.6 m (743.5 ft) above msl, respectively. Normal pool elevation for WOL is about 227.1 m (745 ft) msl. Maximum lake elevation (without overtopping the gates) with the gates closed is about 228.6 m (750 ft) msl. Crest elevation of WOD is about 230.13 m (755.05 ft) msl at its lowest point near the longitudinal center (Tschantz, 1987).

Fig. 18. Daily streamflow at the White Oak Creek station (MS3) for the period October 1990—December 1991

Fig. 19. Daily streamflow at the Melton Branch station (MS4) for the period October 1990—December 1991

Fig. 20. Daily streamflow at the White Oak Dam station (MS5) for the period October 1990—December 1991

Monitoring status: ESP collects hourly and daily (totalizer) discharge data by ultrasonic flow meters for compliance purposes. ESD's Surface Water Hydrology Group collects stage height data at four sensor locations, including lake level, for conversion to discharge data.

2. **White Oak Creek (WOC, X14, MS3)**

Physical description: Station is on WOC above the confluence with MB. Water flows into a stilling pool impounded by a concrete sill; through twin stainless steel, sharp-crested, 100° V-notch weirs contained in the sill; into a 11.0-m (36-ft) wide channel; then across a rectangular, concrete, broad-crested weir before finally spilling back into the natural channel downstream from the station. The elevations of the top of the V-notch weirs, the crests of the V-notch weirs, and the broad-crested weir are about 230.21 m, 229.45 m, and 229.21 m (755.31, 752.81, and 752.05 ft) msl, respectively.

Monitoring status: ESP collects hourly and daily (totalizer) discharge data by ultrasonic flow meters for compliance purposes. ESD's Surface Water Hydrology Group collects stage height data at three sensor locations for conversion to discharge data.

3. **Melton Branch (MB, X13, MS4)**

Physical description: Station is on MB above the confluence with WOC. Water flows into a stilling pool impounded by a concrete sill; through a stainless steel, sharp-crested, 120° V-notch weir contained in the sill; into a 7.3-m (24-ft) wide channel; then across a rectangular, concrete, broad-crested weir before finally spilling into a tailwater pool downstream from the station. The elevations of the top of the V-notch weir, the crests of the V-notch weir, and the broad-crested weir are about 230.3 m, 229.6 m, and 229 m (755.60, 753.35, and 751.43 ft) msl, respectively.

Monitoring status: ESP collects hourly and daily (totalizer) discharge data by ultrasonic flow meters for compliance purposes. ESD's Surface Water Hydrology Group collects stage height data at three sensor locations for conversion to discharge data.

4. **White Oak Creek Headwaters (WOCHW)**

Physical description: Station is in the upper reaches of WOC, north of Bethel Valley Road, and upstream from any ORNL facility discharges. Therefore, this station is considered a background monitoring station for WOC. The control device is a compound, stainless steel, critical-flow flume.

Monitoring status: ESD's Surface Water Hydrology Group operates electronic and mechanical data loggers; maintains instrumentation; collects punch-tapes and electronic data storage packs; processes tapes and storage packs; and generates, verifies, and stores discharge data. ESP operates a flow totalizer at this station.

5. East Seep (ESP)

Physical description: Station is in WAG 7 on the east seep tributary to the headwaters of WOL. The control device is a stainless steel, sharp-crested, 90° V-notch weir.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Surface Water Hydrology Group maintains instrumentation; collects punch tapes; processes the tapes; and generates, verifies, and stores discharge data.

6. West Seep (WSP)

Physical description: Station is in WAG 2 bordering the east slope of WAG 6 on the west seep tributary to the headwaters of WOL. The control device is a compound, stainless steel, sharp-crested weir consisting of a 120° V-notch, low-flow section and a rectangular, high-flow section.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Surface Water Hydrology Group maintains instrumentation; collects punch tapes; processes the tapes; and generates, verifies, and stores discharge data.

7. WAG4-2 (MS1)

Physical description: Station is on the upper reaches of an unnamed tributary to White Oak Creek that runs along the southern boundary of SWSA 4. Access to the site is through SWSA 4 from Lagoon Road. The control device is a Plasti-fab, prefabricated fiberglass, 5-cm (2-in.), 45° trapezoidal flume.

Monitoring status: Instrumentation includes an Omnidata Easy Logger (electronic data logger) with a submerged pressure transducer installed in the stilling pool for measuring stage. ESD's Surface Water Hydrology Group maintains instrumentation, retrieves data storage packs, and downloads and archives stage data.

8. Ish Creek

Physical description: Station is at the bridge on New Zion Patrol Road, 2.7 km (1.7 miles) west of State Highway 95 and 0.6 km (0.4 mile) upstream from the mouth at Clinch River kilometer 30.7 (mile 19.1). The low-flow control device is a stainless steel, critical-flow flume, and the high-flow control device is the rectangular, concrete, culvert (bridge) opening.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Surface Water Hydrology Group maintains instrumentation; collects punch tapes; processes the tapes; and generates, verifies, and stores discharge data.

9. Raccoon Creek

Physical description: Station is in the upper reaches of Raccoon Creek, approximately 0.4 km (0.25 mile) west of State Highway 95, 0.15 km (0.1 mile) south of New Zion Patrol Road, and 2.1 km (1.3 mile) upstream from the mouth at Clinch River kilometer 31.5 (mile 19.5). The control device is a stainless steel, sharp-crested weir in three sections: a 56° V-notch in the center of the channel for stages from 0 to 1.25 ft and a vertical extension of the V-notch and two rectangular weir plates with end contractions, one on each side of the V-notch, for stages from 1.25 to 2.5 ft.

Monitoring status: Instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. ESD's Surface Water Hydrology Group maintains instrumentation; collects punch tapes; processes the tapes; and generates, verifies, and stores discharge data.

10. WAG 6 Tributaries (FA, FB, DA, and DB)

Physical description: Stations are on the four drainages in WAG 6 (all draining into White Oak Lake). Proceeding west to east: station FA is a 5-cm (2-in.), 60° trapezoidal flume; station FB is a 15-cm (6-in.) Parshall flume; station DA is a 0.46-m (18-in.) Parshall flume; and station DB consists of 15-cm and 0.91-m (6-in. and 36-in.) Parshall flumes in series. All flumes are prefabricated fiberglass flumes with dual 0.3-m (12-in.) stilling wells for upstream (H1) and downstream (H2) head measurements.

Monitoring status: ESD's Surface Water Hydrology Group collected data at all four stations for a brief period, from about late April to early June of 1990. All four stations were recently reinstrumented by the ICM monitoring program for discharge data collection.

11. Melton Branch Tributary (HRTF)

Physical description: Station is on the tributary to Melton Branch in the vicinity of the old Homogenous Reactor Test Facility upstream from the confluence with MB and downstream from station HRT (Station 14 below). The control device is a Manning 0.46-m (18-in.), prefabricated fiberglass Palmer-Bowlus flume.

Monitoring status: No monitoring is conducted at this station. Some limited stage data were collected by ESD from August 1989 to January 1990 for an independent study on storm-flow sampling. These data are available in electronic files but have not been processed.

12. WAG4-2A (T-2A)

Physical description: Station is just above the mouth of an unnamed tributary to White Oak Creek that runs along the southern boundary of SWSA 4 in the vicinity of the old intermediate detention pond. The control device is a Plasti-Fab prefabricated fiberglass, 12.7-cm (5-in.), 45° trapezoidal flume.

Monitoring status: Currently not instrumented. ESD collected stage-height data from approximately October 1983-January 1989.

13. Melton Branch (MB2)

Physical description: Station is on MB upstream from the confluence with the HRT tributary. The control device is a 1.83-m (6-ft) wide, stainless steel, sharp-crested, trapezoidal weir.

Monitoring status: ESP operates a flow totalizer at this station.

14. Melton Branch Tributary (HRT, HRE)

Physical description: Station is on the tributary to MB in the vicinity of the old Homogenous Reactor Test Facility. The control device is a stainless steel, sharp-crested, 90° V-notch weir.

Monitoring status: No monitoring is conducted at this station. ESP has monitoring equipment (flow totalizer, samplers, etc.) available on-site in an instrument enclosure.

15. White Oak Creek and Clinch River Confluence (WOCCON)

Physical description: Station is at the mouth of WOC on the Clinch River at Clinch River mile 20.8. Station is a stage recorder only (no control device).

Monitoring status: ESD's Surface Water Hydrology Group installed an electronic data logger and a submerged pressure transducer in September 1988 to record stages at 15-min intervals. This station was dismantled in January 1991 to make way for the sediment retention dam to be constructed at the mouth of WOC. The Off-Site ERP reinstalled a stage height recorder in the summer of 1991.

16. Upper White Oak Creek (GS6, USGS #03536320)

Physical description: Station is on WOC east of the east gate outside the main plant area and north of the point where WOC crosses White Oak Avenue, near Building 6000, ORNL. The control is a natural bedrock outcropping in the stream.

Monitoring status: The USGS instrumentation includes a Stevens model 7001 float-type gage housed in an instrument shelter over a stilling well on the right bank of the stream. The gage is equipped with a digital punch, stage-height recorder that collects raw stage data at 15-min intervals for conversion to hourly average discharge values.

17. White Oak Creek Parshall Flume (MS2, GS5, USGS #03536380)

Physical description: Station is at the existing MS2 concrete and stainless steel Parshall flume on WOC in the main plant area downstream from the confluence with Fifth Creek and upstream from the STP outfall.

Monitoring status: USGS instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and mounted at the upstream side of the concrete structure containing the flume, near the left bank. The gage is equipped with a digital punch, stage-height recorder that collects raw stage data at 15-min intervals for conversion to hourly average discharge values.

18. Northwest Tributary (NWT, GS4, USGS #03536440)

Physical description: Station is on the Northwest Tributary to WOC above the confluence with First Creek, southwest of the fish ponds behind Building 1504, ORNL. The control device is a concrete and stainless steel, short-crested triangular weir.

Monitoring status: USGS instrumentation includes a bubbler gage equipped with a digital punch, stage-height recorder. The gage collects raw stage data at 15-min intervals for conversion to hourly average discharge values. ESP operates a flow totalizer at this station.

19. First Creek (GS1, USGS #03536450)

Physical description: Station is on the First Creek tributary to WOC (above) between Burial Ground Road and the confluence with the Northwest Tributary. The control device is a compound, stainless steel, critical-flow flume.

Monitoring status: USGS instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. The gage collects raw stage data at 5-min intervals for conversion to hourly average discharge values.

20. 7500 Bridge (MS2A, GS3, USGS #03536550)

Physical description: Station is on WOC below the confluence with First Creek and Northwest Tributary where Melton Valley Drive meets Lagoon Road. The control device is a compound stainless steel, sharp-crested weir consisting of a low-flow trapezoidal section, a trapezoidal transition section, and a rectangular high-flow section.

Monitoring status: USGS instrumentation includes a bubbler gage equipped with a digital punch, stage-height recorder that transmits stage data via a satellite telemetry system to the USGS data base in Nashville, Tennessee. Stage or converted discharge data are available in near-realtime for immediate access and are also processed to produce on-line computer summaries of data. This site also has a rain gage that is part of the data collection platform (DCP) system in use. In addition, ESP operates a flow totalizer at this station.

21. Melton Branch Tributary (East Seven, E7C, GS16, USGS #03537050)

Physical description: Station is on the east tributary (East Seven Creek) to MB adjacent to the proposed SWSA 7. The control device is a prefabricated fiberglass H-flume.

Monitoring status: USGS instrumentation included a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder. This station was discontinued by the USGS in October 1991.

22. Upper Melton Branch (GS2, USGS #03537100)

Physical description: Station is in the upper reaches of MB near the proposed SWSA 7, 1.6 km (1 mile) southeast of ORNL, just upstream from the High Flux Isotope Reactor (HFIR) complex. The control device is a "natural" concrete overflow sill with a broad, flat, triangular notch.

Monitoring status: USGS instrumentation includes a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch, stage-height recorder that collects raw stage data at 15-min intervals for conversion to hourly average discharge values.

23. Melton Branch Tributary (Center Seven, C7C, GS17, USGS #03537200)

Physical description: Station is at the center of three tributaries (Center Seven Creek) to MB, adjacent to the proposed SWSA 7. The low-flow control device is a stainless steel, sharp-crested, 90° V-notch weir, and the high-flow control device is a 0.76-m (2.5-ft), fiberglass H-flume.

Monitoring status: USGS instrumentation included a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch stage-height recorder. This station was discontinued by the USGS in October 1991. ESD installed the V-notch weir for better resolution on low flows. The station is equipped with an electronic data logger and a submerged pressure transducer for stage-height measurements. ESD's Surface Water Hydrology Group collects stage data at the weir and H-flume and archives the data.

24. Melton Branch Tributary (West Seven, W7C, GS18, USGS #03537300)

Physical description: Station is on the west tributary (West Seven Creek) to MB adjacent to the proposed SWSA 7. The control device is a combination stainless steel rectangular/90° V-notch weir.

Monitoring status: USGS instrumentation included a Stevens model 7001 float-type gage housed over a stilling well and equipped with a digital punch stage-height recorder. This station was discontinued by the USGS in September 1989.

Tables 10 and 11 allow comparison of flows at selected gaging stations and monthly discharge and runoff summaries for the eight ESD sites (for which data are available from the ESD Surface Water Hydrology Group) and eight USGS sites (for which data are available in the OREIS data base). The total monthly volume of runoff (natural and imported) from each station was divided by its drainage area to express monthly runoff volume in inches of water. Historically, loss of water to the atmosphere is approximately 55% of the total annual

Table 10. Monthly flow and runoff statistics for ESD stations located
in the vicinity of WOC watershed
Flow rate units=cfs

			SITE ID							
			East Seep	WOC	MBR	WOD	Int Cr.	Raccoon Cr.	WOC/FW	West Seep
DRAINAGE AREA (sqF)			0.032	3.61	1.51	6.15	0.95	0.33	0.00	0.25
YEAR	MONTH	STATISTIC								
1990	OCTOBER	MEAN	0.021	6.676	1.205	8.404	0.233	0.065	0.288	0.102
		MINIMUM	0.003	5.005	0.54	5.56	0.107	0.02	0.167	0.02
		MAXIMUM	0.429	13.437	2.760	13.881	0.581	0.285	0.442	0.404
		RUNOFF (in.)	0.79	2.13	0.92	1.58	0.28	0.23	0.42	0.47
	NOVEMBER	MEAN	0.021	7.188	1.08	6.702	0.318	0.076	0.299	0.131
		MINIMUM	0.000	5.2	0.465	4.167	0.157	0.018	0.191	0.039
		MAXIMUM	0.408	19.165	7.026	24.883	1.796	1.073	0.795	1.046
		RUNOFF (in.)	0.73	2.22	0.80	1.22	0.37	0.08	0.42	0.58
	DECEMBER	MEAN	0.190	30.471	9.315	42.135	4.797	1.609	5.639	1.778
		MINIMUM	0.010	6.252	0.76	5.801	0.242	0.024	0.286	0.089
		MAXIMUM	8.052	211.79	74.265	364.66	46.852	13.721	62.841	14.01
		RUNOFF (in.)	6.85	9.73	7.11	7.90	5.82	5.62	8.13	8.20
1991	JANUARY	MEAN	0.045	13.306	3.093	14.792	2.117	0.33	1.907	0.568
		MINIMUM	0.019	7.749	1.137	7.627	0.819	0.009	0.757	0.178
		MAXIMUM	0.351	26.773	9.563	33.449	4.941	2.224	5.230	1.915
		RUNOFF (in.)	1.62	4.25	2.36	2.77	2.57	1.15	2.75	2.62
	FEBRUARY	MEAN	0.205	29.558	9.807	43.546	5.198	1.58	5.703	1.817
		MINIMUM	0.000	6.443	1.144	6.918	0.621	0.0238	0.618	0.133
		MAXIMUM	3.612	178.628	72.99	308.047	36.601	13.297	41.453	14.198
		RUNOFF (in.)	6.67	8.53	7.41	7.37	5.70	4.99	7.42	7.57
	MARCH	MEAN	0.117	20.474	7.069	27.966	3.195	0.959	2.998	1.218
		MINIMUM	0.031	10.376	2.362	12.84	1.354	0.125	1.305	0.338
		MAXIMUM	1.206	49.027	45.928	131.003	12.284	8.541	11.995	7.934
		RUNOFF (in.)	4.22	6.54	5.40	5.24	3.88	3.35	4.32	5.62

Table 10 (continued)

			SITE ID							
			East Seep	WOC	MBR	WOD	Isb Cr.	Raccoon Cr.	WOCHFV	West Seep
	APRIL	MEAN	0.049	10.189	2.906	13.658	1.283	0.186	1.473	0.401
		MINIMUM	0.016	6.634	1.693	8.805	0.498	0.047	0.723	0.162
		MAXIMUM	0.516	21.362	10.051	28.346	3.272	0.531	3.59	1.437
		RUNOFF (in.)	1.71	3.15	2.15	2.48	1.51	0.63	2.05	1.79
	MAY	MEAN	0.024	7.686	1.845	9.796	0.331	0.068	0.69	0.27
		MINIMUM	0.001	5.383	0.598	6.398	0.187	0.018	0.451	0.071
		MAXIMUM	0.691	16.046	10.331	26.729	0.771	0.581	1.211	0.982
		RUNOFF (in.)	0.86	2.45	1.41	1.84	0.40	0.24	0.99	1.25
	JUNE	MEAN	0.034	12.548	3.476	16.258	0.548	0.15	2.485	0.295
		MINIMUM	0.003	5.456	0.429	6.041	0.140	0.012	0.499	0.066
		MAXIMUM	1.485	44.748	18.39	68.282	2.541	1.136	14.165	1.59
		RUNOFF (in.)	1.19	3.88	2.57	2.95	0.64	0.51	3.47	1.32
	JULY	MEAN	0.019	7.41	1.502	8.926	0.564	0.156	0.657	0.172
		MINIMUM	0.001	5.249	0.634	5.875	0.114	0.014	0.319	0.016
		MAXIMUM	1.527	17.074	3.323	20.853	3.259	1.517	1.575	0.968
		RUNOFF (in.)	0.68	2.37	1.15	1.67	0.68	0.55	0.95	0.79
	AUGUST	MEAN	0.011	5.976	1.692	7.308	0.11	0.017	0.254	0.047
		MINIMUM	0.000	5.2	1.006	3.93	0.06	0.007	0.193	0.01
		MAXIMUM	0.408	9.754	3.007	12.046	0.373	0.109	0.315	0.326
		RUNOFF (in.)	0.40	1.91	1.29	1.37	0.13	0.06	0.37	0.22

Table 10 (continued)

			SITE ID							
			East Seep	WOC	MBR	WOD	Isb Cr.	Raccoon Cr.	WOCHW	West Seep
	SEPTEMBER	MEAN	0.005	5.471	1.333	6.536	0.085	0.007	0.172	0.02
		MINIMUM	0.001	4.366	0.766	4.856	0.052	0.004	0.133	0.004
		MAXIMUM	0.157	11.632	2.189	10.783	0.273	0.033	0.374	0.186
		RUNOFF (in.)	0.17	1.69	0.98	1.19	0.10	0.02	0.24	0.09
	OCTOBER	MEAN	.007	4.978	0.879	5.708	0.114	0.01	0.159	0.029
		MINIMUM	.003	4.262	0.308	4.654	0.062	0.003	0.137	0.015
		MAXIMUM	.266	13.13	2.995	13.414	0.478	0.016	0.442	0.263
		RUNOFF (in.)	0.25	1.59	0.67	1.07	0.14	0.03	0.23	0.13
	NOVEMBER	MEAN	0.02	6.364	1.125	7.348	0.262	0.131	0.235	0.011
		MINIMUM	0.003	4.14	0.44	4.621	0.088	0.063	0.137	0.02
		MAXIMUM	0.718	35.805	14.232	51.058	3.311	2.909	1.531	1.707
		RUNOFF (in.)	0.72	1.97	0.83	1.33	0.31	0.44	0.33	0.05
	DECEMBER	MEAN	0.163	26.603	10.122	38.255	3.941	1.495	3.999	1.708
		MINIMUM	0.016	7.145	1.476	8.636	0.088	0.063	0.923	0.139
		MAXIMUM	4.594	137.397	61.076	220.731	3.311	10.903	23.707	10.229
		RUNOFF (in.)	5.87	8.50	7.73	7.17	4.78	5.22	5.76	7.88

WOCHW = Whiteoak Creek Headwaters.
 WOC = Whiteoak Creek (MS3).
 MBR = Melton Branch (MS4).
 WOD = Whiteoak Dam (MS5).
 ESEEP = East Seep
 WSEEP = West Seep

**Table 11. Monthly flow and runoff statistics for USGS stations located
in the vicinity of WOC watershed
Flow rate units=cfs**

			SITE ID							
			GS1	GS2	GS3	GS4	GS5	GS6	GS16	GS17
DRAINAGE AREA (mi ²)			0.33	0.52	3.28	0.67	2.10	1.31	0.24	0.07
YEAR	MONTH	STATISTIC								
1990	OCTOBER	MEAN	.3	.098	6.53	.53	3.15	.24	.047	.029
		MINIMUM	.14	0	4.9	.38	2.2	.04	0	.01
		MAXIMUM	1	.45	14	1.1	7.3	1.4	.22	.1
		RUNOFF (in.)	1.05	0.22	2.30	0.91	1.73	0.21	0.23	0.48
	NOVEMBER	MEAN	.27	.16	6.1	.53	2.93	.21	.1	.039
		MINIMUM	.13	0.03	4.5	.33	2.1	.06	.01	.01
		MAXIMUM	1.4	1.6	4.5	2.2	8.3	1.8	.9	.26
		RUNOFF (in.)	0.91	0.34	2.08	0.88	1.56	0.18	0.47	0.62
	DECEMBER	MEAN	2.87	2.94	24.6	3.82	15.7	7.72	1.89	.5
		MINIMUM	.14	0.07	5	.44	2.5	.09	0.05	.02
		MAXIMUM	26	28	125	32	106	80	20	4.6
		RUNOFF (in.)	10.03	6.52	8.65	6.58	8.62	6.80	9.06	8.24
1991	JANUARY	MEAN	1.28	.91	13.2	1.09	7.02	1.76	.35	.13
		MINIMUM	.41	.27	7.7	.47	3.6	.17	.1	.06
		MAXIMUM	3	2.6	27	3.5	16	5.4	1.5	.4
		RUNOFF (in.)	4.47	2.02	4.64	1.88	3.86	1.55	1.68	2.14
	FEBRUARY	MEAN	2.7	2.87	25.5	3.78	15.4	7.24	1.57	.5
		MINIMUM	.31	.13	6.3	.41	3.1	.12	0.08	.04
		MAXIMUM	17	22	140	29	93	59	14	4.2
		RUNOFF (in.)	8.52	5.75	8.10	5.88	7.64	5.76	6.80	7.44
	MARCH	MEAN	2.1	2	19.2	2.32	10.8	3.68	.98	.32
		MINIMUM	.97	.57	10	.74	5.1	.92	.18	.09
		MAXIMUM	9	13	74	12	50	25	8.5	2.6
		RUNOFF (in.)	7.34	4.44	6.75	3.99	5.93	3.24	4.71	5.27

Table 11 (continued)

			SITE ID							
			GS1	GS2	GS3	GS4	GS5	GS6	GS16	GS17
DRAINAGE AREA (m ²)			0.33	0.52	3.28	0.67	2.10	1.31	0.24	0.07
YEAR	MONTH	STATISTIC								
	APRIL	MEAN	1.02	.73	10.7	.72	5.74	1.3	.3	0.12
		MINIMUM	.52	.16	7.1	.38	3.6	.44	.08	0.06
		MAXIMUM	2.2	2.8	20	1.7	12	4	1.6	0.50
		RUNOFF (in.)	3.45	1.57	3.64	1.20	3.05	1.11	1.40	1.97
	MAY	MEAN	0.55	0.35	8.09	.47	4.22	.63	.2	.079
		MINIMUM	0.38	0.05	6	.3	2.8	.09	.02	.03
		MAXIMUM	1.4	2.7	16	1.5	9.7	4.6	1.5	.45
		RUNOFF (in.)	1.92	0.78	2.84	0.81	2.32	0.55	0.96	1.30
	JUNE	MEAN	0.65	.93	12.7	.67	7.63	3.19	.51	.14
		MINIMUM	0.35	.01	6	.35	3	.06	.01	.02
		MAXIMUM	2.0	5.6	42	2.9	27	19	3.2	.82
		RUNOFF (in.)	2.20	2.00	4.32	1.12	4.06	2.72	2.37	2.23
	JULY	MEAN	0.50	.066	7.7	.61	4.05	.37	.028	.024
		MINIMUM	0.24	0	5.5	.35	2.3	.06	0	.01
		MAXIMUM	1.9	.45	17	2.9	22	2.2	.16	.09
		RUNOFF (in.)	1.75	0.15	2.71	1.05	2.22	0.33	0.13	0.40
	AUGUST	MEAN	0.29	.011	6.22	.43	2.74	.14	.005	.015
		MINIMUM	0.21	0	5.3	.33	2.2	.05	0	.01
		MAXIMUM	0.78	.07	10	.62	3.9	.64	.03	.06
		RUNOFF (in.)	1.01	0.02	2.19	0.74	1.50	0.12	0.02	0.25

Table 11 (continued)

			SITE ID							
			GS1	GS2	GS3	GS4	GS5	GS6	GS16	GS17
DRAINAGE AREA (mi ²)			0.33	0.52	3.28	0.67	2.10	1.31	0.24	0.07
YEAR	MONTH	STATISTIC								
	SEPTEMBER	MEAN	.17	.003	5.55	.41	2.53	.12	.006	.014
		MINIMUM	0.11	0	4.4	.28	2.2	.04	0	.01
		MAXIMUM	.98	.05	12	.66	7.2	1.3	.05	.07
		RUNOFF (in.)	0.58	0.01	1.89	0.68	1.34	0.10	0.03	0.22
	OCTOBER	MEAN	.16	.015	5.27	.33	2.44	.11		
		MINIMUM	.1	0	4.3	.27	2.1	.04		
		MAXIMUM	1.1	.2	14	.75	7.6	1.5		
		RUNOFF (in.)	0.56	0.03	1.85	0.57	1.34	0.10		
	NOVEMBER	MEAN	.32	.16	6.27	.44	3.25	.35		
		MINIMUM	.1	.01	4.3	.25	1.9	.04		
		MAXIMUM	3.3	3.4	29	3.1	18	5.1		
		RUNOFF (in.)	1.08	0.34	2.13	0.73	1.73	0.30		
	DECEMBER	MEAN	2.6	2.65	23.2	3.24	14.2	5.42		
		MINIMUM	.72	.22	7.1	.47	3.5	.19		
		MAXIMUM	11	16	101	19	67	39		
		RUNOFF (in.)	9.09	5.88	8.16	5.58	7.80	4.77		

¹Station was discontinued on September 30, 1991.

GS1 (USGS 03536450) = First Creek.
 GS2 (USGS 03537100) = Melton Branch near Melton Hill.
 GS3 (USGS 03536550) = WOC below Melton Valley Drive.
 GS4 (USGS 03536440) = Northwest Trib near Oak Ridge.
 GS5 (USGS 03536380) = WOC near Wheat.
 GS6 (USGS 03536320) = WOC near Melton Hill.
 GS16 (USGS 03537050) = Melton Branch Tributary (East Seven) near Oak Ridge.
 GS17 (USGS 03537200) = Melton Branch Tributary (Center Seven) near Oak Ridge.

precipitation in the Oak Ridge area. The remaining 45%, on the average, occurs as runoff. At a number of stations (GS1, GS3, and GS5) in the main plant area or downstream from plant effluents, runoff volumes are greater than precipitation totals for several months during the 15-month reporting period (see Table 8). In addition, annual runoff volume approaches annual precipitation totals at the same stations: approximately 74% at GS1, 85% at GS3, and 75% at GS5. These totals highlight the magnitude and influence of imported water to monitoring stations in the WOC watershed. For comparison, two gaging stations upstream of ORNL effluents, GS2 and the WOC Headwaters (WOCHW) station, had runoff volumes of approximately 41% and 52%, respectively. Drainage areas for each station in the flow system are listed in Tables 10 and 11, respectively. Daily flow data for these sites are listed in tables in Appendix C.

Figure 21 shows monthly mean discharge in WOC at GS3 downstream from Haw Ridge, at monitoring station 3 (MS3) on WOC upstream from the confluence with MB, and the difference between monthly discharge at the two stations. Unpublished stream surveys conducted by the USGS in the late 1980s indicate that, on the average, MS3 discharge is approximately 4.5% greater than GS3 (Borders et al. 1991), indicating that this section of WOC is a gaining reach. The comparison of discharge at these stations shows negative differences in flow for more than half the year (8 months) for the reporting period of May 1987–April 1988 despite the 0.34 miles² of contributing drainage area between the stations. This contribution cast strong doubt on the accuracy of the flow measurements. In June 1988, the monitoring station at GS3 was upgraded with an improved hydraulic control device. In addition, the ESD Surface Water Hydrology Group began collecting and processing discharge data at MS3 and other "major" monitoring stations on the watershed shortly after the end of the 1987–1988 reporting period. Monthly discharge differences between MS3 and GS3 for Water Year 1990 were positive every month except June (-1.6%) and August (-0.7%) of 1990, typically two of the driest months of the year. The average difference in monthly discharge values for the year was 4.9%. This suggests that the accuracy of discharge measurements at these two sites has improved significantly.

Differences in monthly discharge (MS3–GS3) for the current reporting period were negative (slightly) for 7 consecutive months (April–November, 1991), exclusively during the spring to late summer period of typically high evapotranspiration rates and/or low to moderate precipitation rates. However, the difference in discharge for the 15-month period was approximately 7.3%. This is greater than previously reported, but this reporting period was also significantly wetter. Therefore, higher differences would be expected because of a contributing area between the stations amounting to 10% of the GS3 drainage area.

Figure 22 shows monthly mean discharge at MS3 on WOC, monitoring station 4 (MS4) on MB above the confluence with WOC, monitoring station 5 (MS5) at WOD, and the differences between the sum of flows at MS3 and MS4 and the flow at WOD (MS5). The occurrence of negative flows, despite an appreciable contributing drainage area (1.04 miles²), highlights the need for field rating and verification of the high-flow, stage-discharge relationships at each of the three gaging stations (see Sect. 1.1.1). However, all the negative differences occurred in months (November 1990, January and July–November 1991) with below-average precipitation, or in the summer and early autumn when evapotranspiration rates are higher and soil moisture deficits tend to be high, resulting in less runoff. Local

Fig. 21. Comparison of monthly mean discharge at USGS monitoring station GS3 and ESD monitoring station MS3

Fig. 22. Comparison of ESD monthly mean discharge at monitoring stations MS3, MS4, and MS5

inflows from ungaged areas around the lake are also negligible at these times. In addition, sections of lower WOC above the headwaters of WOL may be losing reaches, and WOL presents a significant surface area for losses due to evaporation during hot, dry periods. Therefore, a significant portion of the negative differences may be accountable. Nevertheless, the causes of these negative differences should be verified or corrected.

Figure 23 shows monthly mean discharge at the WOCHW station north of Bethel Valley Road, at the foot of Chestnut Ridge, and at GS6 downstream on WOC, south of Bethel Valley Road. During periods of high flow, discharge at GS6 is considerably greater than at WOCHW, which is to be expected due to the increase in drainage area at GS6. However, during periods of low flow, WOCHW discharge is greater than at GS6. This difference is greatly pronounced (as great as 5 times) when referring to daily flow records.

The stream reach between these two stations is a losing reach. The Knox Group (geologic unit), which underlies Chestnut Ridge, is the major water-bearing formation in the watershed (see Sect. 1.2.4). The Chickamauga Group underlies Bethel Valley. The Benbolt formation (Chickamauga Group) lies directly under the reach (losing) between GS6 and WOCHW (G. K. Moore, The University of Tennessee, Knoxville, personal communication to D. M. Borders, The University of Tennessee, Knoxville, April 1992). This formation is made up of limestone layers which bisect WOC and in which pronounced solution channels have formed. Flow is along the strike of these limestone layers. The WOCHW flows from the southern slopes of Chestnut Ridge and then bisects the shallow limestone layers of the Benbolt formation and is intercepted. A popular hypothesis is that the water lost in this reach reappears as surface flow at the duck pond northeast of the 4500 complex. To test this hypothesis, staff members in the ESD Surface Water and Groundwater Hydrology Groups investigated on April 8-9 and 16, 1992.

On April 8, flow at WOCHW was 21.5 L/s (0.76 cfs) and flow at GS6 was 4.25 L/s (0.15 cfs). On April 9, (no precipitation occurred April 8-9) outflow from the duck pond was estimated (by indirect measurements) to be 19 L/s (0.67 cfs). It was also estimated (visually) that <10% of this total was entering the duck pond by surface flow. On April 16, flow at WOCHW was 18.9 L/s (0.67 cfs) and at GS6 flow was 4.25 L/s (0.15 cfs). The duck pond outflow was estimated to be approximately 21 L/s (0.74 cfs). Again, <10% of this flow was estimated to be entering by surface flow. In addition, the estimate of duck pond outflow on April 16 is considered to be the better of the two (including that on April 9).

It appears that the flow, originating as surface flow at WOCHW and ultimately being lost to the subsurface in the Benbolt formation before reaching GS6 through WOC, is reappearing as surface flow in the duck pond. In addition, it appears that the difference between the duck pond outflow and inflow is greater than the flow lost from WOC. This may be due, in part, to measurement and estimation errors, however, the increase in flow appearing at the duck pond is typical of the hydrologic regime. Additional water is being supplied to the duck pond from the Knox formation underlying Chestnut Ridge.

Rating tables for most of the monitoring stations shown in Fig. 17 are available in Appendix D. In most cases, the tables can be used in the field without applying an offset. That is, the stage height can be read by visual inspection of the staff gage and applied directly to the rating table to determine the corresponding discharge. In addition, most of the tables

Fig. 23. Comparison of monthly mean discharge at USGS monitoring station GS6 and ESD monitoring station WOCHW

are in English units (head or stage in feet and discharge in cubic feet per second), but for those that are not, units are clearly stated. For example, at the MS3 monitoring station above the confluence with MB, for a staff gage reading of 0.95 ft, the corresponding discharge is 5.40 cfs. The rating tables are provided as a reference, and the reader is cautioned to apply these ratings carefully. Many circumstances can render these ratings temporarily or permanently invalid.

2.2.2 Flow Augmentation in White Oak Creek Watershed

Flow in WOC in the main ORNL plant area is augmented by the discharge of water imported for plant processes, potable supplies, and sanitary use. The flow is complex because of the effects of storm drainage, leakage into and out of an extensive system of underground pipes, and the increased permeability of disturbed subsurface materials along pipe lines and within construction sites. However, the discharge data from the 6 USGS stations in the vicinity of the main plant permit the isolation of flow from contributing areas where the majority of plant effluents and imported water enter the surface-water system. Figure 24 shows hydrographs of monthly mean discharge at station GS3 on WOC downstream from the main plant area, GS4 on the Northwest Tributary, GS1 on First Creek, GS5 on WOC below its junction with Fifth Creek, and the difference between flow at GS3 and the sum of the three upstream stations. This difference, consistently above 2 cfs, includes runoff from the contributing area between the three upstream stations and GS3 ($\sim 0.18 \text{ mile}^2$), as well as, and most significantly, the three major effluent discharges regulated under the ORNL NPDES permit [the Sewage Treatment Plant ($Q_{\text{avg}} = 0.36 \text{ cfs}$), the Coal Yard Runoff Treatment Facility ($Q_{\text{avg}} = 0.045 \text{ cfs}$), and the Nonradiological Wastewater Treatment Facility ($Q_{\text{avg}} = 0.69 \text{ cfs}$)]. These values are taken from the NPDES permit renewal application.

Figure 25 shows monthly mean discharge at WOC station GS5 compared to discharge at station GS6 which is outside the east gate of the main plant and upstream of most plant activities and effluents. The difference in flow between these stations includes the runoff from the contributing drainage area between the stations ($\sim 0.8 \text{ mile}^2$). This area drains Fifth Creek as well as a number of minor effluent discharges from ORNL facilities, including Category I and II outfalls, cooling water discharges, and miscellaneous source discharges. This difference (GS5-GS6) is also consistently above 2 cfs.

Flow in Melton Branch was augmented by effluent discharges of about 0.25 cfs from the High Flux Isotope Reactor (HFIR) and about 0.08 cfs from the Transuranium Processing Facility (TRU) until November 1986, when HFIR was shut down and discharges were substantially reduced. The reactor began operating again in January 1990 and reached full power in May 1990. However, in February 1990, the Non-Radiological Wastewater Treatment Facility (NRWTF) went on-line to treat dilute ORNL process waste streams. This facility now receives the waste effluents from both the TRU (X08) and HFIR (X09) facilities, which were previously routed to temporary holding ponds 7908 and 7909 (TRU) and 7905 (HFIR) before being released to MB. Currently, MB receives blowdown from HFIR, an unidentified process water discharge coming from the headwaters region of the HRE tributary (see Borders, et al. 1991 for explanation), and rainfall runoff.

Fig. 24. Comparison of monthly mean discharge at USGS monitoring stations GS1, GS3, GS4, and GS5

Fig. 25. Comparison of monthly mean discharge at USGS monitoring stations GS5 and GS6

2.2.3 Surface Water Quality

As part of the NPDES program, ESP monitors surface water quality for both radiological and chemical constituents at a number of sites in the WOC flow system. Additional water quality data have been collected at selected sites as part of the BMAP activities and other RAP studies. These instream sites are shown in Fig. 26.

Summaries of chemical and radiological data for instream monitoring sites appear in the previous ESP quarterly environmental data reports and also in the annual environmental reports for the ORR (Energy Systems 1990, 1992). Table 12 shows selected physical and chemical parameters routinely monitored at the primary NPDES/ESP instream sites (among others) for the current reporting period. Sampling sites for selected physical and chemical parameters are shown in Figs. 27-30.

Monthly discharge of selected radionuclides at the primary ESP in-stream sites is calculated from flow and concentration values and presented in the quarterly environmental data reports. Figures 31-34 show the discharge of ^{137}Cs , ^{60}Co , ^3H , and total radiological Sr at WOC (X14), MB (X13), and WOD (X15) for the 15-month reporting period (October 1990–December 1991). The data in Fig. 32 indicate that the discharge of ^{60}Co at MB (X13) exceeded that at WOD (X15) during December 1990 and November 1991. The data in Fig. 33 show inconsistency during some months. The discharge of tritium (^3H) at the basin outlet (X15) is shown as being significantly less than that of an upstream tributary (MB) in February and November of 1991. In addition, monthly totals of ^3H and total strontium at WOD are less than the sum of WOC (X14) and MB (X13), again most notably for February and November of 1991. These results suggest a possible problem with the procedure used for compositing flow-proportional samples from high, medium, and low ranges of flow rates. However, results also suggest an improvement in accuracy since the reporting period of May 1987 through April 1988.

Submerged flow conditions have been documented at the MB monitoring station during high-flow events. Channel constriction downstream of the flow structure causes a backwater effect resulting in higher water levels during these events. Since the instruments were designed and calibrated for free-flow (unobstructed) conditions, flow rates are actually lower than recorded water surface levels would indicate when submergence occurs. Therefore, since the volume of water is overestimated, the total mass of constituents (such as tritium) is also overestimated. The storms of December 22-23, 1990, February 17-20, 1991, and December 1-3, 1991 produced the highest flow rates of the current reporting period, thereby introducing the greatest error in measurement totals for these 3 months. Steps are now being taken to resolve this matter.

Raccoon Creek receives surface runoff and, presumably, groundwater recharge from the western portion of SWSA 3. All other drainage from SWSA 3 is east toward the WOC watershed. The Raccoon Creek monitoring station was built to complete the Stream Sampling Network necessary to determine the extent of radionuclide migration from ORNL's SWSAs; however, composite sampling is not conducted at this site. ESD's Surface Water Hydrology Group collects discharge data at this site, and some evidence of contaminants has been detected in ESP's water quality grab samples collected there.

Fig. 26. Surface-water quality monitoring or sampling sites in WOC and its tributaries

Table 12. Availability of Whiteoak Creek watershed environmental monitoring data from the Environmental Surveillance and Protection Section, Information Integration and Analysis Group
Water Year 1991 (October 1, 1990—September 30, 1991)

LOCATION ¹	FLOW	GENERAL INDICATORS	INORGANICS	ORGANICS	RADIONUCLIDES	CONTACT
¹ WOC headwaters—surface water	Totalizer-weekly	pH, oil & grease, total dissolved solids, specific conductance, dissolved oxygen, total organic carbon, temperature, turbidity, total suspended solids-monthly grab sample	ICP metals and selected AA metals, anions — monthly grab sample		Gross alpha, gross beta, gamma scan — on monthly flow; proportional composite	D. A. Wolf - for rads P. Y. Goldberg - otherwise
² Various locations in WOC watershed - surface water, sediments				total PCBs - quarterly surface water grab sample; total PCBs, total organic carbon - semiannual sediment grab sample		B. M. Horwedel
³ Various locations in WOC watershed - surface water, sediments			Mercury - semiannual surface water grab sample; semiannual sediment grab sample			B. M. Horwedel

Table 12 (continued)

LOCATION ¹	FLOW	GENERAL INDICATORS	INORGANICS	ORGANICS	RADIONUCLIDES	CONTACT
¹ Sewage Treatment Plant (X01) - surface water	Totalizer - daily	See Table 4.45 from Vol. 2, 1991 annual report for sampling and analysis frequencies		for sampling and analysis	gamma scan, gross beta, total radioactive strontium - analysis of monthly composite of weekly flow proportional samples	D. A. Wolf - for rads P. Y. Goldberg - otherwise
² Coalyard Runoff Treatment Facility (X02) - surface water	Totalizer - daily	See Table 4.46 from Vol. 2, 1991 annual report for sampling and analysis frequencies		for sampling and analysis		P. Y. Goldberg
³ Sewage Treatment Plant (X01), Coalyard Runoff Treatment facility (X02), Melton Branch (X13), Nonradiological Wastewater Treatment Facility (X12), and Whiteoak Creek (X14) - surface water	Toxicity tests using fathead minnows and <i>Ceriodaphnia</i> . See the description pertaining to Tables 4.67 and 4.68 of Vol. 2, 1991 annual report appearing in Section 4.4.2 of Vol. 1					A. J. Stewart
⁴ Nonradiological Wastewater Treatment Facility (X12) - surface water	Totalizer - daily	See Table 4.47 from Vol. 2, 1991 annual report for sampling and analysis frequencies		for sampling and analysis	³ H, gamma scan, gross alpha, gross beta, total radioactive strontium - analysis of monthly composite of weekly flow proportional samples	D. A. Wolf - for rads P. Y. Goldberg - otherwise
⁵ Various other effluent points into WOC or its tributaries (including storm drains, parking lot drains, storage area drains, once-through condensate, process and lab drains, steam plant and cooling tower blowdown)	See Tables 4.57-4.61 in Vol. 2, 1991 annual report for sampling and analysis frequencies			for sampling and analysis	Gross beta on category 2 outfalls - quarterly analysis of grab sample	P. Y. Goldberg
⁶ Melton Branch 1 (X13) and WOC (X14) - surface water	Totalizer - daily	See Tables 4.34 and 4.35 in Vol. 2, 1991 annual report for sampling and analysis frequencies		for sampling and analysis	³ H, gamma scan, and total radioactive strontium - analysis of a monthly composite of weekly flow-proportional samples	D. A. Wolf - for rads P. Y. Goldberg - otherwise

Table 12 (continued)

LOCATION ¹	FLOW	GENERAL INDICATORS	INORGANICS	ORGANICS	RADIONUCLIDES	CONTACT
^a 7500 Bridge, Melton Branch 2 and Northwest Tributary - surface water	Totalizer - weekly				7500 Bridge, Melton Branch 2: ³ H, gamma scan, and total radioactive strontium Northwest Tributary: gamma scan, total radioactive strontium - analysis of monthly composite of weekly flow-proportional samples	D. A. Wolf
^a First Creek, Fifth Creek, and Raccoon Creek	Creek level - weekly				Gamma scan, total radioactive strontium - analysis of monthly composite of weekly grab samples	D. A. Wolf
^a Whiteoak Dam - surface water	Totalizer - daily	See Table 4.36 in Vol. 2, 1991 annual report for sampling and analysis frequencies			Gamma scan, gross alpha, gross beta - analysis of weekly flow-proportional samples; ³ H, total radioactive strontium - analysis of monthly composite of weekly flow-proportional samples	D. A. Wolf - for rads P. Y. Goldberg - otherwise

Table 12 (continued)

LOCATION ¹	FLOW	GENERAL INDICATORS	INORGANICS	ORGANICS	RADIONUCLIDES	CONTACT
WAG 1 - groundwater	Not applicable	pH, specific conductance, temperature, dissolved oxygen, redox, turbidity, alkalinity, total organic halides, total organic carbon, total suspended solids, total dissolved solids - semiannually	ICP metals, selected AA metals, TKN, anions, total cyanide, total sulfide	volatiles, BNAEs, PCBs and pesticides/herbicides	Gamma scan, ³ H, gross alpha, gross beta, total radioactive strontium Isotopic alpha (²⁴¹ Am, ²⁴⁴ Cm, ²³⁹ Pu, ²³⁵ Pu, ²³² Th, ²³⁰ Th, ²³³ Th, ²³⁴ U, ²³⁵ U, and ²³⁸ U) - when gross alpha exceeds 0.5 Bq/L	R. S. Loffman
WAG 2 - groundwater	Not applicable	pH, specific conductance, temperature, dissolved oxygen, redox, turbidity, alkalinity, total organic halides, total organic carbon, total suspended solids, total dissolved solids - annually	ICP metals, selected AA, ICP/MS metals, anions	Volatiles and BNAEs	Gamma scan, ³ H, total radioactive strontium, gross alpha, gross beta	D. A. Wolf

Table 12 (continued)

LOCATION ¹	FLOW	GENERAL INDICATORS	INORGANICS	ORGANICS	RADIONUCLIDES	CONTACT
WAGs 3, 4, 5, 7, 8, 9, 11 and 17 - groundwater	Not applicable	pH, specific conductance, temperature, dissolved oxygen, redox, turbidity - 10 wells, quarterly, 16 wells semiannually alkalinity - 10 wells quarterly total organic halides, total organic carbon - 16 wells semiannually	ICP metals, selected AA and ICP/MS metals, anions, total phenolics, total sulfide	Volatiles and BNAEs	Gamma scan, ³ H, total radioactive strontium, gross alpha, gross beta	D. A. Wolf - for WAGs 5, 7 R. S. Loffman - otherwise
SWSA 6 -groundwater	Not applicable			Volatiles - 10 wells quarterly	Gamma scan, ³ H, total radioactive strontium and gross alpha - 10 wells quarterly ³ H, gross beta, and gross alpha - semiannually	D. A. Wolf

¹Station(s) or groups of stations are preceded by a character denoting the station type: B=Background reference station, E=Effluent discharge point(s), A=Ambient water station along WOC or one of its tributaries.

ORNL-DWG 92M-6985

Fig. 27. ORNL surface water and reference sampling locations

Fig. 28. Map of ESP water sampling stations for mercury in the ORNL Melton Valley complex

ORNL DWG 89M 6126R2

Fig. 29. Map of ESP water sampling stations for mercury in the ORNL area

Fig. 30. ESP sample locations for PCB and TOC (sediment only) analyses in the ORNL area

Cesium-137

Fig. 31. Monthly discharge of ^{137}Cs at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990—December 1991

Fig. 32. Monthly discharge of ^{60}Co at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991

Fig. 33. Monthly discharge of ^3H at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991

ORNL DWG 92M-2085

Fig. 34. Monthly discharge of total Sr at ESP monitoring stations X13 (MS4), X14 (MS3), and X15 (MS5) for the period October 1990–December 1991

2.2.4 Contaminants in Sediments

Studies of WOC streambed gravels as indicators of the degree and location of sources of radiological contaminants (Cerling and Spalding 1981; Cerling 1985) were continued during 1986–1987 (Sobocinski et al. 1990). These reports documented the results of studies of new sources of ^{90}Sr and ^{137}Cs in First Creek and upper WOC behind the ORNL main plant. Reports have also been completed on current studies to quantify radionuclide flux at selected sites based on radionuclide and metal concentrations on gravels and the associated streamflow, and to determine the mechanisms and rates of radionuclide and metal sorption and desorption on streambed gravels.

An aerial radiological survey was conducted during September and October of 1986 to provide detailed information on the nature and location of radiological contaminants in floodplain sediments. The study report by EG&G Energy Measurements (Fritzsche 1987) describes the survey methodology and shows detailed contours of total terrestrial gamma exposure rates and activities of ^{137}Cs , ^{60}Co , and ^{208}Th . The four isopleth maps, on aerial photographs of the floodplain, are reproduced here as Figs. 35–38. In 1989, a gamma survey of the ORNL facilities was conducted using a helicopter flying at an altitude of 300 ft. A comprehensive survey of the Oak Ridge Reservation was conducted in April 1992. A gamma survey was conducted by helicopter at an altitude of 250 ft. In addition to the gamma survey, multispectral (MSS) imagery was taken at night from an altitude of 4000 ft to search for seeps. MSS and color infrared (IR) were collected during the daytime at 3000 ft. Other flights flown at 6000 ft collected MSS during the daytime and specific color photographs at various locations at varying heights for different facilities. A high-altitude (43,000 ft) flight was made to survey the entire ORR. These data are being analyzed and will be available in the OREIS data base.

In August 1989, ESP extensively sampled sediment at the monitoring stations on WOC (MS3) and MB (MS4). Multiple sediment samples were collected from the stilling pools upstream from the weirs at MS3 and MS4 and from sediments downstream from the weir at MS4. Samples were analyzed for radionuclides, metals, and PCBs, partly to characterize the contaminated sediments as a waste for ultimate removal and disposal at a later time. Results of these analyses can be obtained from ESP's Information Integration and Analysis Group.

As part of the Clinch River RFI, sediment sampling was conducted in the WOCE in the summer of 1990. Results of initial core sampling near the mouth of the embayment revealed elevated activities of ^{137}Cs for surface sediments. This finding prompted additional surface sediment and core sampling in the embayment. Subsequent sediment samples were analyzed for a wide range of contaminants including radionuclides, metals, and organics.

2.2.5 Outfalls to the White Oak Creek Flow System

Water is supplied to the ORNL plant site from the DOE water treatment plant at an average rate of approximately 4.0 million gallons per day (mgd); (6.19 cfs). This water is then distributed to ORNL facilities through two separate systems, potable and process. Of the total amount of imported water, approximately 38% is lost to the atmosphere as evaporation. The remaining 62% (approximately 3.84 cfs) is subsequently discharged to the WOC surface-

Fig. 35. Terrestrial gamma exposure rates derived from the September–October 1986 survey of the White Oak Creek floodplain

Fig. 36. Gamma energy spectra locations derived from the September–October 1986 survey of the White Oak Creek floodplain

Fig. 37. Cesium-137 photopeak count rate isopleths derived from the September—October survey of the White Oak Creek floodplain

Fig. 38. Cobalt-60 photopeak count rate isopleths derived from the September-October 1986 survey of the White Oak Creek floodplain

water system (Kasten 1986). According to Loar et al. (1991), approximately 30% and 36% of the estimated total effluent volume to the WOC system are contributed by the cooling and process systems, respectively. Discharges from the STP, the steam plant, and leakage account for the remainder in approximately equal proportions (Kasten 1986).

Under the requirements of the Clean Air Act, NPDES Permit No. TN0002941 was issued on April 1, 1986, to ORNL to monitor point sources at their point of discharge into receiving streams. In September 1990, ORNL applied for renewal of the NPDES permit, which expired March 31, 1991. ORNL's NPDES permit application is described in Sect. 1.4.2. Point Source Outfalls are discernible, confined, and discrete conveyances from which a process stream is discharged to receiving waters. The effluent must be monitored before it reaches the receiving water or mixes with any other wastewater stream. The original permit identified at least 176 outfalls.

Ten major effluent discharges (Point Source Outfalls) were regulated under the original permit and accounted for approximately 83% of the water discharged to the WOC system. One additional Point Source Outfall described under the permit was the planned NRWTF, NPDES outfall No. X12. This facility went into service in February 1990. The facility was built to collect, transfer, store, and treat the laboratory's nonradiological wastewaters according to nationally specified criteria. The NRWTF (X12) has combined the treatment of effluents from, and replaced, the following eight outfalls: the 1500 Area (X03), 2000 Area (X04), 190 ponds (X06), Process Waste Treatment Plant (X07), TRU ponds (X08), HFIR ponds (X09), ORR Resin Regeneration Facility (X10), and Acid Neutralization Facility (X11). Therefore, now only three major, treated effluent discharges enter WOC: the STP (X01), the Coal Yard Runoff Treatment Facility (CYRTF) (X02), and the NRWTF (X12) (Table 13).

Table 13. Major treated effluent discharges to White Oak Creek from ORNL

NPDES OUTFALL NO.	EFFLUENT SOURCE	AVERAGE DISCHARGE
X01	Sewage Treatment Plant	0.34 cfs ^a
X02	Coal Yard Runoff Treatment Facility	0.048 cfs ^b
X12	Nonradiological Wastewater Treatment Facility	0.62 cfs ^c
	TOTAL	1.008 cfs

^aThe maximum flow rate is 1.16 cfs.

^bThe maximum flow rate is 0.34 cfs.

^cEstimated.

Additional outfalls to the WOC system are divided into four categories (Category I, Category II, Cooling Water, and Miscellaneous Source Discharges) according to effluent limitations and monitoring requirements.

Outfalls that discharge uncontaminated stormwater runoff are designated as Category I outfalls. Each Category I outfall is identified by a 100 series number or a 300 series number, indicating a Category III outfall that has been reassigned as Category I.

Category II outfalls discharge water from roof drains, parking lot runoff, storage area drains, spill-area drains, once-through cooling water, cooling tower blowdown, and condensate. Numerous Category II outfalls receive contributions from several of these sources. Each Category II outfall is identified by a 200 series number or a 300 series number, indicating a Category III outfall that has been reassigned as Category II.

The ORNL Space Cooling System consists of major and minor cooling towers and numerous once-through, noncontact cooling systems. The total cooling water discharge to WOC is estimated to be approximately 1.65 mgd (2.55 cfs). These discharge flows are made up primarily of cooling tower blowdown and once-through cooling water.

ORNL has 9 major and 18 minor cooling towers for removing heat from facility cooling waters. Each major cooling tower discharges more than 10,000 gpd of blowdown while each minor cooling tower discharges less than 10,000 gpd. In addition, major cooling towers may have occasional high concentrations of chlorine, copper, and/or zinc, whereas the discharge from minor cooling towers is not expected to appreciably lower water quality. The total discharge from all cooling towers is about 0.25 mgd (0.39 cfs).

Discharge from the once-through, noncontact cooling water systems amounts to about 1.4 mgd (2.17 cfs). All ORNL once-through cooling water is supplied by the DOE Water Filtration Plant and is therefore chlorinated. ORNL has a policy that all new sources of once-through cooling water will be dechlorinated prior to being discharged. Initially, these dechlorination systems will be installed on a few outfalls to test the system for further development and refinement. Dechlorination systems will eventually be installed on all applicable outfalls.

3. DATA PROCESSING AND AVAILABILITY

3.1 DATA PROCESSING

3.1.1 Stream Discharge Data

Stream stage data at flumes and weirs are measured and recorded by one of two monitoring systems. Some sites are equipped with electronic data loggers and submerged pressure transducers that record data on electronic data storage packs, and some are equipped with mechanical float and pulley recorders that record data by punching paper tapes. After the paper punch tapes are translated and the data storage packs are read, the data processing for both methods is the same.

Computer files of raw, unaltered stage data are archived. The data are then reduced by removing redundancies. This reduction is done by producing files of breakpoint data with a program called EZ-BRK3 (Craig and Demaree 1992a) written for ESD by Environmental Consulting Engineers (ECE). At this stage of processing, the stage data are corrected for recorder drift according to visual inspections of staff gage readings. The stage data are then processed to produce reports of discharge data with the REPORTER program, also developed by ECE. Hydrographs of the data are produced and compared with field notes to find inaccuracies such as those caused by debris clogging flow-measuring structures, faulty equipment, and submergence. Data are corrected when possible and if the data cannot be corrected, they are removed from the record. Estimates, by hydrograph comparison and precipitation records comparison, are then made using data from stations in the immediate vicinity. For the MS4 site on Melton Branch, all high-flow data are adjusted to account for submergence effects.

3.1.2 Precipitation Data

Rain gage charts are collected weekly from nine rain gage sites equipped with Belfort Universal Recording Rain Gages. These charts are digitized to produce raw breakpoint data using RNF-DIG, a program developed by ECE (Craig and Demaree 1992b). The breakpoint data are then converted into monthly reports of daily rainfall totals using PFREQ, also developed by ECE (Wilson 1992). The PFREQ program also has the ability to produce reports in the Terrestrial Ecology and Hydrology Model (TEHM) format.

Rainfall data for a site are validated by comparing the PFREQ-generated, daily rainfall totals for a site to the site's original rain gage charts. Comparison of data from site to site is also done as an additional check. Original rain gage charts are archived, and hardcopies of monthly reports of daily totals are retained. Computer files of the monthly reports and the breakpoint data used to create the reports are maintained by the ESD Surface Water Hydrology Group.

3.1.3 Software Systems

In addition to the software packages described in the previous section that are used to process the streamflow and meteorological data collected by the ESD Surface Water Hydrology Group, the data may also be processed into LOTUS 1-2-3 or Statistical Analysis System (SAS) files. The data, for the most part, are processed on a PC system. Data are stored on Bernoulli cartridges, floppy, and hard disks. Copies of the files are maintained with each notebook containing reports (listings) of the data. Copies are maintained in separate locations to protect the disks from possible damage. Descriptions of the data backup and security procedures used in the ESD Surface Water Hydrology Group are contained in the "Surface Water Flow and Quality Measuring Sites and Surface Water Data Processing and Interpretation" plan currently under review.

3.2 DATA AVAILABILITY

3.2.1 Environmental Sciences Division

For several years, ESD's Surface Water Hydrology Group has collected and processed discharge data at a number of stations in the WOC watershed and vicinity for modeling studies, independent research, and remedial action activities. Discharge data are available in raw-stage data format, hourly or daily discharge, and in hardcopy or computer formats. The ESD surface-water monitoring stations, for which data are available, are described in this report. Figures 39-41 show continuous daily discharge at the WOC stations MS3, MS4, and MS5 for the 27-month period October 1989-December 1991. At two sites, MS1 on the tributary to WOC draining WAG 4 and GS17 on Center Seven Creek, only raw-stage data are collected and archived. These data are not currently being processed to produce a discharge record.

Nine precipitation gages in the WOC watershed and vicinity are operated by ESD's Surface Water Hydrology Group. Strip charts are collected weekly at each site and processed into monthly records of daily precipitation totals. Improved digitizing software is being developed to make available finer resolution (i.e., hourly data). In addition, daily precipitation data collected at the Oak Ridge NOAA/ATDD station are available from the ESD Surface Water Hydrology Group. Figures 42-43 show continuous daily precipitation data at the ETF site in the WOC watershed and at the NOAA/ATDD site in Oak Ridge for the same 27-month period.

In addition to surface-water discharge and precipitation data, ESD's Surface Water Hydrology Group collects meteorological data. Wind speed and direction, temperature, pan evaporation, solar radiation, and humidity data are available from a number of sites. However, the period of record varies from station to station, and some records are discontinuous.

ORNL DWG 92M-8578

Fig. 39. Daily discharge at the White Oak Creek (MS3) monitoring station for the 27-month period October 1989—December 1991

Fig. 40. Daily discharge at the Melton Branch (MS4) monitoring station for the 27-month period October 1989—December 1991

Fig. 41. Daily discharge at the White Oak Dam (MS5) monitoring station for the 27-month period October 1989—December 1991

ORNL DWG 92M-2089

ETF Raingage

Fig. 42. Daily precipitation at the ETF rain gage for the 27-month period
October 1989—December 1991

NOAA/ATDD Raingage Oak Ridge, TN

Fig. 43. Daily precipitation at the NOAA/ATDD rain gage in Oak Ridge for the 27-month period
October 1989—December 1991

3.2.2 U. S. Department of the Interior, Geological Survey

Surface-water discharge and precipitation data are available from the USGS for a number of stations on the WOC watershed and the Oak Ridge Reservation. In addition, data on water quality, sediment, groundwater level, groundwater quality, and chemical quality of precipitation are available from the USGS for stations in Tennessee and are published in annual 'Water Resources Data Reports for the Water Year' (USGS 1992).

All USGS surface-water discharge data published in this report, and data on precipitation from the 7500 Bridge station, are available by remote access to the USGS computer system based in Nashville, Tennessee. Data are available in unit values (5 min to hourly) at selected stations and daily values for all stations. Rating tables (Tables D.14–D.22, Appendix D), and the data collected for the development of them, are available for most surface-water monitoring stations in the system. In addition, near-realtime discharge data are available from the 7500 Bridge monitoring station (GS3, USGS 03536550) connected to the USGS computer system by satellite telemetry via data collection platforms (DCPs). The 7500 Bridge (GS3) station is the only such station in the WOC watershed on a DCP, thereby providing near-realtime data (15-min delay) under high-flow conditions. The 7500 Bridge monitoring station also has a precipitation gage connected to the DCP with the capability to provide near-realtime rainfall data at 15-min intervals. However, these precipitation data are not reported here because the precipitation gage is uncalibrated and therefore unreliable (See Sect. 5.2). This precipitation gage will be evaluated in FY 1992 for calibration or replacement.

The ESD Surface Water Hydrology Group recently requested from the USGS subdistrict office in Knoxville, Tennessee, unit data for all area (WOC vicinity) surface-water monitoring stations. These data have been obtained for all stations in electronic ASCII format since approximately 1987. While most data from stations in the WOC watershed and vicinity were not available in unit values on the USGS computer system prior to January 1991, unit value data for all ORNL/WOC sites are now accessible to researchers on the USGS computer system.

3.2.3 Environmental Surveillance and Protection Section

The two primary monitoring activities of the ESP are effluent monitoring and environmental surveillance. Those activities that bear directly on the WOC watershed are summarized in Table 12 (Sect. 2.2.2). Also, Fig. 27–30 identify the sampling locations of these data. This information reflects the general activities of the ESP for the 12-month reporting period for their environmental reports (Kornegay 1991).

In addition, hourly discharge data are available from the ambient water monitoring stations on WOC, MB, and WOD. These data are available in near-realtime from the ESP Data Acquisition System (DAS) located on ESP's dedicated VAX 11/750 digital computer system.

3.2.4 Oak Ridge Environmental Information System

Many ORNL programs collect and report hydrologic data for a number of reasons. The ORNL ERP data base (RAP/DIMS; Consolidated Data Base; and now OREIS) is the

repository of all data and information generated by activities related to the ERP. The Bibliographic Data Base is a repository for all published reports produced for the program and for any other pertinent publications. The Records Control Data Base indexes unpublished information (e.g., project plans and field notebooks) generated by the program. The Numeric Data Base is a central repository for technical data generated in the ERP and data from other studies of interest.

The OREIS data base and its contents have been documented in several annual reports (Voorhees et al. 1988, Voorhees et al. 1989, Hook et al. 1990). For information on the OREIS data base and availability of information from the data base, contact:

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ORNL E-mail ID: LDV

4. QUALITY ASSURANCE/QUALITY CONTROL

Quality assurance/quality control (QA/QC) for data collection and data processing in the Environmental Sciences Division's Hydrologic Data Center is governed by a QA plan (Clapp and Borders 1992) developed to comply with the ORNL Quality Assurance Manual. In addition, a QA/QC plan for the WAG 2 RI Plan (1990) and the ERP QA/QC Plan also apply to data collected in the surface-water monitoring project. QC is achieved through several steps. Procedures and guidelines have been developed covering data collection and data processing from the point of data origination in the field to final report preparation. Data verification are mentioned in the data processing section of this report.

Following the lead of the ORNL Office of Environmental and Health Protection, the ESD Surface Water Hydrology Group is initiating a data quality hierarchy along the line of that used for field sampling and laboratory analyses data quality objectives. This hierarchy is summarized in Table 14.

Table 14. Data product hierarchy for the ESD Surface Water Hydrology Group surface-water monitoring program*

LEVEL	DESCRIPTION
0	Unmodified data printout and/or electronic file that includes all variables in the order collected at monitoring stations.
1	Data printout and/or electronic file including only the variables of interest to the user, sorted to the user's specifications, including a description of variable formats and locations for ASCII files. The data are rounded to the appropriate number of significant digits.
2	Data summaries such as maximum, minimum, and mean tables, frequency distributions, data plots. The report quality consists of unaltered REPORTER, LOTUS 1-2-3, or Statistical Analysis System (SAS) procedures output as formatted by the default output option. These summaries can be in hard copy and/or electronic format.
3	Presentations of spatial or temporal relationships among the data or comparisons to regulatory criteria. Regulatory criteria are specified by the user. Report quality consists of data presentations with header and footer information requested by the user. Information can be provided as electronic files or laser printer hard copy.
4	Graphic or tabular data presentation suitable for publication or presentation.

*Adapted from tables in memo dated May 31, 1991, from Mark F. Tardiff, Group Leader, Information Integration and Analysis Group, Office of Environmental and Health Protection, Oak Ridge National Laboratory.

5. SUMMARY AND RECOMMENDATIONS

The collection and reporting of quality hydrologic data are essential to fulfilling the goals of the ERP monitoring program to support a mass-balance approach to determining sources and sinks of contaminants in the WOC system. This process includes defining and quantifying the input of wastes from ORNL WAGs and assessing the output of contaminants from the WOC system, because surface water is the primary pathway for the release of contaminants from the WOC system to off-site areas. The data are also used for the engineering design of remedial measures, evaluation of the effectiveness of past remediation measures, and prediction of remediation performance into the future.

5.1 PROGRESS DURING THE PAST YEAR

During the first quarter (January–March) of 1992, the Site Investigation (SI) Program, which incorporates hydrologic monitoring for the ERP, merged with the WAG 2 RI Program. This allows surface-water monitoring to serve the broader interests of the ERP and to derive the benefits from other sampling programs, particularly the seep and tributary sampling initiative, the sediment sampling and sediment transport modeling tasks, and several groundwater investigations. There has been an immediate use of the monitoring data in the sediment sampling/modeling task, and quality and coverage of the hydrologic modeling have been enhanced in response to needs identified in this task.

During the past year there has been a vast increase in the emphasis on the QA of hydrologic data leading to the generation of better data products. The Surface Water Monitoring Program QA Plan was completed, procedures were developed and implemented, and corrective actions resulting from an ORNL audit of the project in October 1991 were completed successfully.

5.2 RECOMMENDED IMPROVEMENTS

5.2.1 Issues within the ERP Hydrologic Monitoring Activity

Several activities should be initiated to improve the quality and the appropriateness of the data generated for ERP functions. The activities listed below can be accomplished by ESD's Surface Water Monitoring staff in concert with other ERP groups.

- New emphasis on quick turnaround and dissemination of hydrologic data. Now that QA objectives have been achieved, it is reasonable to strive to issue brief data reports each quarter. The goal is to meet this schedule in FY 1993.
- Integration of data into a Geographical Information System (GIS). Surface-water data need to be added to the same systems currently used for analyzing and reporting groundwater data.

- New emphasis on flow and water quality in the WOC tributaries. Tributary characterization is specified to commence in FY 1993 in the WAG 2 S&A plan.

Baseflow and stormwater sampling following the protocols used by Solomon et al. (1991) and currently in use in the WAG 6 ICM environmental monitoring program will be extended to two or perhaps four tributaries. Selection of tributaries for sampling will be based on an initial water quality survey to be implemented in early FY 1993.

New, small, flow-control devices must be installed on contaminated tributaries; others must be reactivated. Candidate sites include T2A at WAG 4, the HRT site below WAG 5, and unnamed tributaries below WAG 7 and to the east of WAG 8.

- A denser rain gage network to track summer thunder showers. Experience in recent months has shown that localized storms can cause significant movement of sediments. Use of spare tipping bucket gages and simple wedge-type gages should suffice. Relocation of one of the WAG 6 gages to WOC headwaters area will give wider coverage.
- Finer resolution of precipitation data for hydrologic modeling. The only rain gage in the WOC watershed that currently has the capability for finer resolution of data (<1 h) is the USGS 7500 Bridge rain gage. However, data from this gage are unreliable because the gage is uncalibrated. It is recommended that this rain gage be calibrated and maintained to provide accurate unit value (15-minute) data. In addition, this station is linked to the USGS satellite telemetry system, making these precipitation data available on a near-realtime basis. This capability can be provided by the USGS at a nominal annual cost.
- Reconstitute the Ad Hoc committee. This working group of ESD and ESP staff, formed in 1990 to evaluate the upgrades to surface-water monitoring on small tributaries at ORNL, has successfully evaluated design alternatives and made recommendations for one site. However, the evaluation process for upgrades to several other sites has not been duplicated. Moreover, the complex issues listed in Sect. 5.2.2 have not been addressed.

5.2.2 Issues for Upper Level Management Approval

This section describes improvements that will probably require decisions and assistance by upper level management within the ERP and ORNL if project goals are to be fully accomplished.

- Resolution of sedimentation problems at flow monitoring sites. Sediments, which are contaminated at most sites in the WOC flow system, have filled the stilling pools upstream from weirs and are adversely affecting the accuracy of discharge measurements in several ways:
 1. increased velocities of approach alter stage-discharge relationships;
 2. stilling wells become plugged, causing erroneous stage data; and

3. accumulated sediments foster the growth of aquatic vegetation, which obstructs weir plates and flumes and clogs sample intake lines.

Regulatory guidance on manual methods and engineered structures (e.g., installation of plugs in control structures for passing sediment downstream) is needed on issues pertaining to sediment removal and disposal, and on mitigation issues. Some progress has been made through the process of NEPA documentation, but the process has been slow. This effort is being coordinated with ESD hydrologists, ESP, ORNL Engineering, and Project Engineering staff. ESP has taken a lead position on this task. Alternatives are being evaluated for removal and disposal or storage of sediments. In addition, more sediment samples will be taken from the floodplain near the WOC (MS3) and MB (MS4) weirs to determine the suitability of moving sediments to low areas in close proximity to the weirs.

- Resolution of tailwater problems at MB (MS4) weir. Discharge data collected from station MS4 on Melton Branch have been shown to be grossly in error during high-flow conditions because of submergence of the broad-crested weir. A number of measures have been employed or proposed to improve data accuracy, but they have not actually corrected the problem. An extended rating, which was developed theoretically using the upstream control above its intended range, has been used by ESD to improve the accuracy of high-flow data. This extended rating will be field-verified and adjusted accordingly by the USGS during FY 1992 and FY 1993. However, the monitoring station should be redesigned to establish a permanent hydraulic control at the upstream location (current low-flow location). An alternative is to remove a section of the concrete trunk line downstream that crosses the channel and improve channel capacity enough to keep the upstream control from submerging.

The trunk line acts as a limiting tailwater control that establishes a maximum degree of improvement to existing submergence conditions at the upstream monitoring station (MS4) that could be achieved without removing the trunk line. Additional modeling studies would be required to determine the magnitude of possible channel improvements on correcting submergence problems if the trunk line were removed. To ensure that MS4 would not be adversely affected by WOC, design flow conditions should be used in model studies to consider the effects of backwater from WOC.

- Reactivation of some recently discontinued surface-water monitoring sites in the upper MB vicinity. USGS monitoring at two gages (GS16, GS17) in the proposed SWSA 7 area was discontinued because of lack of funding (GS18 was discontinued in 1989). Proposed SWSA 7 will be developed with waste-handling and disposal facilities starting in FY 1993. Continuous discharge records will be essential for evaluation of the future impacts of this SWSA to the environment. USGS stations GS16 and GS17 abandoned in FY 1992 and GS18 abandoned in 1989 should be reactivated. The latter station is important because it collects some of the water from WAG 8, identified as a major source of ^{60}Co and, to a lesser extent, ^{137}Cs . It is highly recommended that a funding source (approximately \$25K/year for the three sites) be identified and that monitoring by the USGS be reimplemented at the three SWSA 7 sites. Alternatively, monitoring could be conducted by ESD's Surface Water Hydrology Group or through the ASEMP.

- Elimination of redundancy in data collection. Currently, compliance groups collect flow data at numerous sites where ERP also collects data. ERP must continue collecting data as long as the compliance data logging system and processing systems do not provide for certain site-specific adjustments such as tailwater corrections. New programmable data logging equipment developed by ESP is a significant step towards improved data suitable for ERP needs. Reaching a goal that ESP be the sole surface-water monitoring data collection group at NPDES stations will lead to significant savings in monitoring resources. This coordination should be developed under the direction and support of the upper levels of administration within ORNL. Furthermore, surface-water monitoring efforts should also be coordinated with the groundwater monitoring program (GWPP) to establish unified management of hydrologic monitoring at ORNL.

In conclusion, hydrologic data summaries will continue to be produced as part of the WAG 2/SI Program. Among other uses, the data will be incorporated into the annual ERMA report that provides a comprehensive picture of ER facilities at a watershed scale by identifying and interpreting spatial and temporal trends in contaminant movement within the WOC watershed.

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APPENDIX A

Descriptions of Waste Area Groupings (WAGs) Located in the White Oak Creek Watershed

WAG 1

Description: WAG 1 is the ORNL main plant area, which includes all of the operating research and development facilities within the main security fence at ORNL. Historically, ORNL has developed and tested various reactor concepts, developed and operated fuel reprocessing technologies, produced radioactive and stable isotopes on a large scale, and managed wastes from these activities. These activities have been focused primarily in WAG 1, although several other WAGs have also been involved. WAG 1 consists of 99 sites currently considered to be SWMUs, including radioactive waste collection pipelines and tanks, SWSAs, waste treatment facilities and impoundments, leak and spill sites, and miscellaneous waste handling and storage units. WAG 1 drains into WOC directly through storm drains and through two small tributaries, First Creek and Fifth Creek, which flow through WAG 1 approximately from north to south (ORNL grid). Conceptual modeling studies have demonstrated the potential for rapid transport of contaminants along the massive array of subsurface pipeline trenches directly to WOC and its WAG 1 tributaries.

Releases: Virtually every radionuclide, chemical, and organic compound ever used at ORNL can be found in WAG 1. And, because all drainage and treated effluents from WAG 1 ultimately discharge to WOC, the significant amount of historical release data available indicate that WAG 1 was a major source for radionuclide, heavy metal, and chemical waste releases to WOC. Analysis of the 1989 Environmental Monitoring Report for the Oak Ridge Reservation (Energy Systems 1990) suggests that WAG 1 is still the primary source of ^{60}Co , ^{137}Cs , and ^{90}Sr to the WOC/WOL system. Biological monitoring data have detected polychlorinated biphenyls (PCBs) and chlordane in the reach of WOC affected by WAG 1 (Loar 1990). Sample data also indicate measurable levels of a suite of metals including Cr, Cu, Mo, and Zn. An ongoing remedial investigation of WAG 1 is expected to yield data on groundwater contamination and release rates to WOC. Existing surface-water monitoring programs provide periodic data on continuing releases of selected radioisotopes from WAG 1. Additional monitoring data are needed, however, to determine the level of continuing releases, if any, of the entire suite of contaminants indicated in Table 3.

WAG 3

Description: WAG 3 consists of three SWMUs including SWSA 3, the closed scrap metal area, and the current operating contractors' landfill. This WAG is located in Bethel Valley about 1 km (0.6 mile) west of the west entrance to the ORNL main plant area. SWSA 3 and the closed scrap metal area are inactive landfills containing radioactive solid wastes and surplus materials generated at ORNL between 1946 and 1979. The contractors' landfill was opened in 1975 and is used to dispose of various uncontaminated construction materials and fly ash from the ORNL steam plant. WAG 3 drains into the NWT of WOC. The NWT enters WOC downstream from the main plant area and could contaminate the lower reach of WOC within WAG 1 and ultimately the lower reaches of WOC, and WOL (WAG 2), and the Clinch River.

Releases: There are no reliable records of what was disposed of in SWSA 3, because fire destroyed the records in 1961. Sketches and drawings indicate that alpha and beta-gamma wastes were buried in separate areas or trenches. Some of the alpha wastes may have been placed in drums and buried in concrete-lined trenches, and some were probably placed

in unlined trenches. Hazardous chemical wastes are also likely to have been buried in SWSA 3. Characterization data suggest that SWSA 3 has historically been a source of ^{90}Sr , and samples of surface soils and gravel in the contractors landfill area of WAG 3 revealed ^{90}Sr and ^{137}Cs with ^{60}Co at or near detection levels. Monitoring data (Energy Systems 1990) and historical studies (Stueber et al. 1981) suggest that WAG 3 contributes small quantities of ^{90}Sr and ^{137}Cs to the NWT. However, no data are available on heavy metal or organic contamination. Additional monitoring and characterization data will be required to determine whether WAG 3 is (or has been) a source of contaminants other than ^{90}Sr and ^{137}Cs .

WAG 4

Description: WAG 4, located southwest of the ORNL main plant area, consists of three SWMUs including the LLW line north of Lagoon Road, pilot pits 1 and 2, and SWSA 4. From 1954 to 1975, liquid radioactive wastes were transferred to the waste pits and trenches (WAG 7) through the LLW line north of Lagoon Road. Two known leak sites were covered with bentonite and asphalt caps in 1983. The pilot pit area (Building 7811) was constructed in late 1955 for use in pilot-scale studies of radioactive waste disposal. Currently, all that remain at the site are three large concrete cylinders embedded in the ground, a control building used to store field and laboratory equipment, and four large concrete cylinders used in a municipal waste leaching experiment. SWSA 4, which covers 9.3 ha (23 acres), was opened for routine solid waste burials from 1951 through 1959, but remained open as a disposal area for uncontaminated fill until 1973. Waste from sources outside ORNL accounts for about half of the volume of material buried in SWSA 4. WAG 4 drains to WOC directly and through an unnamed tributary on its southern boundary.

Releases: Records of the composition of radioactive solid waste disposed of in SWSA 4 during all but its last 2 years of operation were lost in a fire. In addition, over half of the waste buried in SWSA 4 came from sources outside ORNL. For these reasons, SWSA 4 must be considered a potential source for a wide range of radioisotopes including transuranics (Table 3). Characterization data have demonstrated that SWSA 4 is a major contributor of ^{90}Sr to the WOC/WOL system. Soil samples have also shown elevated levels of ^{60}Co and ^{137}Cs in SWSA 4. Stream gravel surveys have shown that SWSA 4 has been a source of these isotopes as well as of copper, nickel, and zinc to WOC. Monitoring data (Energy Systems 1990) suggest that SWSA 4 is a major source of ^{90}Sr to the WOC/WOL system and is the largest contributor of ^3H to the reach of WOC above Melton Branch. No data are available on continuing elemental or organic contamination from WAG 4. Additional data will be required to determine whether and to what extent WAG 4 is a continuing source of heavy metals and organics.

WAG 5

Description: WAG 5 is approximately 2 km (1.2 miles) south of the main plant area in Melton Valley between WOC and MB, upgradient from their confluence. This WAG consists of 22 SWMUs in SWSA 5 and SWSA 5 North (Transuranium Waste Storage Area), including two line leak sites, an old landfill, the Bldg. 7835 process waste sludge basin, and the surface facilities constructed to support both Old and New Hydrofracture facilities (including several LLW storage tanks and two impoundments). Melton Branch separates the New Hydrofracture Facility (NHF) from the remainder of WAG 5. SWSA 5, which covers 32.3 ha

(80 acres), received radioactive wastes from 1959 through 1973. The area known as SWSA 5 North, which covers 4 ha (10 acres), has been used for "retrievable storage" of transuranic wastes since 1970. WAG 5 drains into WOC directly, into two unnamed tributaries to WOC, into MB, and into an unnamed tributary to MB.

Releases: Approximately 200,000 Ci of LLW and TRU wastes are buried at SWSA 5. In addition, more than 62,000 Ci of TRU waste is retrievably stored in SWSA 5 North, much of it buried in concrete casks (Stewart et al. 1989). Eight 190,000 L stainless steel tanks at the NHF site hold concentrate from the LLW evaporator. The Old Hydrofracture Facility (OHF) pond contains contaminated water and sediments with almost 500 Ci of activity. The predominant isotopes in all the LLW facilities are ^{60}Co , ^{90}Sr , and ^{137}Cs . TRU wastes are primarily ^{244}Cm , with lesser amounts of several other isotopes. Some lead and mercury were also buried with the TRU wastes (Stewart et al. 1989). At least two separate studies have identified radioactively contaminated groundwater around WAG 5 (Ashwood et al. 1990b, Wickliff et al. 1990). Groundwater near the OHF pond is contaminated with ^3H and ^{90}Sr . Six wells and one seep around SWSA 5 were contaminated with ^{90}Sr , ^{137}Cs , and RCRA-regulated hazardous wastes (e.g., lead). Wells along the southern perimeter of SWSA 5 contained measurable levels of ^{90}Sr . One well in SWSA 5 North contained ^{244}Cm and ^{241}Am , and another had elevated levels of ^3H . Stream gravel surveys suggest that SWSA 5 has been a source of ^{90}Sr , chromium, nickel, and zinc to Melton Branch. Monitoring data (Energy Systems 1990) suggest that WAGs 5 and 9 combined contribute about one-third of the ^{90}Sr and more than half of the ^3H that enters WOC. It is not possible, with current monitoring data, to separate the contribution of WAG 5 from that of WAG 9. In addition, operational monitoring of SWSA 5 North has detected levels of ^{244}Cm and ^{241}Am in groundwater down-gradient of the burial trenches (Ashwood et al. 1991). Additional data will be required to accurately assess past and continuing releases of radioisotopes, heavy metals, and organic compounds from WAG 5.

WAG 6

Description: WAG 6 consists of three SWMUs including SWSA 6, the Emergency Waste Basin (EWB), and the Explosives Detonation Trench (EDT). All three facilities are in Melton Valley, approximately 2 km (1.2 miles) southwest of the main plant area south of Lagoon Road and north of WOL. SWSA 6, which covers 28 ha (68 acres), is currently the only operating LLW disposal site at ORNL. Portions of this site have been closed under RCRA regulations because of the disposal of RCRA-regulated waste after 1980. The EWB was constructed in 1961-1962 to provide storage if wastes could not be released from ORNL to WOC. However, there is no reported use of the basin for waste storage. The EDT was used to destroy explosive and shock-sensitive chemicals. A closure plan has been filed for the detonation trench. WAG 6 drains to WOL directly through four unnamed surface drainages and indirectly from its eastern hillslope to the west seep tributary to WOL in WAG 7.

Releases: As the only operating LLW disposal site at ORNL, SWSA 6 continues to receive solid LLW for burial by improved confinement disposal technologies such as concrete silos, steel-lined auger holes, and concrete vaults on a concrete pad. Through the end of 1984, more than 250,000 Ci of LLW had been disposed of in SWSA 6. RCRA-regulated wastes (e.g., scintillation fluids, oils, cleaning solutions, alcohols, paint thinners, kerosene, jet fuel, acids, and sodium) were disposed of in several trenches and auger holes. Subsequently,

these disposal areas have been temporarily capped with high-density polyethylene (HDPE). Some site characterization data identified in the WAG 6 RI Plan have been collected, and the final RI was expected to be issued in 1991. Tritium, ^{60}Co , ^{90}Sr , and ^{137}Cs were the principal radioactive contaminants found in samples of 35 groundwater wells. These same contaminants were found in surface water and in both surface and subsurface soil samples. Trace levels of TRU isotopes were also found in two wells and two surface samples. Trace levels of several metals and solvents were found in a few wells. Only trace levels of metals or organics were found in surface water or soil samples. Solomon et al. (1988) and Ashwood and Spalding (1991) sampled wells in burial trenches and found numerous radioisotopes, heavy metals, volatile organic compounds (VOCs), and nitrates. Stream gravel samples indicate that SWSA 6 has been a source of ^{60}Co , ^{90}Sr , ^{137}Cs , and possibly of copper, molybdenum, and zinc to WOL. No indication of organic contamination was found in the stream gravel samples. In addition, no radionuclide contamination has been detected in samples from the small drainage down-gradient from the EWB. Existing monitoring data do not permit continuing releases from SWSA 6 to be quantified, primarily because of the absence of routine flow monitoring and sampling of the four tributaries that drain the WAG. A monitoring network on these streams is needed to estimate past and determine continuing, contaminant discharges to WOL.

WAG 7

Description: WAG 7 is in Melton Valley about 1.6 km (1 mile) southwest of the main plant area. The major SWMUs in this WAG, in terms of radioactive contamination, are seven pits and trenches used to dispose of liquid LLW between 1951 and 1966. WAG 7 also includes a decontamination facility, three leak sites, a storage area containing shielded transfer tanks and other equipment, and seven fuel wells containing the acid solutions of enriched uranium from HRE fuel. WAG 7 drains to the east and west seep tributaries to WOL, to WOC directly, and to two unnamed tributaries to WOC.

Releases: More than 1,100,000 Ci of liquid LLW, primarily ^{90}Sr , ^{106}Ru , and ^{137}Cs , was transferred to the waste pits and trenches; another 2000 Ci of ^{137}Cs was placed in the shielded transfer tanks; and nearly 4 kg of ^{235}U in liquid form was placed in the HRE fuel disposal auger holes. RCRA-regulated contaminants may also be present in this WAG, but data are insufficient to determine which ones. Characterization studies suggest that WAG 7 has been a source of ^3H , ^{60}Co , ^{90}Sr , ^{99}Tc , chromium, and zinc. Studies by Olsen et al. (1983) have also shown the presence of ^{233}U in the vicinity of Trench 7. No organic contamination traceable to WAG 7 has been found. Existing monitoring data are insufficient to characterize contaminant releases from WAG 7. Additional data will be required to determine the nature and extent of past and continuing releases.

WAG 8

Description: WAG 8 is in Melton Valley south of the main plant area and north of MB. Most of the reactor facilities other than those in WAG 1 are in Melton Valley. WAG 8 includes the Molten Salt Reactor Experiment (MSRE) and HFIR. In addition, WAG 8 includes associated tank and piping systems, six leak sites and an old transfer line, five surface impoundments, a contractor spoils area, and RCRA-permitted hazardous waste storage facilities. Liquid LLW and process wastes from the reactors and associated facilities are

collected on-site in tanks and then pumped to the main plant area for storage and treatment. Wastes from the HRE (WAG 9) were pumped using the same transfer system. WAG 8 drains directly into MB and into the West Seven tributary to MB.

Releases: The following summary is derived from the environmental data package for WAG 8. There is no inventory of the contents of the LLW collection and storage tanks, which are still in active use. Historical data are insufficient to determine whether or not any contamination remains at the two leak sites in WAG 8. The EP-toxicity test found that samples of the sludge in the four impoundments were not hazardous. There is probably less than 10 Ci of radioisotopes in these ponds. There is no indication that radioactive or hazardous wastes were ever introduced into the waste treatment facilities that are part of the ORNL sewage treatment system. The solid waste storage facilities are used to store hazardous and mixed wastes. However, stream gravel studies by Cerling and Spalding (1981) have identified WAG 8 as a major source of ^{60}Co and, to a lesser extent, ^{137}Cs to Melton Branch. The WAG has also been a source of copper, chromium, and zinc. Recent monitoring data suggest that WAG 8 is the source of about half of the ^{60}Co entering the WOC/WOL system. The WAG contributes negligible amounts of other radionuclides. Additional data will be required to determine past and continuing contributions of heavy metals (especially chromium and zinc) and organics from WAG 8 to WOC. No data are presently available on organic contaminants.

WAG 9

Description: WAG 9 is in Melton Valley about 1 km (0.6 mile) southeast of the main plant area just south of Melton Valley Drive. This WAG, consisting of three SWMUs, includes the HRE pond, LLW collection and storage tanks, and a septic tank serving the HRE, now the Nuclear Safety Pilot Plant (NSPP). The HRE pond was constructed in 1955 as a waste storage impoundment for condensate from the HRE waste evaporator. The pond was filled with soil and capped with asphalt in 1970. WAG 9 drains to the HRE (HRT) tributary to MB.

Releases: Stansfield and Francis (1986) found approximately 750 Ci of gross beta activity in the sediments of the HRE impoundment. The primary isotopes contributing to this activity were ^{90}Sr and ^{137}Cs . The sediments passed the EP-toxicity test. Tritium and ^{90}Sr were found in groundwater downgradient from the HRE impoundment, but only trace levels of metals and organics were found. Existing monitoring data are insufficient to separate contributions from WAG 9 and WAG 5. In addition, monitoring data are not routinely collected for detection of trace metal or organic contaminants. Additional data will be required to determine the contributions from WAG 9 to past and continuing contamination of WOC.

WAG 10

Description: WAG 10 consists of the injection wells and grout sheets from four SWMUs, two of which were experimental sites used in the development of the hydrofracturing process at ORNL. The other two sites were operating facilities (now inactive) used to dispose of ORNL's liquid LLW. All four SWMUs are located in Melton Valley; however, they are not adjacent to one another (Fig. 4). WAG 10 is significantly different from the other WAGs in that its grout sheets are at depths of 90 to 300 m (300 to 1000 ft) below ground.

Releases: Approximately 12,000,000 L of liquid wastes were injected into the fractured shale at the two major hydrofracture sites. Except for the isotopes listed in Table 3, little is known about the contaminants that may have been included in the grout mixtures. Analyses of similar wastes currently in storage reveal only negligible levels of heavy metals and no organics. Samples collected from groundwater wells, installed to monitor releases from the grout sheets, have detected ^{90}Sr contamination. No other contaminants have been found, and there is no indication of WAG 10 contamination reaching shallow groundwater or surface water. There is no monitoring data to determine the input, if any, of WAG 10 contaminants to WOC. Until the RI for WAG 10 is complete, it is unclear whether additional monitoring data will be needed.

WAG 13

Description: WAG 13, part of what is now called the 0800 Area, is west of State Highway 95 (White Wing Road) near the Clinch River. There are two SWMUs within WAG 13, both associated with research on transport of ^{137}Cs through the environment. The larger SWMU drains into the Clinch River downstream from the mouth of WOC. However, portions of the smaller SWMU (a 200-m² site where 0.015 Ci of ^{137}Cs was sprayed over the surface) may drain to Duck Creek, a tributary to WOC below WOD.

Releases: Only one small (200 m²) SWMU (13.2) in this WAG drains into WOC. Approximately 0.015 Ci ^{137}Cs in liquid form was sprayed on the surface of this SWMU in 1964. Almost one half-life (30 years), in terms of this material, has passed since that time. An aerial radiological survey of the ORR (Fritzsche 1987) conducted in 1986 showed the presence of ^{137}Cs at the other SWMU, but the radiological exposure maps do not show SWMU 13.2 as a separate source of radiation. The ^{137}Cs was applied to study environmental transport. Therefore, it is likely that some portion migrated into the WOCE below White Oak Dam. Stream gravel surveys have not detected ^{137}Cs in the reach that drains SWMU 13.2; however, ^{90}Sr levels were about 4 times background. Existing monitoring data do not provide enough resolution to determine if WAG 13 is a source of ^{137}Cs . An RI plan is currently being prepared for WAG 13, and execution of that plan should help to determine if the WAG is a source of ^{137}Cs to the WOCE.

WAG 17

Description: WAG 17 is about 1.6 km (1.0 mile) east of the main plant area, south of Bethel Valley Road. This area is the major craft and machine shop area for ORNL and includes the shipping, receiving, machine shops, carpenter shops, paint shops, lead-burning facilities, welding facilities, garage facilities, and material storage to support ORNL operations. The WAG includes 9 SWMUs, all tanks. WAG 17 drains into WOC just south of Bethel Valley Road. WAG 17 effluents, entering WOC approximately 5 km (3 mile) upstream from WOL, may ultimately reach WOL and the Clinch River.

Releases: The SWMUs in WAG 17 are all tanks, and only three of these are underground. These tanks have a volumetric capacity of 39,000 gal of domestic sewage, ~13,000 gal of waste oil, and 5000 gal of photographic wastes. In addition to the SWMUs, four underground tanks (capacity ~31,000 gal) are used for diesel fuel and gasoline, and one 4000-gal, aboveground tank is used for waste oil. There are no reports of releases of

radionuclides or hazardous materials from WAG 17; however, stream gravel surveys show that ^{137}Cs may have been released in the past. The surveys also suggest the presence of Cd, CR, Cu, and Zn. In addition, semivolatile organics were found to be present as tar-like grains on the gravels. Existing monitoring data are insufficient to separate WAG 17 inputs from those of WAG 1, and dilution may obscure the contribution of WAG 17. Additional data will be required to determine continuing contaminant contributions, if any, from WAG 17 to WOC.

APPENDIX B

Daily Precipitation Totals for Stations in White Oak Creek Watershed

Table B.1. Daily precipitation totals at the ETF station for the period October 1, 1990–December 31, 1991
(Units = mm)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.29 (e)	0.00	0.00	0.00	0.00	11.96	0.00	0.00	0.00	40.71	0.00	0.00	0.00	6.62	76.08
2	0.00 (e)	0.00	5.60	0.00	0.00	0.25	0.00	0.00	17.56	14.76 (e)	0.00	0.00	0.00	0.00	50.38
3	0.00	0.00	28.50	0.00	0.00	37.91	0.00	0.51	4.07	0.00 (e)	0.00	0.00	0.00	0.00	25.95
4	27.23	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00 (e)	10.94	0.00	0.00	0.00	0.00
5	0.00	9.92	0.00	0.00	0.51	0.00	4.07	4.33	0.00	5.09 (e)	0.00	0.00	5.09	0.00	0.00
6	0.00	0.00	0.00	0.00	3.31	5.09	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	18.58	0.00	0.00	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.25	0.00
8	20.61	0.00	0.00	0.00	0.00	0.00	4.33	0.00	0.00	0.51 (e)	1.27	0.00	0.00	7.38	0.00
9	0.00	18.58	0.00	0.00	0.00	0.00	3.82	6.11	0.00	0.25 (e)	31.55	0.00	0.00	0.00	27.48
10	8.14	15.27	0.00	12.21	0.00	0.00	0.00	0.00	0.00	0.00	20.87	0.00	0.00	0.00	0.25
11	5.60	0.00	0.00	5.34	0.00	0.00	0.00	0.00	0.51	11.20	0.00	0.00	0.00	0.00	0.00
12	1.53	0.00	0.00	0.00	0.00	10.94	1.53	15.27	43.77	3.82	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	11.45	0.00	33.59 (e)	8.40	12.72	0.00	0.00	6.36	1.53	0.00	0.00	0.00	47.07
14	0.00	0.00	2.54	0.00	1.27 (e)	0.00	0.00	0.00	0.00	0.00	3.56	0.00	8.65	0.00	6.87
15	0.00	0.00	2.04	4.33	0.00 (e)	0.00	13.23	0.00	0.00	0.00	2.54	0.00	24.43	0.00	0.00
16	0.00	0.00	0.00	3.56	0.00 (e)	0.00	0.00	2.04	0.25	0.00	0.00	0.00	0.00	0.00	0.00
17	2.04	0.00	14.50	0.00	38.93 (e)	10.43	0.00	0.00	11.20	0.00	0.00	0.00	0.00	0.00	0.00
18	17.30	0.00	14.50 (e)	0.00	56.74 (e)	2.29	0.00	2.54	0.51	3.31	1.53	9.16	0.00	0.00	0.00
19	0.00	0.00	0.00 (e)	5.34	56.23 (e)	0.00	10.18	18.32	0.00	0.00	12.98	6.36	0.00	0.00	0.00
20	0.00	0.00	7.12 (e)	2.04	6.36	0.00	0.00	2.80	13.49	0.00	0.00	0.00	0.00	7.63	0.00
21	0.00	0.00	0.51 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	33.84	1.27
22	19.59	0.76	78.37 (e)	0.00	0.00	4.83	0.00	0.00	13.49	0.00	0.00	0.00	0.00	36.13	3.05

Table B.1 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
23	0.00	0.76	49.87 (c)	0.00	0.00	18.83	0.00	0.00	3.82	0.00	0.00	0.00	0.76	0.00	28.50
24	0.00	0.00	1.27 (c)	0.00	0.00	0.00	0.00	0.00	19.85	16.03	0.00	33.08	0.00	0.00	0.00
25	0.00	0.00	0.00 (c)	0.00	0.00	0.00	0.00	0.51	21.63	0.00	0.00	5.09	0.00	0.00	0.00
26	0.00	0.00	1.53 (c)	0.00	0.00	0.00	0.00	0.00	0.00	0.25	18.58	0.00	0.00	0.00	0.00
27	0.00	0.00	27.74 (c)	0.00	0.00	6.87	6.36	11.96	0.00	0.00	0.25	0.00	0.00	0.00	4.58
28	0.00	15.01	15.78	0.00	0.00	4.07	1.02	13.49	0.00	0.00	0.00	0.00	0.00	0.00	21.63
29	0.00	0.00	6.11	0.00		52.42	5.85	0.00	0.00	0.00	4.58	0.00	0.00	0.00	0.00
30	0.00	0.00	24.68	6.36		0.00	1.78	0.00	0.00	0.00	1.02	0.00	0.00	33.33	0.00
31	0.00		0.00	0.00		0.00		0.00		0.00	0.00		0.00		0.00
TOTAL	104.33	60.31	292.11	57.76	196.95	174.81	64.89	77.86	150.13	102.29	111.20	53.69	38.93	125.19	293.13
MAX	27.23	18.58	78.37	18.58	56.74	52.42	13.23	18.32	43.77	40.71	31.55	33.08	24.43	36.13	76.08

(c) = Estimated data based on data from nearby stations.

Table B.2 Daily precipitation totals at the First Creek (1ST) station for the period October 1, 1990—December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	3.31	0.00	0.00	0.00	0.00	12.21 (e)	0.00	0.00	0.00	10.18	0.00	0.00	0.00	6.36	78.12	
2	0.00	0.00	8.14	0.00	0.00	3.05 (e)	0.00	0.00	4.58	25.19	0.00	0.00	0.00	0.00	51.15	
3	0.00	0.00	29.52	0.00	0.00	31.30 (e)	0.00	0.00	5.09	0.00	0.00	0.00	0.00	0.00	23.16	
4	22.39	0.00	0.00	0.00	0.00	0.51 (e)	0.00	0.00	0.00	0.00	3.56	0.00	0.00	0.00	0.00	
5	0.00	9.92	0.00	0.00	1.27	0.00	5.09	7.38	0.00	2.54	0.00	0.00	5.34	0.00	0.00	
6	0.00	0.00	0.00	0.00	5.34	9.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.00	21.37	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	25.95	0.00	0.00	0.00	0.00	0.00	6.62	0.76	0.00	1.27	0.51	0.00	0.00	6.62	0.00	
9	0.00	21.12	0.00	0.00	0.00	0.00	4.07 (e)	5.34	0.00	0.25	24.94	0.00	0.00	0.00	25.19	
10	8.14	12.47	0.00	12.47	0.00	0.00	0.00 (e)	0.00	0.00	0.00	5.34	0.00	0.00	0.00	0.00	
11	3.05	0.00	0.00	5.09	0.00	0.00	0.00 (e)	0.00	0.51	0.00	0.00	0.76	0.00	0.00	0.00	
12	1.02	0.00	0.00	0.00	0.00	11.20	3.56 (e)	12.72	49.11	8.65	0.00	0.51 (e)	0.00	0.00	0.00	
13	0.00	0.00	10.94	0.00	37.91	8.91	12.47 (e)	0.00	0.00	2.54	0.51	0.00 (e)	0.00	0.00	41.98	
14	0.00	0.00	2.54	0.00	1.53 (e)	0.00	0.00 (e)	0.00	0.00	0.00	3.82 (e)	0.00 (e)	8.91	0.00	6.36	
15	0.00	0.00	1.78	4.83	0.00 (e)	0.00	13.99 (e)	0.00	0.00	0.00	3.82	0.00 (e)	25.70	0.00	0.00	
16	0.00	0.00	0.00	4.58	0.00 (e)	0.00	0.00 (e)	7.89	0.00	0.25	0.00	0.00 (e)	0.00	0.00	0.00	
17	3.05	0.00	15.78	0.00	39.19 (e)	7.89	0.00	0.00	11.70	0.25	0.00	0.00 (e)	0.00	0.00	0.00	
18	20.36	0.00	14.25	0.00	59.03 (e)	5.34	0.00	11.70	0.00	2.80	1.53	4.07 (e)	0.00	0.00	0.00	
19	0.00	0.00	0.00	5.60	53.18 (e)	0.00	13.49	18.83	0.00	0.00	12.21	5.34 (e)	0.00	0.00	0.00	
20	0.00	0.00	7.63	2.29	5.34 (e)	0.00	0.00	3.56	8.91	0.00	0.00	0.00	0.00	6.36	0.00	
21	0.00	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	32.57	1.02	
22	20.10	1.78	82.44	0.00	0.00 (e)	7.12	0.00	0.00	8.40	0.00	0.00	0.00	0.00	33.33	2.29	

Table B.2 (continued)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
23	0.00	0.76	50.89	0.00	0.76 (c)	19.59	0.00	0.00	4.07	0.00	0.00	0.00	0.51	0.00	31.04	
24	0.00	0.00	0.00	0.00	0.00 (c)	0.00	0.00	0.00	19.34	24.94	0.00	31.81	0.00	0.00	0.51	
25	0.51	0.00	0.00	0.00	2.80 (c)	0.00	0.00	0.76	17.56	0.00	0.00	5.09	0.00	0.00	0.00	
26	0.00	0.00	0.00	0.00	0.00 (c)	0.00	0.00	0.00	0.76	0.51	18.32	0.00	0.00	0.00	0.00	
27	0.00	0.00	33.08	0.51	0.00 (c)	10.94	7.63	16.54	0.00	0.00	0.00	0.00	0.00	0.00	4.58	
28	0.00	14.76	12.98	0.25	0.00 (c)	7.38	1.27	17.56	0.00	0.00	0.00	0.00	0.00	0.00	18.83	
29	0.00	0.00	5.60	0.00		51.40	6.62	0.00	0.00	0.00	11.20	0.00	0.00	0.00	0.00	
30	0.00	0.00	25.70	7.63		0.00	1.02	0.00	0.00	0.00	0.00	0.00	0.00	25.95	0.00	
31	0.00		0.00	0.00		0.00		0.00		0.00	0.00		0.00		0.00	
TOTAL	107.89	60.81	301.27	64.63	206.36	186.77	75.83	103.05	130.03	79.39	85.75	47.58	40.46	111.20	284.22	
MAX	25.95	21.12	82.44	21.37	59.03	51.40	13.99	18.83	49.11	25.19	24.94	31.81	25.70	33.33	78.12	

(e) = Estimated data based on data from nearby stations.

Table B.3. Daily precipitation totals at the SWSA 7 (SW7) station for the period October 1, 1990—December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	2.54	0.00	0.00	0.51	0.00	12.21	0.25	0.00	4.33	1.78	0.00	0.00	0.00	6.11	72.52	
2	0.00	0.00	6.62	0.00	0.00	3.05	0.00	0.00	1.53	16.29	0.00	0.00	0.00	0.00	47.33	
3	0.00	0.00	28.50	0.00	0.00	31.30	0.00	1.27	37.66	0.00	0.00	0.00	0.00	0.00	24.17	
4	24.68	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	2.80	0.00	0.00	0.00	0.00	
5	0.00	10.94	0.00	0.00	0.76	0.00	5.09	5.09	0.00	4.07	0.00	0.00	3.05	0.00	0.00	
6	0.00	0.00	0.00	0.51	4.58	10.94	0.00	0.00	0.00	0.00	0.00	19.59	0.00	0.00	0.00	
7	0.00	0.00	0.00	18.32	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	
8	21.63	0.00	0.00	0.00	0.00	0.00	8.14	0.51	0.00	0.25	0.00	0.00	0.00	6.87	0.00	
9	0.00	14.25	0.00	0.00	0.00	0.00	3.82	6.11	0.00	0.25	23.16	0.00	0.00	0.00	25.95	
10	9.16	15.27	0.00	13.49	0.00	0.00	0.00	0.00	0.00	0.00	12.21	0.00	0.00	0.00	0.51	
11	2.80	0.00	0.00	4.58	0.00	0.00	0.00	0.00	0.25	2.54	0.00	0.51	0.00	0.00	0.00	
12	1.02	0.00	0.00	0.00	0.00	9.67	4.07	11.20	46.56	11.45	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	10.43	0.00	35.11	9.67	11.70	0.00	0.00	2.29	0.00	0.00	0.00	0.00	44.02	
14	0.00	0.00	2.54	0.00	3.82	0.00	0.00	0.00	0.00	0.00	3.82	0.00	6.36	0.00	6.87	
15	0.00	0.00	1.53	6.11	0.00	0.00	14.76	0.00	0.00	0.51	2.80	0.00	25.45	0.00	0.00	
16	0.00	0.00	0.00	3.56	0.00	0.00	0.00	9.16	0.00	1.02	0.00	0.00	0.00	0.00	0.00	
17	2.54	0.00	15.01	0.00	39.19	11.20	0.00	0.00	9.16	0.00	0.00	0.00	0.00	0.00	0.00	
18	16.54	0.00	14.25	0.00	59.03	2.80	0.00	31.81	0.00	4.83	1.27	4.07	0.00	0.00	0.00	
19	0.00	0.00	0.00	6.36	53.18	0.00	20.87	15.27	0.00	0.00	10.94	5.34	0.00	0.00	0.00	
20	0.00	0.00	6.87	2.80	5.34	0.00	0.76	5.85	9.41	0.00	0.00	0.00	0.00	7.12	0.00	
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	34.61	1.78	
22	19.59	2.04	75.06	0.00	0.00	6.36	0.00	0.00	16.03	0.00	0.00	0.00	0.00	32.82	2.80	
23	0.00	0.51	50.89	0.00	0.76	18.32	0.00	0.00	3.82	0.00	0.00	0.00	1.02	0.00	27.48	

Table B.3 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
24	0.00	0.00	2.04	0.00	0.00	0.00	0.00	0.00	33.08	11.70	0.00	32.57 (e) ¹	0.00	0.00	0.00
25	0.76	0.00	0.00	0.00	2.80	0.00	0.00	0.00	18.58	0.51	0.00	5.09 (e)	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.25	0.51	18.83	0.00 (e)	0.00	0.00	0.00
27	0.00	0.00	28.50	0.51	0.00	11.45	7.89	17.05	0.76	0.00	0.00	0.00 (e)	0.00	0.00	2.80
28	0.00	15.52	16.03	0.51	0.00	6.87	1.27	16.29	0.00	0.00	0.00	0.00 (e)	0.00	0.00	19.85
29	0.00	0.00	6.62	0.00		52.16	6.36	0.00	0.00	0.00	3.82	0.00 (e)	0.00	0.00	0.00
30	0.00	0.00	25.19	9.16		0.25	1.78	0.00	0.00	0.00	0.00	0.00 (e)	0.00	24.17	0.00
31	0.00		0.00	0.00		0.00		0.00		0.00	0.00		0.00		0.00
TOTAL	101.27	58.52	290.08	66.41	204.58	186.77	87.28	119.59	181.68	58.02	79.64	67.18	35.88	111.96	276.08
MAX	24.68	15.52	75.06	18.32	59.03	52.16	20.87	31.81	46.56	16.29	23.16	32.57	25.45	34.61	72.52

¹(e) = Estimated data based on data from nearby stations.

Table B.4 (continued)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
24	0.00	0.00	1.27	0.00	0.00	0.00	0.00	0.00	19.85	18.07	0.00	29.77	0.00	0.00	0.00	
25	0.00	0.00	0.00	0.00	2.04	0.00	0.00	0.76	20.87 (c)	0.00	0.00	4.58	0.00	0.00	0.00	
26	0.00	0.00	1.53	0.00	1.02	0.00	0.00	0.00	0.00 (c)	0.51	18.07	0.00	0.00	0.00	0.00	
27	0.00	0.00 (c)	27.74 (c)	0.00	0.00	8.14	7.12	13.49	0.00 (c)	0.00	0.00	0.00	0.00	0.00	4.33	
28	0.00	15.78 (c)	15.78 (c)	0.00	0.00	4.58	1.02	14.25	0.00 (c)	0.00	0.00	0.00	0.00	0.00	19.59	
29	0.00	0.00 (c)	6.11 (c)	0.00		52.16	7.12	0.00	0.00 (c)	0.00	4.07	0.00	0.00	0.00	0.00	
30	0.00	0.00 (c)	24.68 (c)	7.89		0.76	1.78	0.00	0.00 (c)	0.00	0.51	0.00	0.00	26.46	0.00	
31	0.00		0.00	0.00		0.00		0.00		0.00	0.00		0.00		0.00	
TOTAL	108.91	65.39	292.88	64.63	203.31	185.75	72.77	87.53	153.69	105.34	104.58	47.58	37.66	111.20	277.35	
MAX	26.21	18.83	78.37	19.34	59.54	52.16	14.25	16.54	47.07	40.71	31.81	29.77	24.94	34.10	76.34	

(c) = Estimated data based on data from nearby stations.

Table B.5. Daily precipitation totals at the SWSA 4 (SW4) station for the period October 1, 1990—December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	3.31	0.00	0.00	0.00 (e)	0.00 (e)	12.21 (e)	0.00	0.00 (e)	0.00	19.59	0.00	0.00	0.00	6.62	78.12	
2	0.00	0.00	7.12	0.00 (e)	0.00 (e)	3.05 (e)	0.00	0.00 (e)	9.16	19.85	0.00	0.00	0.00	0.00	52.93	
3	0.00	0.00	28.75	0.00 (e)	0.00 (e)	31.30 (e)	0.00	0.00 (e)	6.62	0.00	0.00	0.00	0.00	0.00	22.90	
4	22.39	0.00	0.76	0.00 (e)	0.00 (e)	0.51 (e)	0.00	0.00 (e)	0.00	0.00	2.29	0.00	0.00	0.00	0.00	
5	0.00	9.92	0.00	0.00	1.27 (e)	0.00 (e)	4.07	7.38 (e)	0.00	4.33	0.00	0.00	2.29	0.00	0.00	
6	0.00	0.00	0.00	0.00	5.34 (e)	9.92 (e)	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
7	0.00	0.00	0.00	18.83	0.00 (e)	0.00 (e)	0.00	0.00 (e)	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.00	
8	23.66	0.00	0.00	0.00	0.00 (e)	0.00 (e)	7.12	0.76 (e)	0.00	0.76	0.76 (e)	0.00	0.00	5.85	0.00	
9	0.00	20.10	0.00	0.00	0.00 (e)	0.00 (e)	4.07	5.34 (e)	0.00	0.25	31.81 (e)	0.00	0.00	0.00	23.66	
10	7.89	13.49	0.00	11.70	0.00 (e)	0.00 (e)	0.00	0.00 (e)	0.00	0.00	18.32 (e)	0.00	0.00	0.00	0.25	
11	3.56	0.00	0.00	5.34	0.00 (e)	0.00 (e)	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
12	0.76	0.00	0.00	0.00	0.00 (e)	0.00 (e)	3.56	12.72 (e)	44.78	0.00	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	10.69	0.00	37.91 (e)	8.91	12.47	0.00 (e)	0.51	10.69	1.02 (e)	0.00	0.00	0.00	41.98	
14	0.00	0.00	2.54	0.00	1.53 (e)	0.00	0.00	0.00 (e)	0.00	0.00	3.31 (e)	0.00	8.65	0.00	7.38	
15	0.00	0.00	1.27	3.56	0.00 (e)	0.00	13.99	0.00 (e)	0.00	0.00	2.80	0.00	23.66	0.00	0.00	
16	0.00	0.00	0.00	4.07	0.00 (e)	0.00	0.00	6.11	0.00	2.04	0.00	0.00	0.00	0.00	0.00	
17	4.83	0.00	14.76	0.00	39.19 (e)	7.38	0.00	0.00	7.38	0.00	0.00	0.00	0.00	0.00	0.00	
18	15.27	0.00	13.99	0.00	59.03 (e)	6.36	0.00	9.41	0.00	2.80	1.27	4.83	0.00	0.00	0.00	
19	0.00	0.00	0.00	3.82	53.18 (e)	0.00	13.23	16.03	0.00	0.00	8.40	5.34	0.00	0.00	0.00	
20	0.00	0.00	6.36	2.29	5.34 (e)	0.00	0.00	6.11	11.70	0.00	0.00	0.00	0.00	6.11	0.00	
21	0.00	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	29.77	1.02	
22	19.59	1.78	79.64	0.00	0.00 (e)	7.12	0.00	1.78	9.16	0.00	0.00	0.00	0.00	33.84	2.54	
23	0.76	0.51	50.38	0.00	0.76 (e)	20.36	0.00	0.00	3.31	0.00	0.00	0.00	0.76	0.00	27.74	

Table B.5 (continued)

DAY	1990												1991											
	OCT		NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC								
24	0.00	0.00	0.00	2.04	0.00	0.00 (c)	0.00	0.00	0.00	17.81	21.12	0.00	30.03	0.00	0.00	0.25								
25	0.00	0.00	0.00	0.00	0.00 (c)	2.80 (c)	0.00	0.00	2.29	19.08	0.25	0.00	5.09	0.00	0.00	0.00								
26	0.00	0.00	0.00	0.00	0.00 (c)	0.00 (c)	0.00	0.00	0.00	1.27	0.51	16.54	0.00	0.00	0.00	0.00								
27	0.00	0.00	0.00	33.08 (c)	0.51 (c)	0.00 (c)	10.43	6.87	13.99	0.00	0.00	0.00	0.00	0.00	0.00	3.31								
28	0.00	14.50	12.98 (c)	0.25 (c)	0.00 (c)	0.00 (c)	5.09	0.00	21.37	0.00	0.00	0.00	0.00	0.00	0.00	18.32								
29	0.00	0.25	5.60 (c)	0.00 (c)			52.16	7.38	0.00	0.00	0.00	4.58	0.00	0.00	0.00	0.00								
30	0.00	0.00	25.70 (c)	7.63 (c)			0.00	1.02 (c)	0.00	0.00	0.00	0.00	0.00	0.00	25.45	0.00								
31	0.00		0.00 (c)	0.00 (c)			0.00		0.00		0.00	0.00		0.00		0.00								
TOTAL	102.04	60.56	295.67	58.02	206.36	186.77	73.79	103.31	132.06	82.19	91.09	45.29	35.37	107.63	280.41									
MAX	23.66	20.10	79.64	18.83	59.54	52.16	13.99	21.37	47.33	21.12	31.81	30.03	23.66	33.84	78.12									

(c) = Estimated data based on data from nearby stations.

Table B.6. Daily precipitation totals at the Ish Creek (ISH) station for the period October 1, 1990–December 31, 1991
(Units = mm)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	6.62	0.00	0.00	0.00	0.00	11.96	0.00	0.00	0.00	43.51	0.00	0.00	0.00	5.85	76.59
2	0.00	0.00	7.89	0.00	0.00	0.51	0.00	0.00	0.00	22.14	0.00	0.00	0.00	0.00	47.33
3	0.00	0.00	29.77	0.00	0.00	36.90	0.00	0.00	0.00	9.92	0.00	0.00	0.00	0.00	72.65
4	21.63	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	11.70	0.00	0.00	0.00	0.00
5	0.00	9.92	0.00	0.00	1.27	0.00	4.58	6.36	0.00	1.53	0.00	0.00	3.31	0.00	0.00
6	0.00	0.00	0.00	0.00	5.85	7.63	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
7	0.00	0.00	0.00	24.68	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00
8	19.59	0.00	0.00	0.76	0.00	0.00	4.58	0.51	0.00	4.33	0.00	0.00	0.00	7.38	0.00
9	0.00	20.61	0.00	0.00	0.00	0.00	4.07	3.05	0.00	0.00	28.24	0.00	0.00	0.00	24.17
10	6.87	12.72	0.00	12.72	0.00	0.00	0.00	0.00	0.00	0.00	7.38	0.00	0.00	0.00	0.25
11	5.09	0.00	0.00	5.85	0.00	0.00	0.00	0.51	0.00	0.51	0.00	0.00	0.00	0.00	0.00
12	0.51	0.00	0.00	0.00	0.00	11.20	3.82	13.23	49.62	9.41	0.00	0.00	0.00	0.00	0.00
13	0.00	0.00	11.20	0.00	38.93	10.43	11.96	0.00	0.00	0.51	0.76	0.00	0.00	0.00	39.19
14	0.00	0.00	2.80	0.00	2.04	0.00	0.00	0.00	0.00	0.00	1.02	0.00	5.85	0.00	6.87
15	0.00	0.00	1.78	6.36	0.00	0.00	12.21	0.00	0.00	0.00	4.33	0.00	30.53	0.00	0.00
16	0.00	0.00	0.00	6.11	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00
17	2.04	0.00	16.03	0.00	39.44	8.40	0.00	0.00	4.33	0.00	0.00	0.00	0.00	0.00	0.00
18	19.34	0.00	12.72	0.00	55.22	5.34	0.00	0.00	0.00	3.31	1.78	1.78	0.00	0.00	0.00
19	0.00	0.00	0.00	4.33	58.52	0.00	8.91	16.03	0.00	0.00	8.65	4.58	0.00	0.00	0.00
20	0.00	0.00	7.12	3.05	6.62	0.00	0.00	4.07	5.09	0.00	0.00	0.00	0.00	7.12	0.00
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.51	0.00	0.00	0.00	0.00	29.52	0.00
22	18.58	1.53	86.01	0.00	0.00	6.87	0.00	0.00	15.52	0.00	0.00	0.00	0.00	37.15	2.80

Table B.6 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
23	0.00	0.51	48.35	0.00	0.00	20.61	0.00	0.00	6.11	0.00	0.00	0.00	1.02	0.00	30.03
24	0.00	0.00	0.51	0.00	0.00	0.00	0.00	0.00	21.37	15.52	0.00	31.30	0.00	0.00	0.00
25	0.00	0.00	1.02	0.00	2.80	0.00	0.00	0.00	19.59	0.00	0.00	5.09	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.76	17.81	0.00	0.00	0.00	0.00
27	0.00	0.00	29.01	0.76	0.00	6.36	5.85	9.16	0.00	0.00	0.00	0.00	0.00	0.00	4.07
28	0.00	14.76	17.30	0.25	0.76	7.12	1.53	15.78	0.00	0.00	0.00	0.00	0.00	0.00	20.61
29	0.00	0.00	6.62	0.00		49.87	10.69	0.00	0.00	0.00	2.80	0.00	0.00	0.00	0.00
30	0.00	0.00	23.41	7.63		0.00	1.02	0.00	0.00	0.00	0.51	0.00	0.00	27.23	0.00
31	0.00		0.25	0.00		0.00		0.00		0.00	0.00		0.00		0.00
TOTAL	100.25	60.05	301.78	72.52	211.45	183.72	69.21	68.70	132.06	102.04	85.24	42.75	40.71	114.25	274.55
MAX	21.63	20.61	86.01	24.68	58.52	49.87	12.21	16.03	49.62	43.51	28.24	31.30	30.53	37.15	76.56

Table B.7. Daily precipitation totals at the Walker Branch Watershed (RG1) station
for the period October 1, 1990—December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	5.34	0.00	0.00	0.00	0.00	13.49	0.00	0.00	6.87	1.27	0.00	0.00	0.00	5.85	74.55	
2	0.00	0.00	5.85	0.00	0.00	0.76	0.00	0.00	2.29	24.94	0.00	0.00	0.00	0.00	49.11	
3	0.00	0.00	31.30	0.00	0.00	29.01	0.00	0.00	20.61	0.00	0.00	0.00 (e)¹	0.00	0.00	26.97	
4	21.12	0.00	0.00	0.00	0.00	0.25	0.00	0.00	0.00	0.00	1.02	0.00 (e)	0.00	0.00	0.00	
5	0.00	10.69	0.00	0.00	0.76	0.00	3.82	7.63	0.00	0.25	0.00	0.00 (e)	5.85	0.00	0.00	
6	0.00	0.00	0.00	0.00	6.11	1.78	0.00	0.51	0.00	0.00	0.00	8.40 (e)	0.00	0.00	0.00	
7	0.00	0.00	0.00	23.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	
8	23.92	0.00	0.00	0.76	0.00	0.00	4.83	0.00	0.00	0.00	1.27	0.00 (e)	0.00	6.36	0.00	
9	0.00	17.81	0.00	0.00	0.00	0.00	5.09	5.60	0.00	0.00	4.07	0.00 (e)	0.00	0.00	23.41	
10	7.89	11.45	0.00	11.45	0.00	0.00	0.00	0.00	0.00	0.00	4.07	0.00 (e)	0.00	0.00	0.25	
11	1.02	0.00	0.00	5.85	0.00	0.00	0.00	0.00	0.00	2.04	0.00	5.85	0.00	0.00	0.00	
12	1.78	0.00	0.00	0.00	0.00	11.70	3.31	3.56	73.28	25.70	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	10.18	0.00	29.77	10.18	11.96	0.00	0.51	9.16	0.00	0.00	0.00	0.00	36.64	
14	0.00	0.00	2.04	0.00	9.92	0.00	0.00	0.00	0.00	0.00	3.31	0.00	8.14	0.00	8.91	
15	0.00	0.00	3.56	5.60 (e)	0.00	0.00	15.52	0.00	0.00	0.00	6.11	0.00	28.50	0.00	0.00	
16	0.00	0.00	0.00	4.33 (e)	0.00	0.00	0.00	10.43	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17	1.02	0.00	20.61	0.00 (e)	37.91	11.96	0.00	0.00	27.48	1.02	0.00	0.00 (e)	0.00	0.00	0.00	
18	17.56	0.00	15.01	0.00	55.47	0.25	0.00	20.61	0.76	4.33	1.53	2.54 (e)	0.00	0.00	0.00	
19	0.00	0.00	0.00	5.85 (e)	56.49	0.00	12.47	13.49	0.00	0.00	9.41	15.01 (e)	0.00	0.00	0.00	
20	0.00	0.00	6.36	2.54 (e)	5.85	0.00	0.51	1.02	7.12	0.00	0.00	0.00 (e)	0.00	6.11	0.00	
21	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 (e)	0.00	31.30	0.00	
22	17.81	1.27	33.72	0.00 (e)	0.00	4.58	0.00	0.00	0.00	0.00	0.00	0.00 (e)	0.00	35.88	2.80	

Table B.7 (continued)

DAY	1990					1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC		
23	0.00	0.76	49.87	0.00 (e)	0.00	18.07	0.00	26.46	3.56	0.00	0.00	0.00 (e)	0.51	0.00	29.52		
24	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.51	29.26	7.63	0.00	30.79 (e)	0.00	0.00	0.00		
25	0.00	0.00	0.00	0.00 (e)	1.78	0.00	0.00	0.00	29.01	0.00	0.00	5.09 (e)	0.00	0.00	0.00		
26	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.51	8.65	19.08	0.00 (e)	0.00	0.00	0.00		
27	0.00	0.00	29.01	0.25 (e)	0.00	6.87	8.14	12.47	0.76	0.00	0.00	0.00 (e)	0.00	0.00	3.31 (e)		
28	0.00	13.74	18.07	0.76 (e)	0.00	5.85	1.02	6.87	0.00	0.00	0.00	0.00 (e)	0.00	0.00	19.85 (e)		
29	0.00	0.00	6.11	0.00 (e)		51.91	6.87	0.00	0.00	0.00	15.52	0.00 (e)	0.00	0.00	0.00		
30	0.00	0.00	24.17	8.14		0.00	1.27	0.00	0.00	0.00	0.00	0.00 (e)	0.00	24.17	0.00		
31	0.00		0.00	0.00		0.00		0.00		0.00	0.00		0.00		0.00		
TOTAL	97.46	55.73	365.85	69.47	204.07	166.67	74.81	109.16	202.04	84.99	65.39	67.68	43.00	109.67	275.32		
MAX	23.92	17.81	83.72	23.92	55.47	51.91	15.52	26.46	73.28	25.70	19.08	30.79	28.50	35.88	74.55		

(e) = Estimated data based on data from nearby stations.

Table B.8. Daily precipitation totals at the Walker Branch Watershed (RG3) station
for the period October 1, 1990–December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	3.56	0.00	0.00 (e)	0.00 (e) ¹	0.00	13.49 (e)	0.00	0.00 (e)	6.87 (e)	1.27 (e)	0.00	0.00	0.00	5.09	72.26	
2	0.00	0.00	5.85 (e)	0.00	0.00	0.76 (e)	0.00	0.00	2.29 (e)	27.99 (e)	0.00	0.00	0.00	0.00	46.82	
3	0.00	0.00	31.30 (e)	0.00	0.00	29.01 (e)	0.00	1.27	20.61 (e)	0.00	0.00	0.00	0.00	0.00	27.23	
4	21.88	0.00	0.00 (e)	0.00	0.00	0.25 (e)	0.00	0.00	0.00 (e)	0.00	1.27	0.00	0.00	0.00	0.00	
5	0.00	10.69	0.00 (e)	0.00	0.76 (e)	0.00 (e)	3.56	9.16	0.00	0.76	0.00	0.00	4.33	0.00	0.00	
6	0.00	0.00	0.00 (e)	0.00	6.11 (e)	1.78	0.00	0.76	0.00	0.00	0.00	8.40	0.00	0.00	0.00	
7	0.00	0.00	0.00 (e)	23.92	0.00 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	25.19	0.00	0.00 (e)	0.51 (e)	0.00 (e)	0.00	5.09	0.00	0.00	0.51	3.31	0.00	0.00	6.11	0.00	
9	0.00	18.83	0.00 (e)	0.00 (e)	0.00 (e)	0.00	5.85	5.85	0.00	0.25	3.05	0.00	0.00	0.00	22.90	
10	8.65	11.20	0.00 (e)	11.45 (e)	0.00 (e)	0.00	0.00	0.00	0.00	0.00	4.33	0.00	0.00	0.00	0.51	
11	1.02	0.00	0.00 (e)	5.85 (e)	0.00 (e)	0.00	0.00	0.51	0.51	2.04	0.00	4.33	0.00	0.00	0.00	
12	1.53	0.51	0.00 (e)	0.00 (e)	0.00 (e)	9.67	3.31	2.80	68.70	29.01	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	10.18 (e)	0.00 (e)	36.39	12.47	11.96	0.00	0.76	3.56	0.00	0.00	0.00	0.00	36.39	
14	0.00	0.00	2.04 (e)	0.00 (e)	2.54	0.25	0.00	0.00	0.51	0.25	3.05	0.00	5.34	0.00	8.14	
15	0.00	0.00	3.56 (e)	5.60 (e)	0.00	0.00	15.52	0.00	0.00	0.00	5.60	0.00	30.53	0.00	0.00	
16	0.00	0.00	0.00 (e)	4.33 (e)	0.00	0.00	0.00	11.70	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00	
17	2.29	0.00	20.61 (e)	0.00 (e)	38.42	7.89	0.00	0.00	22.90	1.02 (e)	0.00	0.00	0.00	0.00	0.00	
18	17.05	0.00	14.76 (e)	0.00 (e)	53.94	4.33	0.00	17.05	0.76	4.33 (e)	1.27	2.54	0.00	0.00	0.00	
19	0.00	0.00	0.00	5.85 (e)	50.89	0.00	14.50	10.94	0.00	0.00 (e)	10.69	15.01	0.00	0.00	0.00	
20	0.00	0.00	6.36	2.54 (e)	7.63	0.00	1.78	2.80	6.62 (e)	0.00 (e)	0.00	0.00	0.00	6.11	0.00	
21	0.00	0.00	0.51	0.00 (e)	0.00	0.00	0.00	0.00	0.00 (e)	0.00 (e)	0.00	0.00	0.00	30.53	0.00	
22	18.58	1.53	86.01	0.00 (e)	0.00	3.56	0.00	0.00	0.00 (e)	0.00 (e)	0.00	0.00	0.00	36.13	2.80	

Table B.8 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
23	0.00	0.76 (e)	47.84 (e)	0.00 (e)	0.00	19.08	0.00 (e)	29.77	3.56 (e)	0.00 (e)	0.00	0.00	0.51	0.00	30.28
24	0.00	0.00 (e)	0.00 (e)	0.00 (e)	0.00	0.00	0.00 (e)	0.00	29.26 (e)	7.63 (e)	0.00	30.79	0.00	0.00	0.00
25	0.00	0.00 (e)	0.00 (e)	0.00 (e)	2.85	0.00	0.00 (e)	0.00	29.01 (e)	0.00 (e)	0.00	5.09	0.00	0.00	0.00 (e)
26	0.00	0.00 (e)	0.00 (e)	0.00 (e)	0.00 (e)	0.00	0.00 (e)	0.00	0.51 (e)	13.99	19.34	0.00	0.00	0.00	0.00 (e)
27	0.00	0.00 (e)	29.01 (e)	0.25 (e)	0.00 (e)	7.38	8.14 (e)	12.21	0.76 (e)	0.00	0.00	0.00	0.00	0.00	3.31 (e)
28	0.00	13.74 (e)	18.07 (e)	0.76 (e)	0.00 (e)	5.09	1.02 (e)	5.85 (e)	0.00 (e)	0.00	0.00	0.00	0.00	0.00	19.85 (e)
29	0.00	0.00 (e)	6.11 (e)	0.00 (e)		52.16	6.87 (e)	0.00 (e)	0.00 (e)	0.00	23.16	0.00	0.00	0.00	0.00
30	0.00	0.00 (e)	24.17 (e)	7.63		0.51	1.27 (e)	0.00 (e)	0.00 (e)	0.00	0.00	0.00	0.00	29.01	0.00
31	0.00		0.00 (e)	0.00		0.00		0.00 (e)		0.00	0.00		0.00		0.00
TOTAL	99.75	57.25	306.36	68.70	199.49	167.68	78.88	110.69	193.64	92.62	75.06	66.16	40.71	112.98	270.48
MAX	25.19	18.83	86.01	23.92	53.94	52.16	15.52	29.77	67.70	29.01	23.16	30.79	30.53	36.13	72.26

(e) = Estimated data based on data from nearby stations.

Table B.9. Daily precipitation totals at the Bear Creek Burial Ground (BUR) station
for the period October 1, 1990—December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	2.54	0.00	0.00	0.00	0.00	13.23	0.00	0.00	9.92	5.34	0.00	0.00	0.00	4.83	83.46	
2	0.00	0.00	6.36	0.00	0.00	2.04	0.00	0.00	1.27	30.03	0.00	0.00	0.00	0.00	51.91	
3	0.00	0.00	31.81	0.00	0.00	31.55	0.00	1.27	18.32	0.00	0.00	0.00	0.00	0.00	26.97	
4	24.43	0.00	0.00	0.00	0.00	1.02	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.00	
5	0.00	11.20	0.00	0.00	1.27	9.25	4.33	6.87	0.00	2.80	0.00	0.00	5.34	0.00	0.00	
6	0.00	0.00	0.00	0.00	6.62	1.02	0.00	0.76	0.00	0.00	0.00	8.40	0.00	0.00	0.00	
7	0.00	0.00	0.00	23.92	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
8	25.45	0.00	0.00	1.02	0.00	0.00	6.11	0.51	0.00	0.25	4.83	0.00	0.00	5.09	0.00	
9	0.00	17.81	0.00	0.00	0.00	0.00	5.85	5.09	0.00	0.25	2.80	0.00	0.00	0.00	25.45	
10	7.89	11.20	0.00	12.21	0.00	0.00	0.00	0.00	0.00	0.00	1.78	0.00	0.00	0.00	0.25	
11	1.27	0.00	0.00	4.58	0.00	0.00	0.00	1.02	0.00	2.29	0.00	5.34	0.00	0.00	0.00	
12	1.78	0.00	0.00	0.00	0.00	10.18	4.58	1.27	77.61	34.86	0.00	0.00	0.00	0.00	0.00	
13	0.00	0.00	10.94	0.00	35.11	13.23	11.70	0.00	0.00	5.09	0.00	0.00	0.00	0.00	35.62	
14	0.00	0.00	1.78	0.00	2.80	0.00	0.00	0.00	0.00	1.53	0.00	0.00	6.36	0.00	8.91	
15	0.00	0.00	3.56	5.60	0.00	0.00	14.50	0.00 (e)	0.00	0.00	6.36	0.00	32.82	0.00	0.00	
16	0.00	0.00	0.00	4.33	0.00	0.00	0.00	11.70 (e)	0.00	0.00	0.00	0.00	0.00	0.00	0.00	
17	0.76	0.00	21.63	0.00	40.20	7.38	0.00	0.00 (e)	22.90	0.76	0.00	0.00	0.00	0.00	0.00	
18	19.85	0.00	13.74	0.00	59.03	5.85	0.00	17.05 (e)	0.51	2.80	1.27	2.29	0.00	0.00	0.00	
19	0.00	0.00	0.00	5.85	65.39	0.00	22.14	10.94 (e)	0.00	0.25	11.45	10.43	0.00	0.00	0.00	
20	0.00	0.00	6.36	2.54	0.00	0.00	1.27	2.80 (e)	8.40	1.78	0.00	0.00	0.00	6.11	0.00	
21	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00 (e)	0.00	0.00	0.00	0.00	0.00	34.10	1.27	

Table B.9 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
22	18.07	2.04	88.55	0.00	0.00	3.56	0.00	0.00	0.00	0.00	0.00	0.00	0.00	38.42	3.05
23	0.00	0.76	58.78	0.00	0.51	21.37	0.00	18.32	7.38	0.00	0.00	0.00	0.00	0.00	30.79
24	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	35.62	4.83	0.00	34.10	0.00	0.00	0.51
25	0.00	0.00	0.00	0.00	3.05	0.00	0.00	0.00	29.26	0.00	0.00	5.09	0.00	0.00	0.00
26	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	16.29	17.56	0.00	0.00	0.00	0.00
27	0.00	0.00	30.03	0.25	0.00	8.91	8.40	17.05	0.00	0.00	0.00	0.00	0.00	0.00	3.31
28	0.00	17.30	18.07	0.76	0.00	7.63	0.25	7.89	0.00	1.53	0.00	0.00	0.00	0.00	19.85
29	0.00	0.00	6.36	0.00		50.64	7.38	0.00	0.00	0.00	7.89	0.00	0.00	0.00	0.00
30	0.00	0.00	24.68	8.14		0.00	0.51	0.00	0.51	0.00	0.00	0.00	0.00	26.72	0.00
31	0.00		0.00	0.00		0.00		0.00	0.00	0.00	0.00		0.00		0.00
TOTAL	102.04	60.56	322.65	69.21	213.99	177.86	87.02	102.54	211.70	110.69	55.73	65.65	44.53	115.27	291.35
MAX	25.45	17.81	88.55	23.92	65.39	50.64	22.14	18.32	35.62	34.86	17.56	34.10	32.82	38.42	83.46

Table B.10. Daily precipitation data at the NOAA/ATDD station, Oak Ridge, Tennessee
for the period October 1, 1990–December 31, 1991
(Units = mm)

DAY	1990				1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	
1	2.54	0.00	0.00	0.00	0.00	13.49	0.00	0.00	12.72	0.00	0.00	0.00	0.00	5.09	78.63	
2	0.00	0.00	6.62	0.00	0.00	3.31	0.00	0.00	2.54	6.36	0.00	7.63	0.00	0.00	55.98	
3	0.00	0.00	34.61	0.51	0.00	37.40	0.00	0.00	3.05	0.00	0.00	0.00	0.00	0.00	24.43	
4	24.68	0.00	0.00	0.00	0.00	1.02	0.00	1.02	0.00(1)	5.09	0.76	0.00	0.00	0.00	0.00(1)	
5	0.00	11.70	0.00	0.00	1.53	0.00	9.92	6.62	0.00	0.00	0.00	0.00(1)	6.87	0.00	0.00	
6	0.00	0.00	0.00	0.25	5.85	1.27	0.00	0.25	0.00	0.00	0.00	1.27	0.00	0.00	0.00	
7	0.00	0.00	0.00	25.45	0.00(1)	0.00	0.00	0.00	0.00	0.00	0.00(1)	0.00	0.00	0.00	0.00	
8	27.23	0.00	0.00	0.76	0.00	0.00	7.12	0.51	0.00	0.00	49.62	0.00	0.00	4.58	0.00	
9	0.00	21.37	0.00	0.00(1)	0.00	0.00	6.36	6.62	0.00	0.00	3.05	0.00	0.00	0.00	24.68	
10	7.38	6.36	0.00	11.70	0.00	0.00	0.00	0.00	0.00	0.00(1)	1.27	0.25	0.00	0.00(1)	0.00	
11	0.51	0.00	0.00	4.07	0.00	0.00	0.00	0.76	2.54	2.54	0.00	0.25	0.00	0.00	0.00	
12	1.27	0.00	0.00	4.33	0.00	10.18	7.89	1.53	53.69	21.12	0.00	0.00	0.00	0.00(1)	0.00(1)	
13	0.00	0.00	10.18	0.00	35.88	15.78	9.92	0.00	0.00	0.00	0.00(1)	0.00	0.00	0.00	31.55	
14	0.00	0.00	2.54	0.00	2.04	0.00(1)	0.00(1)	0.00	0.00	0.00	0.76	0.00	8.14	0.00	7.89	
15	0.00	0.00	5.09	6.11	0.00	0.00	18.32	0.00	0.00(1)	1.02	3.56	0.00	28.75	0.00	0.00	
16	0.00	0.25	0.00(1)	3.05	0.00	0.00	0.00	7.38	2.29	0.00	0.00	0.00	0.00	0.00	0.00	
17	4.58	0.00	22.14	0.00	40.71	10.18	0.00	0.00	27.48	8.14	1.53	0.00	0.00	0.00	0.00	
18	13.99	0.00	15.27	0.00	53.18	3.31	0.00	5.09	0.00	6.62	0.51	15.27	0.00	0.00	0.00	
19	0.00	0.00	0.00	6.36	54.71	0.00	22.14	7.12	0.00	1.27	10.69	9.67	0.00	0.00(1)	0.00	
20	0.00	0.00	5.85	2.04	4.33	0.00(1)	0.00	1.78	3.05	0.00	0.00	0.00	0.00	5.09	0.00	
21	0.00	0.00	0.00	0.00(1)	0.00	0.00	0.00	0.00	0.00(1)	0.00	0.00	0.00	0.00	31.81	1.78	
22	20.36	1.78	92.37	0.00(1)	0.00(1)	6.87	0.00	0.00	6.87	0.00	0.00	0.00	0.00	31.55	2.29	

Table B.10 (continued)

DAY	1990				1991											
	OCT	NOV	DEC		JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
22	20.36	1.78	92.37		0.00(1)	0.00(1)	6.87	0.00	0.00	6.87	0.00	0.00	0.00	0.00	31.55	2.29
23	0.00	2.54	49.87		0.00	0.00(1)	20.36	0.00	5.34	32.57	0.00	0.00	0.00(1)	1.02	0.00	31.04
24	0.00	0.00	0.00(1)		0.00	0.00	0.00	0.00	0.00	16.54	41.22	0.00	31.81	0.00	0.00	0.00
25	1.02	0.00	0.00		0.00	3.82	0.00	0.00	1.53	15.78	0.00	0.00	6.62	0.00	0.00	0.00
26	0.00	0.00	0.00		0.00	0.00	0.00	0.00	0.00	0.25	9.41	26.21	0.00	0.00	0.00	0.00
27	0.00	0.00	34.86		0.76	0.00	7.63	8.91	15.52	0.00(1)	0.00	0.00	0.00	0.00	0.00(1)	2.04
28	0.00	17.05	12.98		1.53	0.00	5.60	0.51	3.82	0.00	0.51	0.00	0.00	0.00	0.00	17.56
29	0.00	0.00	6.62		0.00		52.93	6.11	0.00(1)	0.00	0.00	19.59	0.00	0.00	0.00	0.00(1)
30	0.00	0.00	22.65		8.65		0.00	0.51	0.00	0.00	0.00(1)	0.00	0.00	0.00	27.48	0.00
31	0.00		0.00		0.00(1)		0.00		0.00		0.00	0.00		0.00		0.00
TOTAL	103.56	61.07	321.63		75.57	202.04	189.31	97.71	64.89	179.39	103.31	117.56	72.77	44.78	105.60	277.86
MAX	27.23	21.37	92.37		25.45	54.71	52.93	22.14	15.52	53.69	41.22	49.62	31.81	28.75	31.81	78.63

(1) = Trace

APPENDIX C

Daily Streamflow for Monitoring Stations in White Oak Creek Watershed

Table C.1. Daily streamflow at the East Seep monitoring station for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.007	0.013	0.013	0.059	0.024	0.058	0.079	0.023	0.008	0.091	0.003	0.004	0.003	0.009	0.970
2	0.008	0.012	0.014	0.047	0.023	0.067	0.062	0.017	0.022	0.095	0.003	0.003	0.006	0.006	1.007
3	0.007	0.011	0.256	0.042	0.022	0.386	0.051	0.016	0.029	0.076	0.004	0.003	0.009	0.006	0.493
4	0.048	0.014	0.089	0.040	0.022	0.211	0.046	0.016	0.019	0.035	0.005	0.002	0.008	0.006	0.109
5	0.013	0.029	0.044	0.040	0.023	0.106	0.055	0.027	0.010	0.033	0.006	0.003	0.007	0.006	0.052
6	0.006	0.016	0.029	0.036	0.033	0.094	0.043	0.025	0.007	0.017	0.006	0.007	0.004	0.005	0.031
7	0.006	0.011	0.021	0.092	0.026	0.076	0.039	0.019	0.006	0.012	0.006	0.006	0.004	0.005	0.023
8	0.067	0.009	0.016	0.057	0.026	0.057	0.043	0.017	0.006	0.010	0.004	0.003	0.004	0.010	0.018
9	0.018	0.054	0.013	0.049	0.026	0.049	0.051	0.026	0.005	0.014	0.043	0.003	0.004	0.007	0.134
10	0.023	0.151	0.013	0.071	0.025	0.041	0.040	0.006	0.005	0.021	0.048	0.004	0.005	0.006	0.111
11	0.035	0.047	0.011	0.133	0.022	0.038	0.033	0.001	0.005	0.024	0.010	0.005	0.005	0.006	0.056
12	0.018	0.027	0.010	0.090	0.022	0.050	0.035	0.045	0.146	0.014	0.008	0.003	0.006	0.006	0.036
13	0.012	0.020	0.025	0.060	0.202	0.109	0.097	0.033	0.042	0.031	0.009	0.002	0.004	0.006	0.343
14	0.010	0.016	0.039	0.045	0.243	0.077	0.064	0.018	0.019	0.010	0.015	0.003	0.004	0.006	0.448
15	0.009	0.013	0.026	0.045	0.083	0.057	0.158	0.009	0.013	0.011	0.013	0.002	0.060	0.008	0.107
16	0.008	0.013	0.020	0.058	0.051	0.046	0.075	0.018	0.011	0.014	0.008	0.002	0.011	0.007	0.059
17	0.004	0.012	0.069	0.040	0.356	0.054	0.054	0.016	0.021	0.011	0.009	0.002	0.006	0.008	0.041
18	0.071	0.010	0.186	0.035	1.851	0.113	0.042	0.019	0.017	0.011	0.016	0.003	0.006	0.008	0.029

Table C.1 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
19	0.022	0.010	0.171	0.042	1.657	0.069	0.068	0.033	0.008	0.010	0.025	0.005	0.006	0.007	0.022
20	0.012	0.010	0.094	0.045	0.470	0.055	0.049	0.084	0.025	0.009	0.008	0.004	0.006	0.011	0.020
21	0.010	0.009	0.067	0.036	0.150	0.045	0.038	0.029	0.019	0.009	0.006	0.004	0.006	0.062	0.021
22	0.064	0.010	1.152	0.031	0.091	0.061	0.033	0.018	0.025	0.008	0.005	0.005	0.006	0.262	0.021
23	0.050	0.013	1.370	0.030	0.070	0.229	0.029	0.016	0.038	0.005	0.006	0.005	0.006	0.28	0.209
24	0.025	0.009	0.294	0.027	0.055	0.097	0.025	0.013	0.076	0.016	0.006	0.038	0.006	0.013	0.135
25	0.021	0.008	0.229	0.023	0.053	0.065	0.022	0.011	0.197	0.009	0.007	0.015	0.005	0.012	0.065
26	0.016	0.008	0.183	0.022	0.044	0.055	0.023	0.012	0.143	0.004	0.023	0.006	0.004	0.010	0.045
27	0.014	0.008	0.233	0.022	0.037	0.059	0.034	0.027	0.056	0.005	0.010	0.003	0.005	0.010	0.034
28	0.014	0.048	0.549	0.022	0.033	0.066	0.031	0.103	0.030	0.004	0.009	0.003	0.006	0.010	0.187
29	0.014	0.024	0.223	0.019		0.756	0.040	0.030	0.017	0.004	0.008	0.003	0.004	0.010	0.120
30	0.016	0.016	0.314	0.038		0.279	0.032	0.018	0.012	0.004	0.010	0.003	0.003	0.059	0.065
31	0.016		0.148	0.028		0.117		0.013		0.004	0.005		0.003		0.045
AVG	0.021	0.021	0.190	0.045	0.205	0.117	0.049	0.024	0.034	0.019	0.011	0.005	0.007	0.02	0.163
MIN	0.003	0.000	0.010	0.019	0.000	0.031	0.016	0.001	0.003	0.001	0.000	0.001	0.003	0.003	0.016
MAX	0.429	0.408	8.052	0.351	3.612	1.206	0.516	0.691	1.485	1.527	0.408	0.157	0.266	0.718	4.594
TOTAL FLOW (1000 ft ³)	57.3	55.9	511.3	123.1	496.1	314.6	128.7	65.6	89.6	53.5	29.8	13.0	19.3	53.2	437.0

Table C.2. Daily streamflow at the White Oak Creek (MS3) monitoring station for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5.563	5.2 (c)	6.261	26.773	7.432	14.037	16.608	7.180	6.571	9.991	5.243	5.381	4.884	5.411	117.659
2	5.477	5.4 (c)	6.252	19.800	6.755	12.786	13.294	6.599	6.414	17.074	5.200	5.372	4.693	4.528	137.397
3	5.264	5.634	33.259	16.470	6.587	49.027	11.349	6.478	14.226	12.086	4.968	5.295	4.762	4.259	81.632
4	9.925	5.766	15.648	14.061	6.645	35.085	9.969	6.213	8.936	9.057	5.448	5.265	4.834	4.469	24.368
5	6.163	7.851	11.404	12.350	6.720	21.872	10.891	7.567	7.505	8.466	5.449	5.391	5.587	4.730	15.183
6	5.393	6.430	9.881	11.335	7.753	20.469	9.911	6.267	6.821	7.201	5.417	5.918	4.444	4.793	11.855
7	5.339	6.265	8.405	27.211	6.998	16.871	9.187	6.110	6.466	6.612	5.638	5.617	4.582	4.737	9.860
8	12.992	6.284	8.117	18.204	6.821	13.619	9.566	5.943	5.850	6.497	5.526	5.506	4.597	5.294	8.375
9	6.953	11.159	7.292	14.854	6.783	12.023	9.619	6.921	5.612	6.471	9.754	5.654	4.596	4.730	20.765
10	6.724	19.165	7.064	16.442	6.443	10.807	8.280	6.231	5.470	6.558	6.937	5.577	4.760	4.740	16.345
11	7.160	9.632	7.041	23.356	6.621	10.376	7.843	5.790	5.456	6.525	5.906	5.766	4.680	4.733	12.142
12	6.347	8.298	6.777	18.446	6.593	10.961	7.906	8.089	38.965	6.434	5.917	5.381	4.350	4.910	10.241
13	5.895	7.644	7.975	14.770	26.608	19.302	14.107	6.590	15.910	12.983	5.659	5.195	4.502	4.524	37.320
14	5.582	7.279	9.667	12.860	33.925	14.080	9.634	6.122	10.398	6.787	5.826	5.211	4.443	4.490	62.535
15	5.682	6.898	7.911	12.168	18.847	12.315	21.362	6.006	8.637	6.169	6.072	5.077	13.130	4.352	23.213
16	5.757	6.634	7.366	14.277	13.728	11.132	13.094	8.002	7.894	6.516	5.496	5.165	5.497	4.262	15.596
17	5.467	6.648	14.756	11.531	39.058	11.234	11.293	6.049	9.541	6.324	5.315	4.916	4.908	4.140	12.405
18	13.437	6.391	25.231	10.723	178.628	17.987	10.268	13.334	8.259	6.512	5.438	5.249	4.679	4.350	10.778
19	6.682	6.287	21.013	11.046	174.228	12.397	13.624	8.898	7.689	6.077	7.272	6.617	4.455	4.480	9.062
20	5.843	6.047	18.287	11.356	107.771	11.421	10.291	16.561	9.042	5.999	5.575	4.825	4.262	5.136	7.981

Table C2 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
21	5.432	6.044	15.035	10.417	40.387	10.646	8.675	8.507	7.380	5.786	5.737	4.401	4.636	10.746	7.422
22	11.143	5.756	145.540	9.607	26.605	12.205	7.904	7.320	7.953	5.622	5.465	4.366	4.831	35.805	7.145
23	8.296	6.021	211.790	9.067	19.821	35.327	7.654	7.114	8.625	5.658	5.514	4.501	4.694	7.958	32.325
24	6.697	5.754	44.002	8.843	16.365	19.129	7.204	6.284	28.655	9.642	5.260	11.632	4.899	6.735	23.130
25	5.936	5.628	25.804	8.435	14.253	14.885	6.961	5.969	44.748	7.169	5.269	6.670	4.778	5.770	15.290
26	5.824	5.653	18.573	8.004	12.742	12.611	6.634	5.383	32.565	6.364	8.613	4.984	4.428	5.481	11.870
27	5.234	5.948	25.039	7.749	11.598	11.059	8.118	8.783	18.210	6.149	6.305	5.082	4.402	5.182	10.193
28	5.135	9.979	80.747	7.860	10.934	12.037	7.543	16.046	12.949	6.314	5.811	4.740	4.551	5.192	27.086
29	5.144	6.912	40.895	7.526		97.657	9.204	8.098	10.584	5.864	7.015	4.737	4.964	4.646	19.576
30	5.055	7.039	48.867	9.140		47.594	7.707	7.179	9.118	5.564	6.677	4.642	4.841	10.343	14.352
31	5.4 (c)		48.713	7.814		23.747		6.652		5.249	5.557		4.663		11.601
MEAN	6.676	7.188	30.471	13.306	29.558	20.474	10.189	7.686	12.548	7.41	5.976	5.471	4.978	6.364	26.603
MAX	13.437	19.165	211.790	26.773	178.628	49.027	21.362	16.046	44.748	17.074	9.754	11.632	13.130	35.805	137.397
MIN	5.055	5.2	6.252	7.749	6.443	10.376	6.634	5.383	5.456	5.249	5.200	4.366	4.262	4.140	7.145
Total Flow (1000 ft ³)	17880.1	18631.7	81614.4	35639.7	71508.9	54838.0	26412.4	20558.0	32525.3	19847.9	16008.3	14181.1	13334. 2	16495.9	71254.5

Table C.3. Daily streamflow at the Melton Branch (MS4) monitoring station for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.878	0.504	0.963	5.542	1.232	3.103	4.312	1.396	0.953	2.190	1.811	1.705	1.070	0.526	61.076
2	0.784	0.478	0.937	3.678	1.233	3.923	3.276	1.235	1.040	3.323	1.780	1.735	1.052	0.551	57.567
3	0.792	0.490	13.648	2.864	1.254	22.885	2.598	1.038	6.490	2.641	1.761	1.696	1.071	0.505	32.141
4	1.906	0.549	4.424	2.297	1.144	12.242	2.207	1.059	3.405	1.535	1.849	1.621	1.096	0.486	5.523
5	0.997	1.115	1.976	2.016	1.328	5.611	2.569	1.302	1.484	1.568	1.698	1.702	1.137	0.484	2.748
6	0.858	1.111	1.485	2.007	1.807	6.405	2.047	1.156	1.127	1.238	1.664	1.844	1.103	0.480	1.947
7	0.871	0.832	1.2 (e)	8.054	1.511	6.293	1.907	0.918	0.920	1.078	1.666	1.790	1.104	0.49 (e)	1.692
8	2.769	0.849	1.1 (e)	4.523	1.237	4.051	2.055	0.680	0.756	1.032	1.671	1.687	1.113	0.56 (e)	1.476
9	1.311	1.621	1.0 (e)	3.066	1.211	3.247	2.610	0.934	0.501	0.996	3.007	1.662	1.121	0.480	8.896
10	1.176	7.026	0.90 (e)	3.967	1.219	2.662	2.038	0.833	0.429	0.896	2.445	1.640	1.147	0.457	7.253
11	1.575	2.201	0.86 (e)	9.563	1.272	2.362	1.696	0.754	0.493	0.814	1.900	1.644	1.146	0.453	3.350
12	1.022	1.435	0.76 (e)	5.674	1.257	2.631	1.714	1.550	10.191	0.681	1.804	1.517	1.203	0.440	2.414
13	0.867	1.151	0.88 (e)	3.662	12.735	7.105	5.164	1.204	3.961	1.208	1.763	1.233	1.204	0.493	20.560
14	0.889	0.899	1.5 (e)	2.828	15.969	4.869	3.312	0.775	1.810	0.634	1.840	1.232	1.209	0.574	30.999
15	0.936	0.805	1.2 (e)	2.471	4.809	3.514	10.051	0.598	1.335	0.901	1.743	1.212	2.995	0.538	6.238
16	0.881	0.766	1.6 (e)	3.759	2.904	2.912	4.473	1.045	0.914	1.496	1.525	1.184	1.493	0.546	3.608
17	0.886	0.670	2.6 (e)	2.827	16.772	2.875	3.118	0.845	1.431	1.445	1.475	1.148	1.201	0.535	2.673
18	2.725	0.480	8.2 (e)	2.491	72.990	7.492	2.505	3.973	1.707	1.683	1.532	0.973	0.624	0.538	2.066
19	1.313	0.489	4.5 (e)	2.690	69.237	3.971	4.648	3.396	1.492	1.646	1.908	1.084	0.566	0.540	1.688
20	1.043	0.486	3.5 (e)	3.159	31.465	3.098	3.926	10.331	2.063	1.553	1.614	0.860	0.296	0.608	1.543

Table C.3 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
21	1.020	0.486	3.164	2.602	9.811	2.732	2.939	2.793	2.011	1.519	1.504	0.843	0.309	1.786	1.509
22	2.379	0.555	59.866	2.213	5.922	3.346	2.451	1.657	2.704	1.506	1.413	0.828	0.358	14.232	1.488
23	2.438	0.641	74.265	1.999	4.290	13.656	2.128	1.303	3.643	1.449	1.061	0.766	0.308	1.688	13.971
24	1.558	0.865	8.470	1.736	3.309	5.439	1.864	1.116	8.369	1.746	1.006	2.189	0.417	0.912	8.384
25	1.276	0.749	3.933	1.529	2.783	3.299	1.730	0.968	18.390	1.628	1.048	1.292	0.418	0.686	3.786
26	1.0 (e)	0.465	2.644	1.429	2.353	2.590	1.693	0.903	13.526	1.593	1.741	0.991	0.349	0.696	2.559
27	0.82 (e)	0.576	5.936	1.285	1.859	2.397	2.252	2.150	5.183	1.599	1.524	0.999	0.353	0.623	2.039
28	0.70 (e)	1.868	31.539	1.258	1.631	3.857	1.981	6.583	3.314	1.579	1.625	0.950	0.445	0.517	11.158
29	0.60 (e)	1.306	10.918	1.137		45.928	2.192	2.244	2.499	1.815	1.651	0.961	0.486	0.473	7.019
30	0.56 (e)	0.957	19.057	2.000		18.142	1.742	1.406	2.144	1.828	1.735	1.011	0.442	1.867	3.737
31	0.54 (e)		15.726	1.574		6.522		1.079		1.748	1.688		0.435		2.685
MEAN	1.205	1.08	9.515	3.093	9.805	7.069	2.906	1.845	3.476	1.502	1.692	1.333	0.879	1.125	10.122
MAX	2.769	7.026	74.265	9.563	72.990	45.928	10.051	10.331	18.390	3.323	3.007	2.189	2.995	14.232	61.076
MIN	0.54	0.465	0.76	1.137	1.144	2.362	1.693	0.598	0.429	0.634	1.006	0.766	0.308	0.440	1.476
Total Flow (1000 ft ³)	3228.4	2801.6	24948.0	8285.9	23720.7	18935.8	7533.8	4944.1	9010.1	4023.7	4531.9	3455.9	2356.1	2917.2	27111.8

(e) = Estimated data.

Table C.4. Daily streamflow at the White Oak Dam (MSS) monitoring station for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5.972	4.672	5.902	35.421	9.301	13.555	23.303	9.022	8.244	13.986	7.109	6.969	5.525	5.406	170.861
2	5.700	4.335	5.801	22.573	8.814	18.025	17.687	8.108	8.685	16.839	6.525	6.834	5.530	5.545	220.731
3	5.560	4.167	37.445	17.307	8.645	65.298	14.483	7.655	14.452	20.853	6.169	6.749	5.502	4.852	125.923
4	9.947	4.165	25.261	14.677	7.895	59.016	14.110	7.720	16.076	12.469	6.433	6.635	5.619	4.721	36.755
5	8.653	5.378	13.029	13.979	6.972	30.151	13.775	8.650	11.395	11.156	6.823	6.617	6.025	4.889	19.454
6	6.593	6.182	10.663	13.073	8.221	23.709	12.680	8.374	8.937	9.345	6.600	6.921	5.811	5.039	14.590
7	6.430	5.110	9.185	32.147	8.118	25.218	11.556	7.406	7.694	8.148	6.642	7.117	5.385	5.063	12.585
8	13.544	4.831	8.511	24.880	7.326	17.638	11.561	6.727	6.963	7.674	6.613	6.745	5.378	5.443	10.474
9	11.067	6.665	7.879	17.942	7.049	14.523	12.919	7.687	6.492	7.483	12.046	6.730	5.396	5.516	20.710
10	9.027	24.883	7.610	15.840	6.918	13.986	12.013	7.587	6.124	7.344	11.505	6.711	5.528	5.162	30.019
11	10.322	12.359	7.622	33.449	7.452	13.255	10.358	6.835	6.041	7.614	8.245	6.806	5.717	5.115	16.336
12	9.510	8.172	7.477	26.020	7.985	12.840	10.269	8.329	34.401	7.531	7.266	6.719	5.470	5.239	13.683
13	8.401	7.255	6.553	18.912	27.403	23.711	17.412	10.222	31.372	12.532	7.131	6.264	5.377	5.103	33.438
14	7.590	7.079	11.137	14.639	60.503	19.835	14.681	7.973	13.833	8.322	7.230	6.182	5.456	5.006	120.870
15	7.228	6.705	9.504	12.055	25.935	15.494	28.346	7.278	11.661	6.938	7.488	5.996	13.414	4.887	34.354
16	7.365	6.612	7.800	11.175	16.960	14.040	19.960	8.071	10.423	7.261	6.798	6.057	9.078	4.793	19.971
17	7.337	6.172	11.884	10.593	37.316	13.608	15.053	8.810	10.127	7.218	6.402	5.861	6.568	4.621	14.886
18	13.707	5.898	28.025	9.944	308.047	24.223	13.886	10.558	12.663	7.510	6.451	5.915	5.622	4.669	13.376
19	10.910	5.476	33.549	9.364	277.384	16.818	15.520	14.084	10.578	7.383	7.632	7.339	5.222	4.863	11.219
20	8.187	5.285	19.974	8.869	180.662	14.385	15.471	26.729	11.816	7.056	8.073	6.067	4.781	5.170	9.856

Table C.4 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
21	7.229	5.252	18.021	8.806	56.292	13.956	13.142	13.393	10.925	6.936	6.827	5.288	4.695	8.645	9.153
22	10.224	5.211	198.733	8.642	34.089	14.453	11.537	9.852	9.241	6.679	6.579	4.859	5.052	51.058	8.636
23	13.881	5.637	364.680	9.061	24.181	43.695	10.744	8.490	13.108	6.663	6.202	4.856	5.083	13.925	33.944
24	10.048	5.445	63.196	11.014	18.920	25.998	9.978	7.639	15.904	8.877	5.910	9.927	5.064	8.902	39.194
25	8.012	5.257	29.431	8.953	15.790	17.636	9.311	7.017	68.282	9.802	5.797	10.783	5.187	7.050	20.457
26	7.169	4.836	20.087	8.176	14.686	14.288	8.805	6.368	55.530	8.060	8.398	6.918	4.858	6.368	14.920
27	6.627	5.018	21.638	7.769	13.729	14.144	9.705	8.469	25.361	7.480	3.930	5.868	4.654	6.000	13.068
28	6.402	7.916	119.583	7.627	12.705	16.759	10.219	21.535	16.234	7.411	9.054	5.582	4.728	5.730	30.432
29	6.269	8.563	55.683	7.874		131.003	10.854	13.620	13.599	7.267	5.933	5.477	5.020	5.401	31.953
30	6.047	6.528	60.008	9.621		90.118	10.422	10.366	11.605	7.023	11.121	5.304	5.239	6.289	19.355
31	5.571		80.328	10.156		35.569		9.11		5.875	7.621		4.991		14.719
MEAN	8.404	6.702	42.135	14.792	43.546	27.966	13.658	9.796	16.258	8.926	7.308	6.536	5.708	7.348	38.255
MAX	13.881	24.883	364.680	33.449	308.047	131.003	28.346	26.729	68.282	20.853	12.046	10.783	13.414	51.058	220.731
MIN	5.560	4.167	5.801	7.627	6.918	12.840	8.805	6.368	6.041	5.875	3.930	4.856	4.654	4.621	8.636
Total Flow (1000 c ³)	22509.6	17371.9	112855.7	39619.5	105347.1	74904.3	35403.0	26238.3	42143.1	23905.9	19574.2	16942.6	15290.7	19048.4	102463.7

(c) = Estimated data.

Table C.5. Daily streamflow at the Ish Creek monitoring station for the period October 1, 1990—December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.120	0.172	0.247	4.941	0.689	1.414	3.272	0.482	0.206	1.987	0.087	0.079	0.091	0.088	13.264
2	0.108	0.166	0.242	3.301	0.654	1.865	2.494	0.411	0.196	2.873	0.073	0.075	0.087	0.095	19.647
3	0.107	0.165	2.529	2.543	0.660	6.779	2.130	0.373	0.234	3.259	0.060	0.071	0.080	0.088	12.039
4	0.255	0.157	2.413	2.127	0.661	6.588	1.762	0.371	0.283	1.924	0.079	0.061	0.082	0.086	4.701
5	0.177	0.206	1.488	1.795	0.684	4.052	1.621	0.456	0.211	1.259	0.095	0.064	0.090	0.088	2.710
6	0.138	0.225	0.954	1.518	0.797	3.225	1.254	0.407	0.177	0.752	0.076	0.074	0.098	0.092	2.019
7	0.124	0.181	0.707	4.023	0.769	2.638	1.057	0.332	0.166	0.528	0.070	0.079	0.094	0.088	1.416
8	0.357	0.167	0.556	3.485	0.698	2.225	1.000	0.299	0.158	0.412	0.062	0.074	0.098	0.107	0.930
9	0.229	0.335	0.457	2.675	0.682	1.958	0.996	0.341	0.157	0.382	0.291	0.072	0.101	0.106	2.044
10	0.184	1.796	0.409	2.495	0.703	1.623	0.873	0.300	0.147	0.305	0.373	0.070	0.101	0.101	2.727
11	0.252	0.848	0.381	3.883	0.659	1.354	0.729	0.279	0.140	0.276	0.139	0.070	0.100	0.095	2.149
12	0.232	0.555	0.348	3.558	0.621	1.365	0.701	0.394	1.809	0.240	0.108	0.069	0.101	0.093	1.675
13	0.199	0.427	0.379	2.729	2.759	2.728	1.769	0.406	0.883	0.353	0.101	0.068	0.101	0.094	3.808
14	0.177	0.348	0.676	2.287	6.256	2.388	1.538	0.300	0.404	0.225	0.108	0.063	0.102	0.094	9.518
15	0.157	0.296	0.526	2.064	3.590	2.160	2.594	0.258	0.294	0.184	0.130	0.058	0.478	0.091	4.747
16	0.147	0.265	0.482	2.369	2.454	1.872	2.270	0.240	0.254	0.178	0.102	0.054	0.196	0.094	2.965
17	0.140	0.248	1.127	2.041	5.074	1.729	1.919	0.232	0.225	0.168	0.093	0.052	0.144	0.094	2.272
18	0.490	0.229	2.743	1.855	32.489	2.600	1.545	0.210	0.201	0.192	0.094	0.054	0.128	0.094	1.709
19	0.302	0.217	2.959	1.848	36.601	2.157	1.465	0.241	0.173	0.184	0.116	0.074	0.121	0.094	1.086

Table C.5 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	0.230	0.205	2.244	1.908	21.162	1.962	1.086	0.635	0.212	0.159	0.107	0.080	0.116	0.104	0.783
21	0.202	0.198	2.022	1.613	8.380	1.733	0.884	0.330	0.193	0.157	0.092	0.075	0.116	0.283	0.708
22	0.457	0.193	21.159	1.438	5.196	1.798	0.787	0.253	0.340	0.158	0.085	0.068	0.116	0.311	0.675
23	0.581	0.209	46.852	1.367	3.527	4.839	0.695	0.229	0.483	0.151	0.076	0.065	0.116	0.666	3.719
24	0.377	0.192	8.953	1.241	2.636	3.474	0.603	0.211	0.884	0.196	0.068	0.273	0.114	0.361	4.800
25	0.288	0.180	5.014	1.065	2.289	2.540	0.531	0.191	2.569	0.182	0.061	0.189	0.101	0.255	2.999
26	0.245	0.174	3.257	0.983	2.001	2.142	0.498	0.187	2.541	0.158	0.154	0.132	0.101	0.203	2.266
27	0.217	0.170	3.543	0.962	1.618	1.849	0.534	0.246	1.352	0.157	0.121	0.108	0.097	0.174	1.829
28	0.197	0.380	11.911	0.942	1.288	1.788	0.550	0.771	0.741	0.140	0.101	0.101	0.085	0.160	3.954
29	0.188	0.379	7.567	0.820		12.284	0.748	0.387	0.510	0.136	0.096	0.098	0.076	0.150	4.090
30	0.182	0.275	7.748	0.936		8.926	0.603	0.278	0.364	0.126	0.102	0.093	0.062	0.418	2.774
31	0.174		8.444	0.819		5.004		0.233		0.114	0.096		0.065		2.167
MEAN	0.233	0.318	4.797	2.117	5.198	3.195	1.283	0.331	0.548	0.564	0.11	0.085	0.114	0.262	3.941
MAX	0.581	1.796	46.852	4.941	36.601	12.284	3.272	0.771	2.541	3.259	0.373	0.273	0.478	3.311	19.647
MIN	0.107	0.157	0.242	0.819	0.621	1.354	0.498	0.187	0.140	0.114	0.060	0.052	0.062	0.088	0.675
Total Flow (1000 ft ³)	625.2	825.9	12849.1	5670.3	12575.4	8558.7	3327.1	888.4	1421.1	1513.3	295.1	221.4	307.2	679.8	10557.1

Table C.6. Daily streamflow at the Raccoon Creek monitoring station for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.030 (e)	0.018	0.029	0.734	0.038	0.276	0.468	0.051	0.034	1.513	0.009	0.010	0.005	0.009	10.903
2	0.020 (e)	0.022	0.025	0.399	0.054	0.312	0.275	0.037	0.030	1.517	0.008	0.008	0.004	0.012	9.503
3	0.020 (e)	0.02 (e)	2.590	0.238	0.052	4.583	0.181	0.031	0.037	0.662	0.007	0.006	0.003	0.012	5.233
4	0.055	0.02 (e)	0.341	0.158	0.051	1.684	0.135	0.029	0.033	0.176	0.012	0.004	0.004	0.014	0.872
5	0.066	0.03 (e)	0.130	0.121	0.048	0.668	0.128	0.054	0.027	0.113	0.018	0.004	0.005	0.015	0.278
6	0.065	0.02 (e)	0.076	0.096	0.075	0.765	0.101	0.042	0.022	0.068	0.012	0.004	0.005	0.012	0.175
7	0.067	0.02 (e)	0.054	2.224	0.073	0.620	0.083	0.029	0.012	0.047	0.007	0.006	0.004	0.006	0.109
8	0.251	0.018	0.042	0.570	0.058	0.289	0.082	0.024	0.012	0.040	0.008	0.005	0.004	0.007	0.077
9	0.096	0.224	0.034	0.288	0.053	0.205	0.107	0.030	0.015	0.044	0.109	0.005	0.005	0.008	1.318
10	0.062	1.073	0.030	0.508	0.051	0.159	0.117	0.028	0.012	0.049	0.085	0.005	0.004	0.009	0.637
11	0.063	0.147	0.027	1.603	0.045	0.125	0.090	0.022	0.016	0.039	0.024	0.005	0.004	0.009	0.236
12	0.076	0.077	0.024	0.726	0.043	0.133	0.068	0.114	1.136	0.029	0.016	0.004	0.004	0.010	0.144
13	0.040	0.064	0.028	0.393	2.341	1.035	0.531	0.093	0.160	0.069	0.019	0.004	0.004	0.010	3.333
14	0.029	0.042	0.172	0.304	2.179	0.406	0.269	0.049	0.053	0.049	0.012	0.005	0.004	0.009	4.033
15	0.023	0.029	0.073	0.285	0.502	0.215	0.785	0.034	0.034	0.045	0.011	0.004	0.080	0.009	0.742
16	0.020 (e)	0.026	0.058	0.609	0.238	0.163	0.251	0.027	0.026	0.036	0.009	0.004	0.015	0.011	0.327
17	0.020 (e)	0.027	0.487	0.335	3.531	0.147	0.207	0.025	0.030	0.020	0.008	0.004	0.008	0.011	0.199
18	0.070 (e)	0.022	1.524	0.136	13.297	0.857	0.175	0.021	0.037	0.016	0.010	0.005	0.007	0.012	0.128

Table C.6 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	0.033	0.018	0.402	0.108	4.868	0.175	0.194	0.356	0.021	0.024	0.017	0.007	0.013	0.010	0.074
21	0.025	0.021	0.321	0.081	1.437	0.139	0.155	0.069	0.031	0.021	0.012	0.006	0.008	0.058	0.067
22	0.285	0.025	59.700	0.059	0.767	0.232	0.134	0.042	0.060	0.023	0.007	0.008	0.008	2.909	0.063
23	0.172	0.024	53.800	0.043	0.443	2.483	0.100	0.028	0.119	0.023	0.007	0.008	0.007	0.259	2.602
24	0.068	0.019	1.484	0.027	0.276	0.545	0.072	0.024	0.362	0.061	0.007	0.033	0.011	0.075	0.993
25	0.058	0.019	0.614	0.015	0.197	0.278	0.056	0.018	1.097	0.034	0.007	0.025	0.016	0.067	0.358
26	0.055	0.019	0.315	0.013	0.158	0.193	0.047	0.019	0.724	0.020	0.015	0.011	0.015	0.065	0.204
27	0.042	0.019	1.475	0.012	0.118	0.152	0.051	0.059	0.172	0.017	0.024	0.009	0.014	0.041	0.141
28	0.038	0.093	5.648	0.011	0.096	0.264	0.053	0.581	0.085	0.014	0.014	0.007	0.016	0.014	2.154
29	0.039	0.064	1.769	0.009		8.541	0.111	0.089	0.053	0.014	0.010	0.007	0.016	0.012	0.821
30	0.043	0.033	3.440	0.027		2.977	0.071	0.046	0.042	0.015	0.023	0.007	0.012	0.252	0.353
31	0.033		2.062	0.019		0.882		0.032		0.02	0.016		0.003		0.204
MEAN	0.065	0.076	1.609	0.33	1.58	0.959	0.186	0.068	0.15	0.156	0.017	0.007	0.01	0.131	1.495
MAX	0.285	1.073	13.721	2.224	13.297	8.541	0.531	0.581	1.136	1.517	0.109	0.033	0.016	2.909	10.903
MIN	0.02	0.018	0.024	.009	0.038	0.125	0.047	0.018	0.012	0.014	0.007	0.004	0.003	0.006	0.063
Total Flow (1000 ft ³)	173.0	196.0	4312.1	885.3	3824.3	2569.8	482.2	184.2	389.8	417.8	48.1	20.2	27.7	342.1	4006.3

(c) = Estimated data.

Table C.7. Daily streamflow at the White Oak Creek Headwaters (WOCHW) monitoring station
for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.167	0.265	0.286	5.232	0.665	1.666	3.590	0.675	0.741	1.575	0.315	0.194	0.146	0.162	10.294
2	0.177	0.232	0.289	3.188	0.645	1.748	2.708	0.632	0.673	1.434	0.300	0.191	0.151	0.141	23.707
3	0.191	0.204	1.844	2.188	0.645	4.422	2.260	0.605	1.347	1.381	0.290	0.176	0.145	0.137	16.797
4	0.313	0.192	2.238	2.009	0.645	6.459	1.967	0.589	1.634	1.104	0.285	0.175	0.137	0.137	5.377
5	0.239	0.216	1.663	1.853	0.649	3.998	1.799	0.626	1.410	0.967	0.288	0.170	0.177	0.137	2.799
6	0.224	0.199	1.312	1.644	0.713	3.142	1.553	0.598	1.164	0.832	0.273	0.199	0.151	0.137	2.063
7	0.213	0.194	1.031	2.791	0.694	2.431	1.350	0.557	0.936	0.733	0.259	0.177	0.144	0.137	1.609
8	0.442	0.186	0.795	2.901	0.657	2.047	1.245	0.525	0.750	0.676	0.248	0.171	0.137	0.157	1.265
9	0.307	0.297	0.634	2.403	0.645	1.795	1.181	0.534	0.638	0.634	0.311	0.160	0.137	0.151	1.625
10	0.288	0.795	0.533	2.400	0.645	1.575	1.098	0.513	0.550	0.603	0.293	0.161	0.137	0.151	2.124
11	0.304	0.706	0.475	3.166	0.647	1.378	1.008	0.499	0.499	0.586	0.271	0.165	0.137	0.137	1.955
12	0.261	0.559	0.428	3.181	0.618	1.305	0.964	0.506	4.007	0.631	0.255	0.149	0.137	0.137	1.697
13	0.238	0.450	0.431	2.647	1.539	1.894	1.279	0.503	4.391	1.177	0.249	0.145	0.137	0.137	2.578
14	0.222	0.372	0.482	2.290	4.252	1.881	1.322	0.474	2.355	0.738	0.261	0.145	0.138	0.137	10.383
15	0.207	0.310	0.460	2.050	3.017	1.856	2.330	0.451	1.746	0.635	0.280	0.137	0.442	0.137	4.921
16	0.197	0.286	0.445	2.007	2.191	1.753	2.331	0.522	1.390	0.563	0.242	0.137	0.225	0.137	2.990
17	0.192	0.282	0.840	1.724	3.770	1.670	2.122	0.500	1.312	0.510	0.238	0.133	0.189	0.137	2.293
18	0.403	0.263	2.315	1.562	37.168	2.037	1.882	0.823	1.388	0.493	0.239	0.135	0.171	0.137	1.850

Table C.7 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
19	0.310	0.249	3.337	1.492	41.453	1.883	1.759	0.877	1.261	0.463	0.271	0.191	0.162	0.137	1.435
20	0.270	0.227	2.557	1.492	26.101	1.846	1.491	1.211	1.247	0.437	0.249	0.147	0.151	0.148	1.171
21	0.281	0.233	2.210	1.330	10.764	1.730	1.251	1.054	1.114	0.426	0.240	0.146	0.151	0.294	1.030
22	0.416	0.248	29.670	1.222	6.936	1.654	1.114	0.858	0.998	0.400	0.221	0.152	0.151	1.531	0.923
23	0.442	0.237	62.841	1.165	4.196	3.025	1.024	0.771	0.982	0.387	0.207	0.153	0.151	0.627	2.162
24	0.410	0.213	8.477	1.098	2.962	3.070	0.920	0.714	3.965	0.429	0.193	0.374	0.151	0.415	3.545
25	0.380	0.209	5.655	1.003	2.361	2.502	0.837	0.623	14.165	0.412	0.204	0.261	0.151	0.301	2.741
26	0.341	0.197	3.222	0.933	1.949	2.175	0.779	0.550	11.055	0.391	0.288	0.201	0.145	0.230	2.213
27	0.322	0.191	2.975	0.899	1.623	1.996	0.790	0.662	5.489	0.382	0.240	0.171	0.137	0.196	1.889
28	0.305	0.336	12.150	0.880	1.537	1.843	0.754	1.055	3.199	0.368	0.221	0.151	0.137	0.179	2.627
29	0.302	0.316	7.957	0.798		11.995	0.772	1.085	2.298	0.359	0.223	0.154	0.137	0.167	3.199
30	0.290	0.306	7.868	0.828		10.566	0.723	0.979	1.861	0.339	0.231	0.155	0.137	0.292	2.589
31	0.276		9.404	0.757		5.623		0.834		0.319	0.216		0.139		2.143
MEAN	0.288	0.299	5.639	1.907	5.703	2.998	1.473	0.69	2.485	0.657	0.254	0.172	0.159	0.235	3.999
MAX	0.442	0.795	62.841	5.232	41.453	11.995	3.590	1.211	14.165	1.575	0.315	0.374	0.442	1.531	23.707
MIN	0.167	0.191	0.286	0.757	0.618	1.305	0.723	0.451	0.499	0.319	0.193	0.133	0.137	0.137	0.923
Total Flow (1000 ft ³)	771.5	775.2	15105.0	5109.1	13796.8	8032.4	3819.2	1849.0	6442.5	1761.3	682.7	447.1	426.7	609.8	10713.1

Table C.8. Daily streamflow at the West Seep monitoring station for the period October 1, 1990–December 31, 1991
(units = cfs)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	0.030	0.039	0.100	1.011	0.175	0.707	0.667	0.152	0.089	0.885	0.014	0.015	0.016	0.036	9.604
2	0.022	0.043	0.095	0.597	0.162	0.591	0.503	0.129	0.164	0.962	0.012	0.014	0.015	0.027	10.229
3	0.020	0.043	2.081	0.416	0.162	4.679	0.417	0.126	0.191	0.968	0.010	0.014	0.018	0.022	5.612
4	0.211	0.043	0.746	0.546	0.162	2.395	0.365	0.121	0.143	0.360	0.020	0.012	0.020	0.020	1.431
5	0.054	0.108	0.324	0.875	0.151	1.055	0.373	0.169	0.087	0.292	0.018	0.011	0.026	0.020	0.911
6	0.038	0.081	0.219	0.801	0.206	0.876	0.342	0.135	0.073	0.188	0.011	0.012	0.017	0.020	0.712
7	0.031	0.052	0.170	1.915	0.179	0.850	0.319	0.121	0.071	0.142	0.013	0.010	0.015	0.021	0.273
8	0.404	0.049	0.138	1.183	0.161	0.611	0.332	0.116	0.066	0.108	0.014	0.008	0.016	0.039	0.139
9	0.096	0.319	0.115	0.567	0.151	0.467	0.361	0.152	0.066	0.085	0.303	0.008	0.015	0.033	1.195
10	0.075	1.046	0.108	0.631	0.147	0.378	0.313	0.119	0.066	0.079	0.326	0.006	0.016	0.027	1.217
11	0.152	0.282	0.097	1.578	0.138	0.338	0.258	0.116	0.066	0.104	0.052	0.010	0.016	0.024	0.495
12	0.114	0.167	0.089	1.080	0.133	0.389	0.248	0.334	1.183	0.141	0.032	0.010	0.023	0.025	0.309
13	0.066	0.121	0.127	0.641	2.071	1.061	0.804	0.551	0.379	0.193	0.028	0.008	0.019	0.024	3.668
14	0.047	0.098	0.276	0.463	2.904	0.852	0.597	0.748	0.167	0.058	0.042	0.005	0.020	0.024	5.001
15	0.036	0.085	0.196	0.391	0.879	0.581	1.437	0.645	0.122	0.058	0.046	0.005	0.263	0.024	1.011
16	0.030	0.079	0.175	0.531	0.477	0.443	0.761	0.599	0.108	0.058	0.026	0.004	0.051	0.024	0.491
17	0.030	0.072	0.904	0.442	3.065	0.454	0.485	0.451	0.160	0.058	0.020	0.005	0.031	0.024	0.325
18	0.401	0.066	2.139	0.378	226.700	1.129	0.362	0.193	0.132	0.060	0.024	0.005	0.025	0.024	0.232
19	0.109	0.065	1.772	0.393	151.600	0.678	0.503	0.224	0.132	0.039	0.085	0.024	0.024	0.024	0.180

Table C.8 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	0.065	0.058	1.151	0.426	5.678	0.499	0.382	0.702	0.183	0.028	0.040	0.014	0.026	0.035	0.159
21	0.048	0.058	0.680	0.364	2.059	0.411	0.321	0.212	0.154	0.023	0.023	0.009	0.023	0.280	0.154
22	0.330	0.058	11.261	0.326	1.412	0.496	0.275	0.149	0.206	0.019	0.019	0.008	0.024	1.707	0.154
23	0.282	0.073	14.010	0.298	1.064	2.758	0.236	0.133	0.252	0.016	0.014	0.007	0.023	0.182	2.186
24	0.125	0.066	1.634	0.265	0.543	1.076	0.202	0.100	0.540	0.164	0.012	0.186	0.023	0.087	1.558
25	0.083	0.060	0.751	0.228	0.389	0.618	0.174	0.076	1.590	0.071	0.010	0.093	0.020	0.057	0.647
26	0.060	0.058	0.456	0.212	0.333	0.450	0.162	0.071	1.489	0.044	0.107	0.040	0.020	0.046	0.399
27	0.049	0.057	1.040	0.203	0.285	0.442	0.209	0.203	0.478	0.038	0.049	0.022	0.020	0.043	0.297
28	0.043	0.270	5.816	0.196	0.261	0.511	0.191	0.982	0.247	0.032	0.026	0.018	0.020	0.036	1.991
29	0.042	0.180	2.007	0.178		7.934	0.248	0.276	0.168	0.028	0.023	0.017	0.020	0.036	1.358
30	0.037	0.129	3.612	0.275		2.978	0.194	0.157	0.129	0.023	0.034	0.017	0.020	0.312	0.635
31	0.036		2.849	0.216		1.07		0.11		0.017	0.02		0.020		0.404
MEAN	0.102	0.131	1.778	0.568	1.817	1.218	0.401	0.270	0.295	0.172	0.047	0.020	0.029	0.011	1.708
MAX	0.404	1.046	14.010	1.915	14.198	7.934	1.437	0.982	1.590	0.968	0.326	0.186	0.263	1.707	10.229
MIN	0.020	0.039	0.089	0.178	0.133	0.338	0.162	0.071	0.066	0.016	0.010	0.004	0.015	0.020	0.139
Total Flow (1000 ft ³)	273.6	339.2	4763.9	1523.1	4395.8	3263.9	1040.3	723.3	766.4	461.5	127.2	53.4	78.3	285.7	4577.3

Table C.9. Daily streamflow at monitoring station GS1 (USGS 03536450) for October 1, 1990–December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.25	.24	.21	e3.0	39	1.3	2.2	.53	e.40	.68	.24	.22	.11	.20	9.7
2	.21	.24	.23	e2.3	37	1.1	1.8	.51	e.40	1.9	.23	.21	.11	.12	11
3	.21	.23	.29	e1.9	36	4.9	1.6	.48	e.50	1.2	.23	.22	.12	.13	7.4
4	.68	.22	1.2	e1.6	36	3.6	1.3	.48	e.50	.97	.28	.22	.13	.13	2.7
5	.27	.37	.96	e1.4	36	2.4	1.3	.67	e.45	.84	.25	.21	.22	.13	1.8
6	.24	.21	.71	e1.2	.48	2.3	1.1	.45	e.40	.63	.25	.21	.13	.13	1.3
7	.23	.20	.53	e2.8	.42	1.7	.99	.40	e.45	.53	.25	.20	.12	.13	1.0
8	1.0	.20	.41	e2.0	39	1.4	1.0	.38	e.40	.46	.25	.20	.13	.20	.72
9	.31	.80	.34	1.5	38	1.2	.99	.49	e.38	.44	.78	.20	.13	.14	2.0
10	.37	1.4	.32	1.8	38	1.1	.83	.40	e.37	.40	.35	.20	.13	.12	1.6
11	.37	.65	.30	2.2	38	.98	.76	.40	e.37	.38	.27	.21	.13	.12	1.3
12	.30	.49	.28	1.9	37	1.1	.74	.61	e2.0	.42	.27	.21	.12	.13	1.1
13	.27	.39	.40	1.6	2.6	1.8	1.4	.43	e.80	.60	.27	.21	.12	.14	3.8
14	.25	.33	.43	1.3	2.9	1.4	.93	.40	e.50	.37	.28	.21	.16	.14	4.9
15	.24	.30	.34	1.3	1.9	1.3	1.8	.40	e.40	.34	.31	.21	1.1	.14	2.6
16	.24	.28	.33	1.4	1.4	1.2	1.3	.63	e.35	.33	.26	.20	.22	.14	1.9
17	.24	.24	1.1	1.1	4.2	1.2	1.2	.41	e.45	.32	.25	.21	.18	.13	1.5
18	1.0	.24	2.1	.98	15	1.7	1.1	.68	.43	e.34	.26	.22	.16	.13	1.2
19	.36	.23	1.6	1.0	17	1.2	1.3	.81	.40	e.44	.47	.31	.15	.14	1.0

Table C.9 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	.30	.22	1.5	1.0	10	1.2	.96	1.1	.52	e.36	.27	.20	.14	.20	.96
21	.26	.22	1.2	.92	4.6	1.1	.86	.54	.41	e.33	.26	.19	.15	.93	.84
22	.83	.22	12	.83	2.9	1.3	.74	.47	.50	e.36	.25	.19	.14	.33	.81
23	.52	.22	26	.75	2.2	3.2	.65	.43	.51	e.38	.23	.20	.11	.59	3.6
24	.38	.21	e4.6	.69	1.8	2.0	.61	.42	1.5	e.60	.23	1.0	.11	.34	2.5
25	.29	.21	e2.6	.60	1.6	1.7	.57	.41	1.8	e.33	.24	.37	.10	.25	2.1
26	.26	.21	e1.8	.55	1.3	1.4	.56	.40	1.5	e.27	.53	.21	.10	.15	1.8
27	.25	.21	e3.0	.52	1.1	1.4	.67	.69	.97	.24	.24	.18	.10	.13	1.4
28	.24	.56	e7.3	.50	.98	1.3	.57	1.4	.70	.24	.21	.18	.11	.10	2.9
29	.24	.26	e4.5	.45		9.0	.72	.59	.56	.25	.37	.18	.12	.10	2.0
30	.24	.21	e5.7	.62		5.6	.58	e.51	.48	.24	.29	.18	.12	.82	1.7
31	.24		e4.9	.47		3.1		e.43		.24	.24		.13		1.4
TOTAL	11.09	10.01	89.79	40.18	76.12	65.18	31.13	16.95	19.40	15.43	9.11	7.16	5.10	9.55	80.53
MEAN	.36	.33	2.90	1.30	2.72	2.10	1.04	.55	.65	.50	.29	.24	.16	.32	2.60
MAX	1.0	1.4	26	3.0	17	9.0	2.2	1.4	2.0	1.9	.78	1.0	1.1	3.3	11
MIN	.21	.20	.21	.45	.36	.98	.56	.38	.35	.24	.21	.18	.10	.10	.72

e=Estimated data.

Table C.10. Daily streamflow at monitoring station GS2 (USGS 03537100) for October 1, 1990–December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.00	.03	.10	1.8	.34	.79	1.6	e.17	.07	.15	.00	.00	.00	.02	.15
2	.00	.03	.10	1.2	.29	1.1	1.2	e.12	.07	.38	.00	.00	.00	.02	.16
3	.00	.03	.35	.92	.27	6.6	.93	e.10	2.9	.45	.00	.00	.00	.01	8.7
4	.06	.03	1.3	.66	.23	3.4	.72	e.10	1.4	.14	.00	.00	.00	.01	1.6
5	.02	.15	.57	.53	.23	1.7	.82	e.15	.43	.16	.00	.00	.01	.01	.77
6	.01	.16	.33	.42	.34	1.9	.59	e.13	.17	.08	.00	.01	.01	.01	.44
7	.00	.09	.22	2.1	.25	1.8	.46	e.09	.10	e.06	.00	.01	.01	.01	.30
8	.39	.05	.16	1.3	.21	1.2	.47	e.08	.06	e.06	.00	.00	.01	.02	.22
9	.08	.18	.13	.90	.17	.98	.70	e.12	e.06	e.06	.07	.00	.01	.02	2.2
10	.05	1.6	.11	1.0	.17	.73	.52	e.09	e.06	e.05	e.06	.00	.01	.02	1.8
11	.18	.45	.10	2.6	.14	.57	.36	e.07	e.05	e.06	e.03	.00	.01	.01	.92
12	.07	.22	.07	1.6	.13	.62	.34	e.20	e.30	.05	e.02	.00	.01	.01	.55
13	.05	.14	.11	1.1	.34	1.8	1.4	e.18	1.2	.22	e.02	.00	.00	.01	6.0
14	.03	.12	.42	.98	4.4	1.3	.91	e.14	.37	.04	e.03	.00	.00	.01	7.8
15	.02	.10	.24	.86	1.5	.95	2.8	e.05	.18	.03	e.03	.00	.20	.01	1.8
16	.02	.09	.18	1.3	.95	.71	1.2	.13	.11	.02	e.02	.00	.04	.01	1.1
17	.02	.07	.89	1.0	5.0	.68	.81	.09	.34	.02	e.02	.00	.02	.01	.73
18	.42	.06	2.8	.77	.22	1.9	.54	1.4	.41	.04	e.01	.00	.01	.01	.46
19	.11	.06	1.9	.84	.21	1.1	1.2	.90	.13	.03	e.07	.00	.01	.01	.34

Table C.10 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	.06	.06	1.2	1.1	9.2	.85	1.1	2.7	.26	.02	.05	.00	.01	.02	.27
21	.04	.05	1.1	.86	3.0	.67	.70	.71	.19	.01	.02	.00	.01	.24	.26
22	.45	.05	18	.72	2.0	.84	.48	.27	.44	.01	.00	.00	.01	.34	.23
23	.45	.06	28	.56	1.5	3.4	.34	e.18	.84	.00	.00	.00	.01	.33	3.7
24	.17	.05	2.8	.47	1.1	1.5	.25	e.09	2.9	.02	.00	.05	.01	.13	2.1
25	.10	.04	1.4	.39	.87	1.1	.20	e.07	5.6	.03	.00	.02	.01	.07	1.1
26	.06	.04	.97	.36	.70	.85	.16	e.06	3.9	.02	.04	.00	.01	.05	.74
27	.05	.04	1.9	.32	.52	.70	.28	e.35	1.5	.03	.02	.00	.01	.04	.54
28	.04	.42	9.1	.31	.41	1.2	.23	e1.5	.77	.02	.00	.00	.01	.04	2.9
29	.04	.24	3.3	.27		13	.34	.45	.39	.01	.00	.00	.01	.03	1.8
30	.03	.13	5.7	.63		5.7	.22	.19	.20	.00	.00	.00	.01	.28	1.1
31	.03		4.4	.46		2.3		.09		.00	.00		.01		.76
TOTAL	3.05	4.84	91.10	28.33	80.32	61.94	21.87	10.97	28.10	2.27	0.51	0.09	0.48	4.87	82.23
MEAN	.098	.16	2.94	.91	2.87	2.00	.73	.35	.94	.073	.016	.003	.015	.16	2.65
MAX	.45	1.6	28	2.6	22	13	2.8	2.7	5.6	.45	.07	.05	.20	3.4	16
MIN	.00	.03	.07	.27	.13	.57	.16	.05	.05	.00	.00	.00	.00	.01	.22

e=Estimated data.

Table C.11. Daily streamflow at monitoring station GS3 (USGS 03536550) for October 1, 1990–December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	5.4	5.1	5.0	25	7.4	14	19	7.1	7.3	11	5.4	5.5	5.0	5.8	85
2	5.1	5.1	5.2	19	7.0	13	15	6.6	7.0	17	5.5	5.5	4.7	4.7	101
3	5.0	4.8	29	15	6.6	43	13	6.9	14	12	5.3	5.5	4.8	4.3	66
4	10	5.0	14	13	6.6	34	12	6.7	9.5	9.3	5.8	5.4	4.9	4.5	25
5	5.8	7.0	10	11	6.7	23	12	8.1	8.0	8.7	5.8	5.5	5.8	4.8	16
6	5.0	5.7	8.7	10	7.8	20	9.9	6.5	7.1	7.5	5.8	5.9	4.3	4.9	12
7	4.9	5.6	7.2	27	7.0	17	9.2	6.4	6.8	6.9	6.1	5.6	4.5	4.8	10
8	13	5.4	7.1	18	6.9	14	9.9	6.2	6.3	6.9	5.9	5.5	4.6	5.4	8.6
9	6.6	9.5	6.5	16	6.7	12	9.9	7.2	6.1	6.9	10	5.8	4.6	5.0	20
10	6.6	17	6.0	17	6.7	11	8.4	6.6	6.0	7.1	6.9	5.7	4.8	4.9	16
11	6.8	8.6	5.8	24	6.4	10	8.1	6.1	6.1	7.2	6.0	5.9	4.8	5.0	12
12	6.0	7.0	5.7	19	6.3	11	8.1	8.3	35	7.3	6.0	5.5	4.7	5.2	11
13	5.7	6.3	6.8	15	24	19	14	6.7	17	13	5.8	5.3	5.0	4.7	31
14	5.4	5.8	8.0	13	32	14	9.7	6.3	11	7.0	5.9	5.4	4.7	4.6	49
15	5.2	5.5	6.2	12	19	12	20	6.5	8.9	6.4	6.3	5.2	14	4.5	23
16	5.4	5.3	6.2	15	14	11	14	8.7	8.2	6.7	5.7	5.3	5.7	4.4	16
17	5.2	5.4	13	12	35	12	12	6.5	9.9	6.5	5.5	5.1	5.1	4.3	13
18	14	5.2	23	11	140	17	11	13	8.6	6.7	5.6	5.4	4.9	4.5	11
19	6.5	5.1	19	11	134	12	14	9.8	8.1	6.3	7.6	6.7	4.8	4.7	8.8

Table C.11 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	5.5	4.8	16	12	81	11	11	16	9.6	6.2	5.7	4.8	4.7	5.4	7.8
21	5.2	5.0	13	11	39	11	9.0	9.1	7.8	6.1	5.9	4.4	5.2	11	7.3
22	12	4.67	117	9.8	27	12	8.3	8.2	8.6	6.2	5.7	4.4	5.3	29	7.1
23	8.1	5.0	e150	9.0	20	30	8.2	7.7	9.2	6.3	5.8	4.5	5.1	7.9	30
24	6.5	4.8	41	8.9	17	18	7.8	6.8	27	9.9	5.5	12	5.3	6.7	23
25	5.9	4.7	25	8.3	14	14	7.3	6.5	42	7.2	5.5	6.7	5.2	5.7	16
26	5.6	4.5	18	7.7	13	12	7.1	6.0	32	6.4	9.1	4.9	4.8	5.4	12
27	5.3	4.9	24	7.7	12	12	8.5	9.9	19	6.3	6.5	5.0	4.9	5.2	11
28	5.2	9.0	65	7.8	11	13	7.2	16	14	6.4	6.1	4.7	5.2	5.1	25
29	5.2	5.6	37	7.7		74	9.1	8.8	11	6.1	7.7	4.8	5.5	4.7	20
30	5.0	5.7	46	9.2		44	7.6	8.0	9.8	5.8	6.6	4.7	5.3	11	15
31	5.4		44	7.7		26		7.5		5.5	5.7		5.1		12
TOTAL	202.5	183.0	788.4	409.8	714.1	596	320.3	250.7	380.9	238.8	192.7	166.6	163.3	188.1	720.6
MEAN	6.53	6.10	25.4	13.2	25.5	19.2	10.7	8.09	12.7	7.70	6.22	5.55	5.27	6.27	23.2
MAX	14	17	150	27	140	74	20	16	42	17	10	12	14	29	101
MIN	4.9	4.5	5.0	7.7	6.3	10	7.1	6.0	6.0	5.5	5.3	4.4	4.3	4.3	7.1

e=Estimated data.

Table C.12. Daily streamflow at monitoring station GS4 (USGS 03536440) for October 1, 1990–December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.45	.33	.49	2.5	.46	.97	1.7	.36	.41	1.1	.38	.47	.34	.37	17
2	.44	.33	.47	1.5	.44	1.0	1.3	.33	.42	2.9	.40	.47	.33	.31	19
3	.41	.34	.43	1.1	.44	8.0	.96	.32	.48	1.7	.38	.49	.33	.30	11
4	.67	.35	1.5	.84	.44	4.6	.77	.30	.47	.97	.39	.47	.34	.28	2.5
5	.45	.47	.95	.70	.45	2.3	.76	.39	.40	.77	.38	.47	.36	.31	1.3
6	.41	.40	.74	.59	.50	2.1	.62	.35	.36	.62	.37	.51	.31	.28	.96
7	.41	.35	.64	3.5	.48	1.7	.57	.37	.38	.56	.33	.50	.28	.28	.71
8	1.0	.36	.55	1.8	.48	1.2	.57	.33	.36	.49	.33	.47	.28	.31	.57
9	.54	.89	.49	1.2	.44	.97	.60	.36	.35	.48	.62	.47	.30	.28	2.2
10	.50	2.2	.44	1.4	.41	.84	.51	.35	.35	.45	.44	.49	.28	.28	1.7
11	.53	.83	.48	2.9	.41	.74	.44	.33	.36	.41	.36	.50	.30	.28	1.0
12	.52	.67	.44	2.6	.42	.78	.44	.47	2.9	.44	.34	.49	.28	.28	.77
13	.44	.54	.50	1.3	3.5	1.9	1.2	.42	.88	.53	.36	.41	.28	.27	5.7
14	.41	.45	.74	1.0	4.7	1.3	.59	.36	.54	.41	.36	.33	.28	.25	8.0
15	.38	.44	.61	.87	1.9	1.1	1.7	.33	.46	.39	.36	.33	.75	.28	2.5
16	.40	.45	.55	1.2	1.2	.90	.99	.38	.41	.41	.33	.31	.33	.28	1.4
17	.38	.42	1.3	.90	5.9	.87	.81	.33	.50	.32	.35	.35	.27	.28	1.1
18	1.1	.41	3.0	.76	.28	1.8	.70	.41	.46	.38	.45	.34	.29	.28	.93
19	.52	.41	2.1	.74	.29	1.1	.87	.45	.41	.40	.54	.35	.28	.31	.62

Table C.12 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	.42	.41	1.6	.80	13	.93	.64	1.3	.50	.36	.46	.31	.28	.32	.55
21	.41	.43	1.4	.71	4.5	.87	.53	.56	.48	.35	.44	.28	.28	.72	.50
22	.96	.41	24	.66	2.6	1.0	.50	.47	.46	.35	.44	.28	.30	.31	.47
23	.84	.41	32	.61	1.6	4.8	.53	.46	.52	.37	.47	.28	.34	.60	4.3
24	.61	.41	4.5	.60	1.2	e3.0	.45	.40	.97	.66	.44	.66	.38	.40	3.1
25	.54	.41	2.2	.60	1.0	e2.4	.45	.38	2.2	.46	.44	.39	.38	.35	1.6
26	.50	.41	1.2	.54	.87	e1.3	.41	.38	1.7	.44	.61	.37	.35	.37	1.2
27	.47	.44	2.7	.53	.75	e1.2	.44	.57	.82	.43	.54	.37	.34	.38	.96
28	.44	.71	11	.52	.66	e1.0	.38	1.5	.64	.41	.52	.35	.35	.35	3.6
29	.41	.59	4.6	.47		e1.2	.49	.58	.53	.41	.55	.35	.33	.33	2.5
30	.38	.54	7.1	.51		6.4	.44	.48	.48	.41	.54	.33	.33	.86	1.6
31	.41		5.7	.50		2.8		.46		.38	.50		.30		1.2
TOTAL	16.35	15.76	118.29	33.85	105.75	71.87	21.46	14.48	20.20	18.82	13.42	12.19	10.17	13.29	100.54
MEAN	.53	.53	3.82	1.09	3.78	2.32	.72	.47	.67	.61	.43	.41	.33	.44	3.24
MAX	1.1	2.2	32	3.5	29	12	1.7	1.5	2.9	2.9	.62	.66	.75	3.1	19
MIN	.38	.33	.44	.47	.41	.74	.38	.30	.35	.35	.33	.28	.27	.25	.47

e = Estimated data.

Table C.13. Daily streamflow at monitoring station GS5 (USGS 03536380) for October 1, 1990–December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	2.6	2.2	2.5	14	3.5	7.7	11	3.6	3.8	e6.2	e2.3	2.4	2.2	2.8	5.9
2	2.3	2.2	2.6	10	3.4	6.8	8.4	3.4	3.5	e1.1	e2.3	2.4	2.2	2.3	6.7
3	2.2	2.2	1.7	8.4	3.3	2.5	6.9	3.2	1.1	e7.5	e2.3	2.4	2.2	2.2	4.5
4	5.4	2.1	7.6	6.9	3.3	1.9	6.1	3.1	6.0	e6.0	e2.4	2.2	2.2	2.2	1.4
5	2.6	3.3	5.3	6.1	3.3	1.2	6.2	4.2	4.9	e5.0	e2.4	2.2	3.0	2.2	8.7
6	2.3	2.6	4.4	5.5	4.1	1.1	5.2	3.3	4.2	e4.0	2.4	2.6	2.4	2.2	6.5
7	2.2	2.4	3.8	1.6	3.5	8.6	4.8	3.1	3.7	e3.5	2.4	2.4	2.1	2.2	5.4
8	7.3	2.2	3.3	9.9	3.3	7.0	5.1	3.0	3.4	e3.5	2.4	2.3	2.1	2.4	4.5
9	3.3	5.4	3.1	8.2	3.2	6.1	5.1	3.8	3.2	e3.5	4.9	2.3	2.2	2.3	1.2
10	3.4	8.3	2.9	9.9	3.1	5.5	4.3	3.1	3.0	e3.6	3.0	2.2	2.2	2.2	8.8
11	3.3	3.8	2.9	1.3	3.2	5.1	3.9	2.8	3.0	e3.7	2.5	2.3	2.2	2.2	6.7
12	2.9	3.3	2.8	1.0	3.2	5.9	4.1	4.3	e2.2	e3.9	2.4	2.2	2.2	2.2	5.7
13	2.8	3.1	3.6	8.3	1.5	1.0	7.7	3.3	e1.1	e6.0	2.3	2.2	2.2	2.1	2.2
14	2.5	3.0	3.8	7.0	1.7	7.3	5.0	3.1	e7.0	e4.5	2.7	2.2	2.3	2.1	3.1
15	2.5	2.9	3.1	6.7	1.0	6.3	1.2	2.9	e5.0	e3.5	3.3	2.2	7.6	2.2	1.3
16	2.4	2.7	2.9	7.7	7.3	5.7	7.5	4.8	e4.5	e3.5	2.6	2.2	2.8	1.9	9.0
17	2.4	2.7	7.5	5.7	2.3	6.2	6.6	3.4	e5.5	e3.4	2.4	2.2	2.4	1.9	7.0
18	7.3	2.5	1.3	5.3	9.0	9.4	5.9	9.7	e5.0	e3.5	2.5	2.4	2.4	2.0	5.9
19	3.0	2.5	1.0	5.6	9.3	6.5	8.3	5.1	e4.5	e3.3	3.9	3.7	2.3	2.0	4.8

Table C.13 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	2.9	2.4	9.0	5.8	5.3	6.0	5.8	8.7	e5.4	e3.3	2.6	2.2	2.3	2.7	4.0
21	2.6	2.3	7.2	5.3	22	5.5	4.9	4.4	e4.3	e3.2	2.4	2.2	2.3	7.4	3.6
22	6.0	2.3	80	4.9	15	6.2	4.6	3.9	e4.7	e3.1	2.4	2.2	2.3	18	3.5
23	3.8	2.4	106	4.7	11	17	4.3	3.4	e5.5	e3.0	2.4	2.2	2.2	3.9	18
24	3.0	2.3	24	4.5	8.8	9.8	4.0	3.2	e17	e5.0	2.2	7.2	2.1	3.4	12
25	2.8	2.3	15	4.3	7.9	7.9	3.9	3.1	e27	e3.2	2.2	3.5	2.1	3.0	8.4
26	2.5	2.2	11	4.0	6.8	6.7	3.9	2.9	e20	e2.8	4.6	2.5	2.1	2.8	6.5
27	2.4	2.2	18	3.8	6.1	6.7	4.5	e6.0	e12	e2.6	2.7	2.3	2.1	2.5	5.7
28	2.3	4.7	40	3.9	5.5	6.5	3.6	e9.5	e7.5	e2.7	2.6	2.2	2.2	2.4	15
29	2.2	2.9	21	3.6		50	4.9	4.5	e6.3	e2.6	3.8	2.2	2.2	2.3	11
30	2.2	2.6	29	4.8		27	3.8	4.1	e5.0	e2.5	3.0	2.2	2.2	7.4	8.4
31	2.2		24	3.8		15		3.8		e2.3	2.5		2.2		6.6
TOTAL	97.6	88.0	486.3	217.6	431.8	335.4	172.3	130.7	228.8	125.4	84.8	75.9	75.5	97.4	438.7
MEAN	3.15	2.93	15.7	7.02	15.4	10.8	5.74	4.22	7.63	4.05	2.74	2.53	2.44	3.25	14.2
MAX	7.3	8.3	106	16	93	50	12	9.7	27	11	4.9	7.2	7.6	18	67
MIN	2.2	2.1	2.5	3.6	3.1	5.1	3.6	2.8	3.0	2.3	2.2	2.2	2.1	1.9	3.5

e=Estimated data.

Table C.14. Daily streamflow at monitoring station GS6 (USGS 03536320) for October 1, 1990—December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.08	.06	.09	5.4	.16	1.7	3.6	.36	.39	1.1	.06	.06	.05	.18	27
2	.04	.06	.13	3.4	.15	1.4	2.5	.28	.24	1.5	.05	.05	.05	.07	39
3	.04	.06	.55	2.3	.14	9.6	1.9	.23	5.2	1.1	.06	.05	.04	.06	23
4	.78	.07	2.1	1.7	.13	7.6	1.6	.21	1.5	.71	.07	.05	.04	.06	5.2
5	.10	.34	1.3	1.4	.14	4.2	1.5	.43	1.1	.56	.06	.05	.23	.06	2.3
6	.06	.10	.96	1.1	.32	3.4	1.1	.24	.78	.36	.06	.08	.05	.06	1.3
7	.06	.08	.61	5.3	.19	2.3	.95	.17	.50	.24	.08	.05	.04	.07	.80
8	1.2	.07	.34	3.1	.15	1.7	.90	.12	.31	.18	.05	.05	.05	.18	.43
9	.15	.94	.16	2.3	.14	1.4	.92	.28	.17	.14	.48	.05	.05	.08	3.0
10	.27	1.8	.12	2.9	.12	1.1	.70	.11	.08	.10	.23	.04	.05	.07	2.0
11	.25	.38	.11	4.1	.12	.92	.58	.09	.06	.14	.09	.06	.04	.07	1.4
12	.14	.19	.11	3.3	.12	1.1	.55	.47	1.3	.67	.17	.04	.04	.06	1.1
13	.10	.14	.34	2.4	5.0	2.6	1.7	.19	4.3	2.2	.08	.04	.04	.06	7.5
14	.07	.11	.39	1.9	6.3	1.7	1.1	.11	2.1	.36	.10	.04	.07	.05	16
15	.07	.10	.22	1.6	3.2	1.5	4.0	.09	1.4	.20	.20	.04	1.5	.05	4.8
16	.06	.09	.18	1.9	1.9	1.3	2.1	.76	1.0	.12	.07	.06	.15	.04	2.5
17	.06	.09	1.7	1.3	9.6	1.4	1.8	.19	1.3	.08	.06	.06	.10	.04	1.6
18	1.4	.08	4.3	1.1	56	2.5	1.5	4.6	1.0	.14	.07	.10	.08	.04	1.1
19	.15	.08	3.5	1.2	59	1.5	2.2	1.1	.86	.09	.41	.35	.07	.04	.68

Table C.14 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	.10	.08	2.8	1.2	31	1.4	1.4	2.2	1.2	.08	.09	.05	.06	.15	.40
21	.08	.07	2.1	1.0	11	1.2	1.0	.84	.73	.07	.06	.05	.06	1.4	.21
22	1.0	.08	49	.83	5.8	1.4	.84	.55	.98	.07	.06	.04	.07	5.1	.19
23	.30	.10	80	.73	3.6	5.9	.72	.39	.86	.06	.05	.04	.05	.29	5.7
24	.17	.09	12	.61	2.5	3.1	.57	.32	13	.46	.06	1.3	.05	.19	3.9
25	.12	.09	5.8	.47	2.0	2.3	.50	.18	19	.16	.06	.34	.05	.14	2.4
26	.10	.09	3.4	.37	1.6	1.8	.44	.10	13	.10	.64	.12	.05	.11	1.6
27	.08	.09	6.1	.31	1.3	1.7	.72	1.0	5.3	.09	.13	.08	.05	.09	1.2
28	.08	.66	21	.26	1.1	1.6	.48	2.3	2.9	.09	.09	.06	.05	.08	4.7
29	.06	.15	9.9	.17		25	.80	.76	1.9	.08	.36	.05	.05	.07	3.3
30	.06	.10	13	.54		14	.48	.58	1.4	.07	.18	.05	.05	1.5	2.1
31	.06		12	.27		5.7		.39		.06	.08		.05		1.5
TOTAL	7.29	6.44	239.26	54.46	202.78	114.02	39.15	19.64	95.56	11.38	4.31	3.50	3.38	10.46	167.91
MEAN	.24	.21	7.72	1.76	7.24	3.68	1.30	.63	3.19	.37	.14	.12	.11	.35	5.42
MAX	1.4	1.8	80	5.4	59	25	4.0	4.6	19	2.2	.64	1.3	1.5	5.1	39
MIN	.04	.06	.09	.17	.12	.92	.44	.09	.06	.06	.05	.04	.04	.04	.19

Table C.15. Daily streamflow at monitoring station GS16 (USGS 03537050) for October 1, 1990—December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT'	NOV'	DEC'
1	.00	.01	.05	.60	e.10	.41	.37	.09	.03	.04	.00	.00			
2	.00	.01	.05	.35	e.09	.50	.26	.05	.04	.16	.00	.00			
3	.00	.01	2.2	.24	e.09	4.1	.21	.04	2.2	.15	.00	.00			
4	.04	.02	.59	.19	e.08	1.7	.18	.04	.71	.05	.00	.00			
5	.01	.10	.22	.16	e.08	.60	.24	.08	.17	.07	.00	.00			
6	.01	.09	.14	.14	e.17	.78	.17	.07	.07	.04	.00	.02			
7	.01	.04	.10	1.2	.15	.77	.14	.04	.04	.02	.00	.01			
8	.18	.02	.08	.57	.12	.41	.17	.03	.02	.01	.00	.01			
9	.04	.10	.06	.33	.10	.28	.29	.07	.02	.01	.02	.00			
10	.02	.90	.05	.49	.10	.21	.20	.04	.01	.01	.03	.00			
11	.09	.20	.05	1.5	.09	.18	.15	.03	.01	.01	.01	.00			
12	.04	.10	.05	.70	.08	.25	.15	.12	2.2	.01	.01	.00			
13	.02	.08	.07	.38	2.2	.99	.77	.10	.62	.14	.00	.00			
14	.01	.06	.25	.26	2.6	.56	.38	.04	.17	.01	.01	.00			
15	.01	.05	.15	.23	.55	.34	1.6	.02	.09	.01	.01	.00			
16	.01	.04	.13	.49	.35	.24	.50	.07	.07	.01	.00	.00			
17	.01	.04	.56	.30	3.2	.26	.28	.05	.11	.01	.00	.00			
18	.21	.04	1.6	.23	14	1.0	.19	1.2	.12	.01	.00	.00			
19	.06	.03	1.0	.28	13	.42	.66	.50	.04	.01	.01	.00			

Table C.15 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
20	.03	.03	.55	.36	4.0	.29	.55	1.5	.11	.01	.01	.00			
21	.02	.02	.46	.28	.89	.23	.31	.31	.08	.01	.00	.00			
22	.22	.02	.13	.22	.49	.33	.22	.13	.23	.01	.00	.00			
23	.20	.03	e20	.19	.34	2.0	.16	.07	.28	.00	.00	.00			
24	.07	.03	1.8	.16	.25	.61	.12	.05	2.0	.01	.00	.05			
25	.05	.02	1.1	.14	.23	.33	.09	.03	3.2	.01	.00	.03			
26	.03	.02	.35	.13	.21	.24	.08	.02	1.9	.01	.02	.01			
27	.03	.02	1.1	.13	.16	.22	.15	.19	.49	.01	.01	.01			
28	.02	.21	5.5	.12	.14	.55	.13	.82	.22	.01	.00	.01			
29	.01	.13	1.6	.10		8.5	.20	.19	.11	.01	.00	.01			
30	.01	.07	3.4	.29		2.5	.13	.08	.06	.01	.01	.01			
31	.01		2.2	.17		.63		.04		.00	.00				
TOTAL	1.47	2.53	58.46	10.93	43.86	30.43	9.05	6.11	15.42	0.88	0.15	0.17			
MEAN	.047	.084	1.89	.35	1.57	.98	.30	.20	.51	.028	.005	.006			
MAX	.22	.90	20	1.5	14	8.5	1.6	1.5	3.2	.16	.03	.05			
MIN	.00	.01	.05	.10	.08	.18	.08	.02	.01	.00	.00	.00			

¹Measurements at this station were discontinued September 30, 1991.

e=Estimated data.

Table C.16. Daily streamflow at monitoring station GS17 (USGS 03537200) for October 1, 1990—December 31, 1991
units = cfs

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC
1	.01	.02	.03	.21	.06	.13	.16	.05	.03	.04	.01	.01			
2	.01	.02	.03	.14	.06	.16	e.12	.04	.03	.09	.01	.01			
3	.01	.01	.59	.10	.06	1.2	e.10	.04	.37	.07	.01	.01			
4	.06	.02	.19	.09	.06	.56	e.09	.04	.17	.04	.01	.01			
5	.02	.05	.08	.08	.06	.22	e.11	.06	.07	.05	.01	.01			
6	.01	.04	.06	.07	.07	.25	e.09	.05	.04	.03	.01	.04			
7	.01	.02	.05	.31	.06	.26	e.08	.04	.03	.03	.01	.02			
8	.10	.02	.04	.21	.06	.17	e.09	.03	.03	.02	.01	.01			
9	.03	.05	.03	.13	.05	.13	e.13	.05	.02	.02	.06	.01			
10	.02	.26	.03	.16	.05	.11	e.10	.04	.02	.02	.04	.01			
11	.04	.08	.03	.40	.05	.09	e.09	.03	.02	.02	.02	.01			
12	.03	.05	.02	.25	.04	.11	e.08	.06	.45	.02	.01	.01			
13	.02	.04	.03	.15	.62	.25	e.23	.05	.17	.05	.01	.01			
14	.01	.03	.07	.11	.81	.21	e.16	.03	.07	.02	.01	.01			
15	.01	.02	.05	.10	.20	.15	e.50	.03	.05	.01	.01	.01			
16	.01	.02	.05	.14	.11	.12	e.20	.05	.04	.01	.01	.01			
17	.01	.02	.14	.11	.87	.12	.12	.04	.06	.01	.01	.01			
18	.08	.02	.45	.10	4.2	.29	.10	.25	.05	.02	.01	.01			
19	.03	.02	.31	.11	3.9	.17	.18	.16	.03	.02	.03	.01			

Table C.16 (continued)

DAY	1990			1991											
	OCT	NOV	DEC	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT ¹	NOV ¹	DEC
20	.02	.02	.17	.12	1.4	.13	.17	.45	.05	.01	.01	.01			
21	.01	.02	.14	.11	.32	.11	.13	.12	.04	.01	.01	.01			
22	.08	.02	3.5	.10	.19	.13	.10	.07	.09	.01	.01	.01			
23	.07	.02	4.6	.09	.14	.62	.09	.05	.11	.01	.01	.01			
24	.04	.02	.34	.08	.11	.23	.07	.04	.41	.02	.01	.07			
25	.03	.02	.16	.07	.10	.14	.06	.03	.82	.02	.01	.03			
26	.02	.02	.11	.06	.09	.11	.06	.03	.60	.01	.04	.02			
27	.02	.02	.29	.06	.08	.12	.08	.08	.17	.01	.02	.01			
28	.02	.08	1.6	.06	.08	.15	.07	.27	.09	.01	.01	.01			
29	.02	.05	.47	.06		2.6	.08	.09	.06	.01	.01	.01			
30	.02	.04	.96	.09		.80	.07	.05	.04	.01	.01	.01			
31	.02		.75	.07		.23		.04		.01	.01				
TOTAL	0.89	1.14	15.37	3.94	13.90	10.07	3.71	2.46	4.23	0.73	0.46	0.43			
MEAN	.029	.038	.50	.13	.50	.32	.12	.079	.14	.024	.015	.014			
MAX	.10	.26	4.6	.40	4.2	2.6	.50	.45	.82	.09	.06	.07			
MIN	.01	.01	.02	.06	.04	.09	.06	.03	.02	.01	.01	.01			

¹Measurements at this station were discontinued September 30, 1991.
 e=Estimated data.

APPENDIX D

Rating Tables for Monitoring Stations in White Oak Creek Watershed

Table D.1 Rating table for low flow at White Oak Dam (MSS) station

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
0.2	0.979	1.05	1.122	1.195	1.27	1.346	1.424	1.503	1.583	1.664		
0.3	1.747	1.83	1.915	2.001	2.088	2.177	2.266	2.356	2.448	2.54		
0.4	2.634	2.729	2.824	2.921	3.018	3.116	3.216	3.316	3.417	3.519		
0.5	3.622	3.726	3.831	3.937	4.043	4.151	4.259	4.368	4.478	4.588		
0.6	4.7	4.812	4.925	5.039	5.153	5.269	5.385	5.502	5.619	5.738		
0.7	5.857	5.977	6.097	6.219	6.341	6.463	6.587	6.711	6.836	6.961		
0.8	7.087	7.214	7.342	7.47	7.599	7.728	7.858	7.989	8.121	8.253		
0.9	8.386	8.519	8.653	8.787	8.923	9.059	9.195	9.332	9.47	9.608		
1	9.747	9.886	10.027	10.167	10.308	10.45	10.593	10.736	10.879	11.023		
1.1	11.168	11.313	11.459	11.606	11.753	11.9	12.048	12.197	12.346	12.495		
1.2	12.646	12.796	12.948	13.1	13.252	13.405	13.558	13.712	13.866	14.021		
1.3	14.177	14.333	14.489	14.646								

Table D.2 Rating table for high flow at White Oak Dam (MS5) station

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
0.2	0.09	0.102	0.116	0.13	0.145	0.162	0.179	0.198	0.218	0.239			
0.3	0.261	0.285	0.31	0.336	0.363	0.392	0.422	0.454	0.487	0.521			
0.4	0.557	0.594	0.633	0.674	0.716	0.759	0.804	0.851	0.9	0.95			
0.5	1.002	1.055	1.11	1.167	1.226	1.287	1.349	1.414	1.48	1.548			
0.6	1.618	1.69	1.764	1.839	1.917	1.997	2.079	2.163	2.248	2.336			
0.7	2.427	2.519	2.613	2.71	2.808	2.909	3.013	3.118	3.226	3.335			
0.8	3.448	3.562	3.679	3.798	3.92	4.044	4.17	4.299	4.43	4.563			
0.9	4.699	4.838	4.979	5.123	5.269	5.418	5.569	5.723	5.879	6.038			
1	6.2	6.364	6.531	6.701	6.874	7.049	7.227	7.407	7.591	7.777			
1.1	7.966	8.158	8.353	8.55	8.751	8.954	9.16	9.37	9.582	9.797			
1.2	10.015	10.236	10.46	10.687	10.917	11.15	11.386	11.625	11.867	12.113			
1.3	12.361	12.613	12.868	13.126	13.387	13.651	13.919	14.189	14.464	14.741			
1.4	15.021	15.305	15.592	15.883	16.177	16.474	16.774	17.078	17.385	17.696			
1.5	18.01	18.327	18.648	18.973	19.301	19.632	19.967	20.305	20.647	20.993			
1.6	21.342	21.694	22.05	22.41	22.774	23.141	23.511	23.886	24.264	24.645			
1.7	25.031	25.42	25.813	26.209	26.609	27.014	27.421	27.833	28.249	28.668			
1.8	29.091	29.518	29.949	30.384	30.822	31.265	31.711	32.161	32.616	33.074			
1.9	33.536	34.002	34.473	34.947	35.425	35.907	36.394	36.884	37.378	37.877			
2	38.38	38.886	39.397	39.912	40.431	40.955	41.482	42.014	42.55	43.09			

Table D2 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
2.1	43.634	44.183	44.736	45.293	45.854	46.42	46.99	47.564	48.143	48.726			
2.2	49.313	49.905	50.501	51.101	51.706	52.316	52.929	53.548	54.17	54.797			
2.3	55.429	56.065	56.705	57.351	58	58.654	59.313	59.976	60.644	61.317			
2.4	61.994	62.675	63.362	64.053	64.748	65.448	66.153	66.863	67.577	68.296			
2.5	69.02	69.748	70.481	71.219	71.962	72.71	73.462	74.219	74.981	75.748			
2.6	76.519	77.296	78.077	78.863	79.654	80.45	81.251	82.057	82.868	83.684			
2.7	84.504	85.33	86.16	86.996	87.837	88.682	89.533	90.389	91.249	92.115			
2.8	92.986	93.862	94.743	95.629	96.52	97.417	98.318	99.225	100.137	101.054			
2.9	101.976	102.904	103.836	104.774	105.717	106.665	107.619	108.578	109.542	110.511			
3	111.486	112.466	113.451	114.442	115.438	116.439	117.446	118.458	119.476	120.499			
3.1	121.527	122.561	123.6	124.645	125.695	126.75	127.811	128.878	129.95	131.027			
3.2	132.11	133.199	134.293	135.392	136.498	137.608	138.725	139.847	140.974	142.107			
3.3	143.246	144.391	145.541	146.697	147.858	149.025	150.198	151.376	152.561	153.751			
3.4	154.946	156.148	157.355	158.568	159.787	161.011	162.241	163.478	164.72	165.967			
3.5	167.221	168.48	169.746	171.017	172.294	173.577	174.866	176.161	177.461	178.768			
3.6	180.081	181.399	182.724	184.054	185.391	186.733	188.082	189.436	190.797	192.164			
3.7	193.536	194.915	196.3	197.691	199.088	200.491	201.9	203.315	204.736	206.164			
3.8	207.598	209.038	210.484	211.936	213.394	214.859	216.33	217.807	219.29	220.78			

Table D.2 (continued)

GAGE HEIGHT (m)	DISCHARGE (cms)										
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
3.9	222.276	223.778	225.286	226.801	228.321	229.849	231.382	232.922	234.468	236.021	
4	237.58	239.145	240.717	242.295	243.879	245.47	247.067	248.671	250.281	251.898	
4.1	253.521	255.15	256.786	258.428	260.077	261.733	263.395	265.063	266.738	268.42	
4.2	270.108	271.803	273.504	275.212	276.926	278.647	280.375	282.109	283.85	285.597	
4.3	287.352	289.113	290.88	292.654	294.435	296.223	298.017	299.818	301.626	303.44	
4.4	305.262	307.09	308.924	310.766	312.614	314.469	316.331	318.2	320.076	321.956	
4.5	323.848	325.744	327.647	329.557	331.473	333.397	335.328	337.265	339.209	341.161	
4.6	343.119	345.084	347.056	349.036	351.022	353.015	355.015	357.022	359.036	361.057	
4.7	363.086	365.121	367.163	369.213	371.269	373.333	375.403	377.481	379.566	381.658	
4.8	383.757	385.863	387.976	390.097	392.225	394.36	396.502	398.651	400.807	402.971	
4.9	405.142	407.32	409.506	411.698	413.898	416.105	418.32	420.542	422.771	425.007	
5	427.251	429.502	431.76	434.026	436.299	438.579	440.867	443.162	445.465	447.775	
5.1	450.092	452.417	454.749	457.089	459.436	461.79	464.152	466.522	468.899	471.283	
5.2	473.675	476.074	478.481	480.896	483.318	485.748	488.185	490.629	493.082	495.542	
5.3	498.009	500.484	502.967	505.457	507.955	510.46	512.974	515.495	518.023	520.559	
5.4	523.103	525.655	528.214	530.781	533.356	535.938	538.528	541.126	543.732	546.345	
5.5	548.966	551.595	554.232	556.876	559.529	562.189	564.857	567.533	570.216	572.908	
5.6	575.607	578.314	581.03	583.753	586.483	589.222	591.969	594.724	597.486	600.257	

Table D.2 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09				
5.7	603.035	605.821	608.616	611.418	614.229	617.047	619.873	622.707	625.55	628.4				
5.8	631.259	634.125	637	639.882	642.773	645.672	648.578	651.493	654.416	657.347				
5.9	660.287	663.234	666.189	669.153	672.125	675.105	678.093	681.089	684.094	687.107				
6	690.128	693.157	696.194	699.24	702.294	705.356	708.426	711.505	714.592	717.687				
6.1	720.791	723.902	727.023	730.151	733.288	736.433	739.586	742.748	745.919	749.097				
6.2	752.284	755.479	758.683	761.895	765.116	768.345	771.582	774.828	778.082	781.345				
6.3	784.616	787.896	791.184	794.481	797.786	801.1	804.422	807.753	811.092	814.44				
6.4	817.796	821.161	824.534	827.917	831.307	834.706	838.114	841.531	844.956	848.389				
6.5	851.832	855.283	858.742	862.211	865.688	869.173	872.667	876.17	879.682	883.203				
6.6	886.732	890.27	893.816	897.371	900.936	904.508	908.09	911.68	915.28	918.888				
6.7	922.504	926.13	929.764	933.408	937.06	940.721	944.39	948.069	951.756	955.453				
6.8	959.158	962.872	966.595	970.327	974.068	977.818	981.576	985.344	989.121	992.906				
6.9	996.701	1000.504	1004.317	1008.138	1011.969	1015.808	1019.657	1023.514	1027.381	1031.256				
7	1035.141	1039.035	1042.938	1046.849	1050.77	1054.7	1058.639	1062.588	1066.545	1070.511				
7.1	1074.487	1078.472	1082.466	1086.469	1090.481	1094.502	1098.533	1102.572	1106.621	1110.679				
7.2	1114.747	1118.823	1122.909	1127.004	1131.108	1135.222	1139.344	1143.476	1147.618	1151.768				
7.3	1155.928	1160.097	1164.276	1168.463	1172.661	1176.867	1181.083	1185.308	1189.542	1193.786				
7.4	1198.039	1202.302	1206.574	1210.855	1215.146	1219.446	1223.756	1228.075	1232.403	1236.741				

Table D.2 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
7.5	1241.089	1245.445	1249.812	1254.188	1258.573	1262.967	1267.372	1271.785	1276.209	1280.641			
7.6	1285.084	1289.536	1293.997	1298.468	1302.948	1307.438	1311.938	1316.447	1320.966	1325.495			
7.7	1330.033	1334.58	1339.138	1343.704	1348.281	1352.867	1357.463	1362.069	1366.684	1371.309			
7.8	1375.943	1380.587	1385.241	1389.905	1394.578	1399.262	1403.954	1408.657	1413.369	1418.091			
7.9	1422.823	1427.565	1432.316	1437.077	1441.848	1446.629	1451.42	1456.22	1461.031	1465.851			
8	1470.681	1475.52	1480.37	1485.23	1490.099	1494.978	1499.867	1504.766	1509.675	1514.594			
8.1	1519.523	1524.462	1529.41	1534.369	1539.338	1544.316	1549.305	1554.303	1559.311	1564.33			
8.2	1569.358	1574.397	1579.445	1584.504	1589.572	1594.651	1599.739	1604.838	1609.947	1615.065			
8.3	1620.194	1625.333	1630.482	1635.641	1640.81	1645.99	1651.179	1656.379	1661.588	1666.808			
8.4	1672.038	1677.278	1682.529	1687.789	1693.06	1698.341	1703.632	1708.933	1714.245	1719.566			
8.5	1724.898	1730.24	1735.593	1740.955	1746.328	1751.711	1757.105	1762.509	1767.923	1773.347			
8.6	1778.782	1784.226	1789.682	1795.147	1800.623	1806.109	1811.606	1817.113	1822.63	1828.158			
8.7	1833.696	1839.244	1844.803	1850.372	1855.952	1861.542	1867.143	1872.754	1878.375	1884.007			
8.8	1889.649	1895.302	1900.965	1906.638	1912.323	1918.017	1923.722	1929.438	1935.164	1940.901			
8.9	1946.648	1952.406	1958.174	1963.953	1969.742	1975.542	1981.353	1987.174	1993.005	1998.848			
9	2004.7												

Table D.3 Rating table for low flow at White Oak Creek station located above the confluence with Melton Branch

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
0.2	0.111	0.125	0.141	0.157	0.175	0.194	0.214	0.235	0.257	0.281			
0.3	0.305	0.331	0.359	0.387	0.417	0.448	0.481	0.515	0.55	0.587			
0.4	0.626	0.665	0.706	0.749	0.793	0.839	0.886	0.935	0.985	1.037			
0.5	1.091	1.146	1.203	1.262	1.322	1.384	1.447	1.513	1.58	1.648			
0.6	1.719	1.791	1.865	1.941	2.019	2.098	2.18	2.263	2.348	2.435			
0.7	2.524	2.615	2.708	2.803	2.899	2.998	3.099	3.201	3.306	3.413			
0.8	3.521	3.632	3.745	3.86	3.977	4.096	4.217	4.34	4.466	4.593			
0.9	4.723	4.855	4.989	5.126	5.264	5.405	5.548	5.693	5.84	5.99			
1	6.142	6.296	6.453	6.612	6.773	6.936	7.102	7.27	7.441	7.614			
1.1	7.789	7.967	8.147	8.33	8.515	8.702	8.892	9.084	9.279	9.477			
1.2	9.676	9.879	10.083	10.291	10.501	10.713	10.928	11.145	11.365	11.588			
1.3	11.813	12.041	12.272	12.505	12.74	12.979	13.22	13.463	13.71	13.959			
1.4	14.21	14.465	14.722	14.982	15.244	15.51	15.778	16.048	16.322	16.598			
1.5	16.877	17.159	17.444	17.732	18.022	18.315	18.611	18.91	19.212	19.516			
1.6	19.824	20.134	20.447	20.763	21.082	21.404	21.729	22.057	22.388	22.721			
1.7	23.058	23.397	23.74	24.086	24.434	24.786	25.14	25.498	25.859	26.222			
1.8	26.589	26.959	27.332	27.708	28.087	28.469	28.854	29.242	29.634	30.028			

Table D.3 (continued)

[illegible]

Table D.4 Rating table for high flow at White Oak Creek station (MS3) located above the confluence with Melton Branch

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
0.2	8.838	9.542	10.265	11.007	11.768	12.546	13.343	14.158	14.99	15.839		
0.3	16.705	17.587	18.486	19.401	20.332	21.279	22.241	23.218	24.211	25.219		
0.4	26.242	27.279	28.331	29.397	30.477	31.572	32.68	33.802	34.938	36.088		
0.5	37.251	38.427	39.617	40.82	42.035	43.264	44.505	45.759	47.026	48.305		
0.6	49.597	50.901	52.217	53.545	54.886	56.238	57.602	58.978	60.366	61.766		
0.7	63.177	64.6	66.034	67.48	68.936	70.405	71.884	73.375	74.876	76.389		
0.8	77.912	79.447	80.992	82.548	84.115	85.693	87.281	88.879	90.488	92.108		
0.9	93.738	95.378	97.029	98.69	100.361	102.043	103.734	105.435	107.147	108.869		
1	110.6	112.341	114.093	115.854	117.624	119.405	121.195	122.995	124.805	126.624		
1.1	128.452	130.29	132.138	133.995	135.861	137.737	139.622	141.516	143.42	145.333		
1.2	147.255	149.186	151.126	153.076	155.034	157.002	158.978	160.963	162.958	164.961		
1.3	166.973	168.994	171.024	173.062	175.109	177.165	179.23	181.304	183.386	185.476		
1.4	187.576	189.683	191.8	193.925	196.058	198.2	200.35	202.509	204.676	206.851		
1.5	209.035	211.227	213.427	215.636	217.853	220.078	222.311	224.552	226.802	229.06		
1.6	231.325	233.599	235.881	238.171	240.469	242.776	245.09	247.412	249.741	252.079		
1.7	254.425	256.779	259.14	261.51	263.887	266.272	268.664	271.065	273.473	275.889		
1.8	278.313	280.744	283.183	285.63	288.084	290.546	293.015	295.492	297.977	300.469		

Table D.4 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
1.9	302.969	305.476	307.991	310.513	313.043	315.58	318.125	320.676	323.236	325.803		
2	328.377	330.958	333.547	336.143	338.746	341.357	343.975	346.6	349.232	351.872		
2.1	354.519	357.173	359.834	362.503	365.178	367.861	370.551	373.248	375.951	378.663		
2.2	381.381	384.106	386.838	389.577	392.324	395.077	397.837	400.604	403.379	406.16		
2.3	408.948	411.743	414.545	417.353	420.169	422.992	425.821	428.657	431.5	434.35		
2.4	437.207	440.07	442.94	445.817	448.701	451.592	454.489	457.393	460.303	463.221		
2.5	466.145	469.076	472.013	474.957	477.908	480.865	483.829	486.8	489.777	492.76		
2.6	495.751	498.747	501.751	504.761	507.777	510.8	513.83	516.866	519.908	522.957		
2.7	526.013	529.075	532.777	536.466	540.166	543.878	547.602	551.338	555.086	558.846		
2.8	562.617	566.401	570.196	574.003	577.823	581.654	585.496	589.351	593.217	597.096		
2.9	600.986	604.888	608.802	612.727	616.665	620.614	624.575	628.548	632.532	636.529		
3	640.537	644.557	648.588	652.632	656.687	660.754	664.833	668.923	673.025	677.139		
3.1	681.265	685.402	689.551	693.712	697.885	702.069	706.265	710.473	714.692	718.923		
3.2	723.166	727.42	731.687	735.964	740.254	744.555	748.868	753.192	757.528	761.876		
3.3	766.235	770.606	774.989	779.383	783.789	788.207	792.636	797.077	801.529	805.993		
3.4	810.469	814.956	819.455	823.965	828.487	833.021	837.566	842.123	846.691	851.271		
3.5	855.862	860.465	865.08	869.706	874.344	878.993	883.654	888.326	893.01	897.705		

Table D.4 (continued)

[illegible]

Table D.5 Rating table at low flow for Melton Branch (MB) station located above the confluence
with White Oak Creek

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
0.2	0.074	0.083	0.094	0.105	0.117	0.13	0.144	0.158	0.173	0.189			
0.3	0.207	0.224	0.243	0.263	0.284	0.306	0.328	0.352	0.377	0.402			
0.4	0.429	0.457	0.486	0.516	0.547	0.579	0.612	0.647	0.682	0.719			
0.5	0.757	0.796	0.836	0.878	0.921	0.965	1.01	1.056	1.104	1.153			
0.6	1.204	1.255	1.308	1.363	1.418	1.475	1.534	1.593	1.655	1.717			
0.7	1.781	1.847	1.914	1.982	2.052	2.123	2.196	2.27	2.345	2.423			
0.8	2.501	2.582	2.664	2.747	2.832	2.918	3.007	3.096	3.188	3.28			
0.9	3.375	3.471	3.569	3.668	3.77	3.872	3.977	4.083	4.191	4.301			
1	4.412	4.525	4.64	4.756	4.875	4.995	5.117	5.24	5.366	5.493			
1.1	5.622	5.753	5.886	6.02	6.157	6.295	6.435	6.577	6.721	6.867			
1.2	7.014	7.164	7.316	7.469	7.624	7.782	7.941	8.102	8.266	8.431			
1.3	8.598	8.767	8.938	9.112	9.287	9.464	9.643	9.825	10.008	10.193			
1.4	10.381	10.571	10.762	10.956	11.152	11.35	11.55	11.752	11.957	12.163			
1.5	12.372	12.583	12.796	13.011	13.228	13.448	13.669	13.893	14.12	14.348			
1.6	14.578	14.811	15.046	15.284	15.523	15.765	16.009	16.256	16.504	16.755			
1.7	17.009	17.264	17.522	17.782	18.045	18.31	18.577	18.847	19.118	19.393			

Table D.5 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)										
	19.67	19.949	20.23	20.514	20.8	21.089	21.38	21.673	21.969	22.268	
1.8											
1.9	22.569	22.872	23.178	23.486	23.797	24.11	24.425	24.744	25.064	25.387	
2	25.713	26.041	26.372	26.705	27.041	27.38	27.72	28.064	28.41	28.759	
2.1	29.11	29.464	29.82	30.179	30.541	30.905	31.272	31.641	32.013	32.388	
2.2	32.765	33.146	33.528	33.914	34.302	34.693					

Table D.6 Rating table for White Oak Creek Headwaters station located in the upper reaches of White Oak Creek and upstream of ORNL facility discharges

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09				
0		0.001	0.002	0.004	0.007	0.011	0.015	0.021	0.027	0.034				
0.1	0.041	0.049	0.057	0.067	0.077	0.088	0.099	0.111	0.123	0.137				
0.2	0.151	0.166	0.1182	0.1197	0.213	0.231	0.249	0.267	0.286	0.306				
0.3	0.327	0.347	0.368	0.391	0.414	0.437	0.46	0.425	0.55	0.575				
0.4	0.561	0.589	0.617	0.645	0.673	0.701	0.732	0.763	0.794	0.825				
0.5	0.856	0.891	0.927	0.962	0.997	0.032	0.068	0.103	0.138	0.174				
0.6	1.209	1.25	1.291	1.332	1.373	1.414	1.455	1.496	1.537	1.578				
0.7	1.619	1.666	1.712	1.759	1.805	1.852	1.898	1.945	1.991	2.038				
0.8	2.084	2.136	2.188	2.24	2.292	2.345	2.4	2.449	2.501	2.553				
0.9	2.605	2.663	2.72	2.778	2.835	2.893	2.95	3.008	3.065	3.123				
1	3.18	3.264	3.348	3.432	3.516	3.6	3.684	3.768	3.852	3.936				
1.1	4.02	4.116	4.212	4.308	4.404	4.5	4.596	4.692	4.788	4.884				
1.2	4.98	5.105	5.23	5.355	5.48	5.605	5.73	5.855	5.98	6.105				
1.3	6.23	6.355	6.48	6.605	6.73	6.855	6.98	7.105	7.23	7.355				
1.4	7.48	7.605	7.73	7.855	7.98	8.105	8.23	8.355	8.48	8.605				
1.5	8.73	8.867	9.004	9.141	9.278	9.415	9.552	9.689	9.826	9.963				

Table D.6 (continued)

[illegible]

Table D.7 Rating table for East Seep station located on the east seep tributary to the headwaters of White Oak Creek

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
0.2	0.052	0.058	0.065	0.072	0.08	0.088	0.096	0.105	0.115	0.124		
0.3	0.135	0.146	0.157	0.169	0.181	0.194	0.207	0.221	0.235	0.25		
0.4	0.266	0.281	0.298	0.315	0.332	0.351	0.369	0.388	0.408	0.429		
0.5	0.449	0.471	0.493	0.516	0.539	0.563	0.587	0.612	0.638	0.664		
0.6	0.691	0.718	0.746	0.775	0.804	0.834	0.865	0.896	0.928	0.96		
0.7	0.994	1.027	1.062	1.097	1.133	1.169	1.206	1.244	1.282	1.322		
0.8	1.361	1.402	1.443	1.485	1.527	1.571	1.614	1.659	1.704	1.75		
0.9	1.797	1.845	1.893	1.942	1.991	2.042	2.093	2.144	2.197	2.25		
1	2.304	2.359	2.414	2.47	2.527	2.585	2.643	2.703	2.762	2.823		
1.1	2.885	2.947	3.01	3.074	3.138	3.203	3.269	3.336	3.404	3.472		
1.2	3.542	3.612	3.682	3.754	3.826	3.899	3.973	4.048	4.124	4.2		
1.3	4.277	4.355	4.434	4.514	4.594	4.675	4.757	4.84	4.924	5.009		
1.4	5.094	5.18	5.267	5.355	5.444	5.533	5.624	5.715	5.807	5.9		
1.5	5.994	6.088	6.184	6.28	6.378	6.476	6.575	6.674	6.775	6.877		
1.6	6.979	7.082	7.187	7.292	7.397	7.504	7.612	7.721	7.83	7.94		
1.7	8.052	8.164	8.277	8.391	8.505	8.621	8.738	8.855	8.974	9.093		
1.8	9.213	9.334	9.457	9.579	9.703	9.828	9.954	10.081	10.208			

Table D.8 Rating table for West Seep Tributary station located in the west seep tributary to the headwaters of White Oak Lake

GAGE HEIGHT (ft)	DISCHARGE (cfs)										
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
0											
0.1	0.016	0.02	0.025	0.03	0.036	0.043	0.05	0.058	0.066	0.075	0.012
0.2	0.085	0.096	0.108	0.12	0.133	0.147	0.162	0.178	0.195	0.212	
0.3	0.23	0.25	0.27	0.291	0.313	0.336	0.359	0.385	0.411	0.438	
0.4	0.466	0.495	0.525	0.556	0.588	0.621	0.655	0.691	0.727	0.765	
0.5	0.803	0.843	0.884	0.927	0.97	1.015	1.06	1.107	1.155	1.205	
0.6	1.255	1.307	1.36	1.415	1.47	1.527	1.585	1.645	1.705	1.767	
0.7	1.83	1.895	1.96	2.028	2.096	2.166	2.237	2.31	2.384	2.46	
0.8	2.537	2.615	2.694	2.776	2.858	2.942	3.027	3.114	3.202	3.292	
0.9	3.383	3.476	3.57	3.666	3.763	3.862	3.962	4.064	4.167	4.272	
1	4.378	4.488	4.599	4.709	4.819	4.93	5.046	5.163	5.279	5.396	
1.1	5.512	5.634	5.755	5.877	5.998	6.12	6.247	6.373	6.5	6.626	
1.2	6.753	6.886	7.02	7.153	7.287	7.42	7.553	7.687	7.82	7.954	
1.3	8.087	8.229	8.371	8.512	8.654	8.796	8.938	9.08	9.221	9.363	
1.4	9.505	9.655	9.804	9.954	10.103	10.253	10.402	10.552	10.701	10.851	
1.5	11	11.157	11.313	11.47	11.626	11.783	11.94	12.096	12.253	12.409	

Table D8 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)										
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09	
1.7	14.233	14.4	14.566	14.733	14.9	15.067	15.233	15.4	15.567	15.733	
1.8	15.9	16.079	16.258	16.437	16.616	16.795	16.973	17.152	17.331	17.51	
1.9	17.689	17.868	18.047	18.226	18.405	18.584	18.762	18.941	19.12	19.299	
2	19.478	19.668	19.858	20.048	20.239	20.429	20.619	20.809	20.999	21.189	
2.1	21.38	21.57	21.76	21.95	22.14	22.33	22.52	22.711	22.901	23.091	
2.2	23.281	23.482	23.682	23.883	24.083	24.284	24.484	24.685	24.885	25.086	
2.3	25.287	25.487	25.688	25.888	26.089	26.289	26.49	26.69	26.891	27.091	
2.4	27.292	27.502	27.713	27.923	28.134	28.344	28.554	28.765	28.975	29.186	
2.5	29.396	29.606	29.817	30.027	30.238	30.448	30.658	30.869	31.079	31.29	
2.6	31.5	31.717	31.933	32.15	32.367	32.584	32.8	33.017			

Table D.9 Rating table for Ish Creek station located upstream from the mouth of the Clinch River at kilometer 30.7 (mile 19.1)

GAGE HEIGHT (ft)	DISCHARGE (cfs)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
0							0.001	0.001	0.002	0.003
0.1	0.004	0.005	0.006	0.007	0.008	0.01	0.012	0.014	0.016	0.018
0.2	0.021	0.024	0.027	0.03	0.033	0.037	0.041	0.046	0.05	0.055
0.3	0.059	0.065	0.07	0.076	0.082	0.088	0.094	0.101	0.109	0.116
0.4	0.123	0.132	0.14	0.149	0.158	0.166	0.174	0.182	0.19	0.198
0.5	0.206	0.217	0.227	0.238	0.248	0.259	0.27	0.28	0.291	0.301
0.6	0.312	0.326	0.341	0.355	0.37	0.384	0.398	0.413	0.427	0.442
0.7	0.456	0.472	0.488	0.505	0.521	0.537	0.553	0.569	0.586	0.602
0.8	0.618	0.639	0.66	0.682	0.703	0.724	0.745	0.766	0.788	0.809
0.9	0.83	0.86	0.89	0.92	0.95	0.98	1.01	1.04	1.07	1.1
1	1.13	1.167	1.204	1.241	1.278	1.315	1.352	1.389	1.426	1.463
1.1	1.5	1.544	1.588	1.632	1.676	1.72	1.764	1.808	1.852	1.896
1.2	1.94	1.993	2.046	2.099	2.152	2.205	2.258	2.311	2.364	2.417
1.3	2.47	2.576	2.682	2.788	2.894	3	3.106	3.212	3.318	3.424
1.4	3.53	3.689	3.848	4.007	4.166	4.325	4.484	4.643	4.802	4.961
1.5	5.12	5.35	5.58	5.81	6.04	6.27	6.5	6.73	6.96	7.19

Table D.9 (continued)

[illegible]

Table D.10 Rating table for Raccoon Creek station

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
0							0.001	0.002	0.003	0.003		
0.1	0.004	0.005	0.007	0.008	0.01	0.012	0.014	0.016	0.019	0.022		
0.2	0.025	0.028	0.031	0.035	0.039	0.043	0.047	0.052	0.057	0.062		
0.3	0.066	0.073	0.079	0.085	0.091	0.098	0.105	0.113	0.121	0.128		
0.4	0.136	0.145	0.154	0.162	0.171	0.18	0.191	0.202	0.212	0.223		
0.5	0.234	0.247	0.259	0.272	0.284	0.297	0.311	0.326	0.34	0.355		
0.6	0.369	0.385	0.402	0.418	0.435	0.451	0.469	0.488	0.506	0.525		
0.7	0.543	0.563	0.584	0.604	0.625	0.645	0.668	0.69	0.713	0.735		
0.8	0.758	0.783	0.808	0.833	0.858	0.883	0.91	0.937	0.964	0.991		
0.9	1.018	1.048	1.077	1.107	1.136	1.166	1.198	1.23	1.261	1.293		
1	1.325	1.359	1.394	1.482	1.463	1.497	1.534	1.571	1.608	1.645		
1.1	1.682	1.721	1.761	1.8	1.84	1.879	1.921	1.963	2.006	2.048		
1.2	2.09	2.135	2.18	2.225	2.27	2.315	2.445	2.575	2.705	2.835		
1.3	2.965	3.165	3.365	3.564	3.764	3.964	4.209	4.454	4.699	4.944		
1.4	5.189	5.47	5.751	6.032	6.313	6.594	6.906	7.218	7.53	7.842		
1.5	8.154	8.493	8.832	9.171	9.51	9.849	10.213	10.577	10.942	11.306		
1.6	11.67	12.056	12.442	12.828	13.214	13.6	14.006	14.412	14.818	15.224		

Table D.10 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
1.7	15.63	16.054	16.478	16.902	17.326	17.75	18.194	18.638	19.082	19.526			
1.8	19.97	20.428	20.886	21.344	21.802	22.26	22.736	23.212	23.688	24.164			
1.9	24.64	25.128	25.616	26.104	26.592	27.08	27.584	28.088	28.592	29.096			
2	29.6	30.123	30.646	31.169	31.692	32.215	32.738	33.261	33.784	34.307			
2.1	34.83	35.376	35.922	36.468	37.014	37.56	38.106	38.652	39.198	39.744			
2.2	40.29	40.857	41.424	41.991	42.558	43.125	43.692	44.259	44.826	45.393			
2.3	45.96	46.547	47.114	47.681	48.248	49.815	50.382	50.949	51.516	52.083			
2.4	51.83	52.435	53.04	53.645	54.25	54.855	55.46	56.065	56.67	57.275			
2.5	57.88												

Table D.11 Rating table for T-2A station located on an unnamed tributary to White Oak Creek
near the southern boundary of SWSA 4

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
0.2	0.16	0.18	0.19	0.2	0.22	0.23	0.24	0.26	0.29	0.3		
0.3	0.31	0.33	0.35	0.37	0.39	0.42	0.44	0.46	0.48	0.51		
0.4	0.54	0.56	0.59	0.62	0.65	0.68	0.71	0.74	0.78	0.81		
0.5	0.84	0.88	0.92	0.95	0.99	1.03	1.07	1.11	1.16	1.2		
0.6	1.24	1.29	1.34	1.38	1.43	1.48	1.53	1.58	1.64	1.69		
0.7	1.74	1.8	1.86	1.92	1.97	2.03	2.1	2.16	2.22	2.29		
0.8	2.35	2.42	2.49	2.56	2.63	2.7	2.77	2.84	2.92	3		
0.9	3.07	3.15	3.23	3.31	3.39	3.48	3.56	3.65	3.74	3.82		
1	3.91	4	4.1	4.19	4.28	4.38	4.48	4.58	4.68	4.78		
1.1	4.88	4.98	5.09	5.2	5.3	5.41	5.52	5.63	5.75	5.86		
1.2	5.98	6.1	6.21	6.33	6.46	6.58	6.7	6.83	6.96	7.08		

Manufacturer's rating for the trapezoidal flume at T-2A is:

$$Q = 2.32 \times H^{2.5} + 0.63 \times H^{1.5} + 0.05 \text{ for } H = 0.20 \text{ to } 1.29 \text{ ft}$$

where Q = discharge (cfs), H = stage (ft)

Table D.12 Rating table for Melton Branch 2 (MB2) upstream from the confluence with the HRT tributary

[illegible]

Table D.13 Rating table for the Palmer Bowlus flume at station on tributary to Melton Branch near the old Homogeneous Reactor Test (HRTF) facility

[illegible]

Table D.14 Rating table for Upper White Oak Creek station (GS6, USGS 03536320) east of the East gate of ORNL and near Building 6000

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
0.2									0.000	0.001			
0.3	0.002	0.004	0.007	0.01	0.013	0.016	0.02	0.024	0.03	0.035			
0.4	0.042	0.049	0.057	0.066	0.077	0.089	0.101	0.114	0.129	0.146			
0.5	0.164	0.184	0.206	0.229	0.256	0.284	0.316	0.35	0.387	0.427			
0.6	0.471	0.518	0.569	0.624	0.684	0.748	0.817	0.891	0.971	1.057			
0.7	1.149	1.247	1.352	1.464	1.584	1.712	1.849	1.994	2.149	2.313			
0.8	2.488	2.674	2.87	3.079	3.3	3.534	3.782	4.043	4.32	4.612			
0.9	4.92	5.2	5.493	5.799	6.119	6.452	6.8	7.15	7.515	7.894			
1	8.288	8.698	9.123	9.565	10.024	10.5	10.931	11.375	11.833	12.304			
1.1	12.79	13.291	13.806	14.337	14.883	15.444	16.022	16.616	17.227	17.855			
1.2	18.5	19.024	19.558	20.103	20.659	21.225	21.802	22.389	22.988	23.598			
1.3	24.22	24.852	25.497	26.153	26.82	27.5	28.13	28.77	29.419	30.078			
1.4	30.748	31.427	32.116	32.815	33.525	34.244	34.975	35.715	36.466	37.228			
1.5	38	38.785	39.58	40.386	41.204	42.032	42.872	43.723	44.585	45.458			
1.6	46.343	47.24	48.148	49.068	50	50.92	51.852	52.795	53.75	54.715			
1.7	55.693	56.682	57.682	58.694	59.718	60.754	61.802	62.862	63.934	65.017			
1.8	66.113	67.222	68.343	69.476	70.621	71.779	72.95	74.133	75.329	76.538			

Table D.14 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
2	90.699	92.067	93.448	94.843	96.252	97.675	99.112	100.563	102.027	103.507		
2.1	105	106.387	107.787	109.197	110.62	112.055	113.501	114.959	116.429	117.911		
2.2	119.405	120.911	122.429	123.959	125.501	127.056	128.622	130.201	131.793	133.396		
2.3	135.012	136.641	138.282	139.935	141.601	143.28	144.971	146.675	148.392	150.121		
2.4	151.864	153.619	155.387	157.168	158.962	160.768	162.589	164.422	166.268	168.127		
2.5	170	172.008	174.031	176.07	178.125	180.196	182.283	184.385	186.503	188.638		
2.6	190.788	192.955	195.137	197.336	199.551	201.783	204.031	206.295	208.576	210.874		
2.7	213.188	215.519	217.867	220.231	222.613	225.011	227.426	229.858	232.308	234.775		
2.8	237.258	239.759	242.278	244.814	247.367	249.938	252.526	255.132	257.756	260.397		
2.9	263.057	265.734	268.429	271.142	273.873	276.622	279.389	282.175	284.979	287.801		
3	290.641	293.5	296.378	299.274	302.188	305.121	308.074	311.044	314.034	317.043		
3.1	320.07	323.117	326.182	329.267	332.371	335.494	338.637	341.799	344.980	348.181		
3.2	351.401	354.641	357.901	361.18	364.479	367.798	371.136	374.495	377.874	381.273		
3.3	384.692	388.131	391.59	395.07	398.569	402.09	405.63	409.192	412.774	416.376		
3.4	420											

Offset* = 0.28

*Offset is the difference between the staff gage reading and stage at zero flow.

Table D.15 Rating table for White Oak Creek Parshall Flume station (GS5, USGS 03536380)

GAGE HEIGHT (ft)	DISCHARGE (cfs)														
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09					
0							0	0.04	0.08	0.123					
0.1	0.18	0.227	0.23	0.34	0.406	0.48	0.544	0.612	0.684	0.76					
0.2	0.84	0.923	1.009	1.099	1.193	1.29	1.383	1.478	1.576	1.677					
0.3	1.78	1.882	1.987	2.095	2.204	2.316	2.43	2.544	2.659	2.777					
0.4	2.897	3.018	3.142	3.268	3.396	3.525	3.657	3.79	3.926	4.063					
0.5	4.202	4.343	4.486	4.631	4.777	4.926	5.076	5.228	5.382	5.537					
0.6	5.695	5.854	6.015	6.177	6.342	6.508	6.676	6.845	7.016	7.189					
0.7	7.364	7.54	7.718	7.897	8.079	8.261	8.446	8.632	8.82	9					
0.8	9.2	9.379	9.56	9.742	9.925	10.109	10.295	10.481	10.669	10.858					
0.9	11.049	11.24	11.433	11.627	11.821	12.018	12.215	12.413	12.613	12.813					
1	13.015	13.218	13.422	13.627	13.833	14.041	14.249	14.459	14.669	14.881					
1.1	15.094	15.308	15.523	15.739	15.956	16.174	16.393	16.613	16.835	17.057					
1.2	17.28	17.505	17.73	17.956	18.184	18.412	18.642	18.872	19.104	19.337					
1.3	19.57	19.805	20.04	20.277	20.514	20.753	20.992	21.233	21.474	21.716					
1.4	21.96	22.204	22.449	22.696	22.943	23.191	23.44	23.69	23.941	24.193					
1.5	24.446	24.7	24.955	25.21	25.467	25.725	25.983	26.243	26.503	26.764					
1.6	27.026	27.289	27.553	27.818	28.084	28.351	28.618	28.887	29.156	29.426					

Table D.15 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
1.7	29.697	29.969	30.242	30.516	30.791	31.066	31.343	31.62	31.898	32.177			
1.8	32.457	32.738	33.02	33.302	33.585	33.87	34.155	34.44	34.727	35.015			
1.9	35.303	35.593	35.883	36.174	36.465	36.758	37.052	37.346	37.641	37.937			
2	38.234	38.531	38.83	39.129	39.429	39.73	40.032	40.334	40.638	40.942			
2.1	41.247	41.552	41.859	42.166	42.475	42.784	43.093	43.404	43.715	44.027			
2.2	44.34	44.654	44.969	45.284	45.6	45.928	46.258	46.588	46.919	47.251			
2.3	47.583	47.917	48.252	48.587	48.923	49.261	49.599	49.938	50.277	50.618			
2.4	50.96	51.302	51.645	51.99	52.335	52.681	53.027	53.375	53.724	54.073			
2.5	54.423	54.774	55.126	55.479	55.832	56.187	56.542	56.898	57.255	57.613			
2.6	57.972	58.332	58.692	59.053	59.415	59.778	60.142	60.507	60.872	61.238			
2.7	61.606	61.973	62.342	62.712	63.082	63.453	63.826	64.198	64.572	64.947			
2.8	65.322	65.698	66.075	66.453	66.832	67.211	67.591	67.972	68.354	68.737			
2.9	69.121	69.505	69.89	70.276	70.663	71.05	71.438	71.828	72.218	72.608			
3	73	73.489	73.979	74.472	74.965	75.461	75.958	76.457	76.957	77.459			
3.1	77.963	78.468	78.975	79.484	79.994	80.506	81.019	81.534	82.051	82.57			
3.2	82.09	83.611	84.135	84.66	85.186	85.714	86.244	86.776	87.309	87.844			

Table D.15 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09		
3.3	88.38	88.918	89.458	89.999	90.542	91.087	91.633	92.181	92.73	93.281		
3.4	93.834	94.389	94.945	95.502	96.062	96.623	97.185	97.75	98.315	98.883		
3.5	99.452	100.023	100.595	101.17	101.745	102.323	102.902	103.482	104.064	104.648		
3.6	105.234	105.821	106.41	107	107.593	108.186	108.782	109.379	109.977	110.576		
3.7	111.18	111.783	112.388	112.995	113.604	114.214	114.826	115.439	116.054	116.671		
3.8	117.289	117.909	118.531	119.154	119.779	120.405	121.033	121.663	122.295	122.928		
3.9	123.563	124.199	124.837	125.477	126.118	126.761	127.405	128.051	128.699	129.349		
4	130	130.624	131.25	131.878	132.507	133.137	133.769	134.402	135.036	135.672		
4.1	136.31	136.949	137.589	138.23	138.874	139.518	140.164	140.812	141.461	142.111		
4.2	142.763	143.416	144.07	144.726	145.384	146.043	146.703	147.365	148.028	148.692		
4.3	149.358	150.026	150.695	151.365	152.037	152.71	153.384	154.06	154.738	155.416		
4.4	156.097	156.778	157.461	158.146	158.832	159.519	160.208	160.898	161.59	162.283		
4.5	162.977	163.673	164.37	165.069	165.769	166.471	167.174	167.878	168.584	169.291		
4.6	170	170.83	171.664	172.499	173.337	174.177	175.019	175.863	176.71	177.559		
4.7	178.41	179.263	180.119	180.977	181.837	182.699	183.564	184.431	185.301	186.172		
4.8	187.046	187.922	188.8	189.681	190.564	191.449	192.336	193.226	194.118	195.012		

$\frac{1}{n} \sum_{i=1}^n \log p_i = -\frac{1}{n} \sum_{i=1}^n \log \left(\frac{1}{n} \right) = -\log \left(\frac{1}{n} \right) = \log n$

[illegible]

Table D.16 Rating table for North West Tributary (NWT, GS4, USGS 03536440) station located above the confluence with First Creek

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09				
0.1								0.100	0.114	0.128				
0.2	0.144	0.161	0.179	0.197	0.217	0.238	0.26	0.283	0.307	0.332				
0.3	0.359	0.386	0.415	0.444	0.475	0.507	0.541	0.575	0.61	0.647				
0.4	0.685	0.724	0.765	0.806	0.849	0.893	0.938	0.985	1.032	1.081				
0.5	1.132	1.183	1.236	1.29	1.345	1.402	1.46	1.519	1.58	1.642				
0.6	1.705	1.77	1.836	1.903	1.971	2.041	2.113	2.185	2.259	2.335				
0.7	2.412	2.49	2.569	2.65	2.733	2.816	2.901	2.988	3.076	3.165				
0.8	3.256	3.349	3.442	3.537	3.634	3.732	3.831	3.932	4.035	4.139				
0.9	4.244	4.351	4.459	4.569	4.68	4.793	4.907	5.022	5.14	5.258				
1	5.379	5.5	5.623	5.748	5.874	6.002	6.132	6.262	6.395	6.529				
1.1	6.664	6.801	6.94	7.08	7.222	7.365	7.51	7.656	7.804	7.954				
1.2	8.105	8.257	8.412	8.567	8.725	8.884	9.045	9.207	9.371	9.536				
1.3	9.703	9.872	10.042	10.214	10.387	10.563	10.739	10.918	11.098	11.28				
1.4	11.463	11.648	11.834	12.023	12.213	12.404	12.597	12.792	12.989	13.187				
1.5	13.387	13.588	13.792	13.996	14.203	14.411	14.621	14.833	15.046	15.261				
1.6	15.478	15.696	15.916	16.138	16.362	16.587	16.814	17.043	17.273	17.505				

Table D.16 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09				
1.7	17.739	17.974	18.212	18.451	18.691	18.934	19.178	19.424	19.672	19.921				
1.8	20.172	20.425	20.68	20.936	21.194	21.454	21.716	21.979	22.244	22.511				
1.9	22.78	23.051	23.323	23.597	23.873	24.151	24.43	24.711	24.994	25.279				
2	25.566	25.854	26.144	26.436	26.73	27.025	27.323	27.622	27.923	28.226				
2.1	28.53	28.837	29.145	29.455	29.767	30.081	30.396	30.714	31.033	31.354				
2.2	31.677	32.002	32.328	32.657	32.987	33.319	33.653	33.989	34.327	34.666				
2.3	35.007	35.351	35.696	36.043	36.392	36.742	37.095	37.449	37.805	38.164				
2.4	38.524	38.886	39.249	39.615	39.983	40.352	40.724	41.097	41.472	41.849				
2.5	42.228	42.609	42.991	43.376	43.763	44.151	44.541	44.933	45.328	45.724				
2.6	46.122	46.522	46.923	47.327	47.733	48.14	48.55	48.961	49.375	49.79				
2.7	50.207	50.626	51.047	51.471	51.896	52.322	52.751	53.182	53.615	54.05				
2.8	54.486	54.925	55.365	55.808	56.252	56.699	57.147	57.597	58.05	58.504				
2.9	58.96	59.419	59.879	60.341	60.805	61.271	61.739	62.209	62.681	63.155				
3	63.631	64.109	64.589	65.071	65.555	66.041	66.529	67.019	67.511	68.005				
3.1	68.501	68.999	69.499	70.001	70.505	71.011	71.519	72.029	72.541	73.055				
3.2	73.571	74.089	74.609	75.131	75.655	76.181	76.71	77.24	77.772	78.306				
3.3	78.842	79.381	79.921	80.464	81.008	81.554	82.103	82.654	83.206	83.761				

Table D.16 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
3.4	84.317	84.876	85.437	86						

Table D.17 Rating table for First Creek station (GS1, USGS 03536450) located on the First Creek tributary to White Oak Creek between Burial Ground Road and the confluence with the Northwest tributary

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09				
0.3							0.000	0.005	0.007	0.010				
0.4	0.015	0.019	0.025	0.031	0.040	0.050	0.058	0.067	0.076	0.088				
0.5	0.100	0.112	0.125	0.139	0.155	0.171	0.188	0.206	0.226	0.247				
0.6	0.270	0.290	0.312	0.334	0.358	0.383	0.410	0.438	0.467	0.498				
0.7	0.530	0.561	0.593	0.626	0.661	0.697	0.734	0.773	0.814	0.856				
0.8	0.900	0.937	0.975	1.014	1.055	1.096	1.139	1.182	1.227	1.273				
0.9	1.320	1.371	1.424	1.478	1.534	1.591	1.650	1.710	1.772	1.835				
1	1.900	1.956	2.014	2.072	2.132	2.192	2.254	2.317	2.381	2.446				
1.1	2.512	2.580	2.649	2.719	2.790	2.862	2.936	3.011	3.087	3.164				
1.2	3.242	3.322	3.403	3.486	3.57	3.655	3.741	3.829	3.918	4.008				
1.3	4.100	4.194	4.289	4.385	4.483	4.582	4.683	4.785	4.888	4.993				
1.4	5.100	5.205	5.312	5.420	5.529	5.640	5.752	5.866	5.981	6.098				
1.5	6.216	6.335	6.456	6.579	6.703	6.829	6.956	7.084	7.215	7.346				
1.6	7.480	7.615	7.751	7.889	8.029	8.170	8.313	8.457	8.603	8.751				
1.7	8.900	9.052	9.206	9.362	9.519	9.678	9.839	10.002	10.166	10.332				
1.8	10.500	10.655	10.812	10.970	11.13	11.291	11.454	11.617	11.783	11.95				

Table D.17 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	12.118	12.288	12.459	12.632	12.806	12.982	13.159	13.338	13.518	13.7				
1.9														
2	13.883	14.068	14.254	14.442	14.631	14.822	15.015	15.209	15.404	15.601				
2.1	15.800	16.086	16.375	16.669	16.966	17.267	17.573	17.882	18.195	18.512				
2.2	18.833	19.158	19.487	19.821	20.158	20.5	20.875	21.255	21.64	22.03				
2.3	22.426	22.827	23.233	23.645	24.062	24.485	24.914	25.348	25.787	26.233				
2.4	26.684	27.141	27.604	28.073	28.548	29.029	29.516	30.01	30.509	31.015				
2.5	31.527	32.045	32.570	33.101	33.639	34.183	34.734	35.292	35.856	36.427				
2.6	37.005	37.590	38.182	38.781	39.387	40	40.83	41.673	42.531	43.403				
2.7	44.290	45.192	46.108	47.039	47.986	48.949	49.927	50.921	51.931	52.957				
2.8	54.000	54.962	55.938	56.927	57.931	58.948	59.98	61.026	62.086	63.161				
2.9	64.251	65.356	66.477	67.612	68.763	69.929	71.111	72.309	73.523	74.753				
3	76.000	77.239	78.494	79.765	81.053	82.357	83.678	85.015	86.369	87.741				
3.1	89.130	90.536	91.959	93.400	94.86	96.337	97.832	99.346	100.879	102.43				
3.2	104.000	105.564	107.147	108.749	110.369	112.009	113.667	115.345	117.043	118.76				
3.3	120.497	122.255	124.032	125.830	127.648	129.487	131.347	133.228	135.131	137.054				
3.4	139.000													

Offset* = 0.36

*Offset is the difference between the staff gage reading and stage at zero flow.

Table D.18 Rating table for 7500 Bridge station (GS3, USGS 03536550) located on White Oak Creek
below Melton Valley Drive

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
2.1									0.000	0.069			
2.2	0.138	0.207	0.276	0.345	0.414	0.483	0.552	0.621	0.690	0.759			
2.3	0.828	0.897	0.966	1.035	1.104	1.173	1.242	1.311	1.380	1.472			
2.4	1.567	1.665	1.767	1.873	1.983	2.096	2.213	2.334	2.459	2.587			
2.5	2.72	2.856	2.997	3.141	3.29	3.443	3.6	3.761	3.926	4.097			
2.6	4.269	4.447	4.629	4.816	5.008	5.203	5.403	5.608	5.817	6.031			
2.7	6.249	6.473	6.7	6.933	7.17	7.412	7.659	7.91	8.167	8.428			
2.8	8.694	8.965	9.241	9.523	9.809	10.1	10.406	10.718	11.035	11.358			
2.9	11.687	12.021	12.361	12.707	13.059	13.417	13.78	14.15	14.525	14.907			
3.0	15.294	15.688	16.087	16.493	16.905	17.323	17.747	18.178	18.615	19.058			
3.1	19.508	19.964	20.426	20.895	21.37	21.852	22.34	22.835	23.337	23.845			
3.2	24.36	24.882	25.41	25.945	26.487	27.036	27.592	28.154	28.724	29.300			
3.3	29.884	30.474	31.072	31.676	32.288	32.906	33.532	34.165	34.806	35.453			
3.4	36.108	36.77	37.44	38.117	38.801	39.493	40.192	40.898	41.612	42.334			
3.5	43.063	43.8	44.504	45.215	45.933	46.657	47.388	48.125	48.87	49.621			
3.6	50.378	51.143	51.914	52.692	53.476	54.268	55.066	55.871	56.684	57.502			

Table D.18 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	58.328	59.161	60.001	60.847	61.701	62.562	63.429	64.304	65.185	66.074	66.955	67.836	68.717	69.598
3.7	58.328	59.161	60.001	60.847	61.701	62.562	63.429	64.304	65.185	66.074	66.955	67.836	68.717	69.598
3.8	66.97	67.872	68.782	69.699	70.623	71.555	72.493	73.439	74.391	75.351	76.311	77.271	78.231	79.191
3.9	76.319	77.293	78.275	79.264	80.26	81.264	82.275	83.293	84.319	85.351	86.383	87.415	88.447	89.479
4.0	86.392	87.439	88.495	89.557	90.627	91.705	92.79	93.882	94.982	96.090	97.198	98.306	99.414	100.522
4.1	97.205	98.327	99.457	100.595	101.74	102.893	104.053	105.222	106.398	107.581	108.764	109.947	111.13	112.313
4.2	108.772	109.971	111.178	112.392	113.614	114.843	116.081	117.326	118.580	119.840	121.099	122.358	123.617	124.876
4.3	121.109	122.386	123.67	124.963	126.263	127.571	128.887	130.211	131.543	132.883	134.214	135.545	136.876	138.207
4.4	134.231	135.586	136.95	138.322	139.702	141.09	142.486	143.89	145.302	146.722	148.133	149.544	150.955	152.366
4.5	148.15	149.586	151.031	152.484	153.944	155.413	156.89	158.376	159.869	161.371	162.873	164.375	165.877	167.379
4.6	162.881	164.4	165.926	167.461	169.004	170.555	172.115	173.683	175.260	176.844	178.425	180.006	181.587	183.168
4.7	178.437	180.039	181.649	183.267	184.894	186.529	188.173	189.825	191.486	193.155	194.824	196.493	198.162	199.831
4.8	194.832	196.518	198.213	199.916	201.628	203.348	205.077	206.814	208.560	210.315	212.066	213.817	215.568	217.319
4.9	212.078	213.85	215.63	217.419	219.217	221.024	222.839	224.663	226.496	228.337	230.178	232.019	233.86	235.701
5.0	230.187	232.046	233.914	235.79	237.675	239.57	241.472	243.384	245.305	247.234	249.163	251.092	253.021	254.95
5.1	249.173	251.12	253.076	255.041	257.015	258.997	260.989	262.990	265.000	267.011	269.022	271.033	273.044	275.055
5.2	269.965	272.47	274.991	277.528	280.08	282.647	285.230	287.828	290.442	293.072	295.696	298.319	300.943	303.566
5.3	295.718	298.379	301.056	303.749	306.458	309.182	311.923	314.680	317.453	320.242	323.031	325.82	328.61	331.401
5.4	323.047	325.869	328.706	331.56	334.431	337.318	340.221	343.141	346.077	349.030	351.983	354.936	357.889	360.842
5.5	352	354.987	357.992	361.014	364.053	367.108	370.181	373.270	376.376	379.500	382.624	385.748	388.872	391.996

Table D.18 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)													
	382.641	385.799	388.974	392.166	395.376	398.602	401.847	405.109	408.388	411.685				
5.6														
5.7	415	418.058	421.132	424.219	427.322	430.438	433.569	436.714	439.873	443.047				
5.8	446.236	449.438	452.655	455.887	459.134	462.394	465.670	468.960	472.265	475.585				
5.9	478.919	482.268	485.632	489.01	492.404	495.812	499.235	502.674	506.126	509.594				
6.0	513.078	516.575	520.088	523.616	527.16	530.718	534.292	537.880	541.484	545.103				
6.1	548.738	552.388	556.052	559.733	563.429	567.139	570.866	574.608	578.366	582.138				
6.2	585.927	589.731	593.551	597.386	601.237	605.103	608.986	612.883	616.797	620.726				
6.3	624.672	628.633	632.61	636.603	640.612	644.636	648.677	652.733	656.806	660.894				
6.4	665.000													

Offset* = 2.18

*Offset is the difference between the staff gage reading and stage at zero flow.

Table D.19 Rating table for East Seven Tributary (GS16, USGS 03537050) station on Melton Branch adjacent to proposed SWSA 7

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09		
1.0	0.000	0.001	0.003	0.004	0.006	0.007	0.009	0.012	0.016	0.022		
1.1	0.029	0.034	0.039	0.045	0.051	0.057	0.064	0.072	0.080	0.087		
1.2	0.094	0.102	0.111	0.120	0.129	0.138	0.149	0.160	0.169	0.179		
1.3	0.190	0.201	0.212	0.224	0.237	0.250	0.263	0.277	0.291	0.305		
1.4	0.321	0.337	0.354	0.371	0.389	0.408	0.428	0.448	0.470	0.492		
1.5	0.515	0.539	0.564	0.585	0.607	0.630	0.653	0.677	0.701	0.726		
1.6	0.753	0.779	0.807	0.835	0.865	0.895	0.926	0.957	0.990	1.024		
1.7	1.058	1.094	1.130	1.162	1.195	1.228	1.262	1.297	1.333	1.370		
1.8	1.407	1.445	1.484	1.523	1.564	1.605	1.648	1.691	1.735	1.780		
1.9	1.826	1.872	1.920	1.965	2.011	2.058	2.106	2.154	2.204	2.254		
2.0	2.305	2.357	2.410	2.461	2.512	2.564	2.617	2.671	2.725	2.781		
2.1	2.837	2.894	2.952	3.011	3.071	3.132	3.194	3.256	3.320	3.384		
2.2	3.450	3.516	3.583	3.652	3.721	3.791	3.863	3.935	4.008	4.083		
2.3	4.158	4.235	4.312	4.391	4.471	4.551	4.633	4.716	4.801	4.886		
2.4	4.972	5.060	5.139	5.218	5.298	5.379	5.461	5.545	5.628	5.713		
2.5	5.799	5.886	5.973	6.062	6.152	6.242	6.334	6.426	6.520	6.614		
2.6	6.710	6.806	6.904	7.002	7.102	7.202	7.304	7.406	7.510	7.615		

Table D.19 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)											
	.00	.01	.02	.03	.04	.05	.06	.07	.08	.09		
2.7	7.720	7.827	7.935	8.044	8.154	8.266	8.378	8.491	8.606	8.722		
2.8	8.838	8.956	9.075	9.196	9.317	9.440	9.563	9.688	9.814	9.942		
2.9	10.070	10.200	10.339	10.479	10.620	10.763	10.908	11.054	11.201	11.350		
3.0	11.500	11.631	11.763	11.896	12.030	12.165	12.301	12.438	12.576	12.716		
3.1	12.856	12.998	13.140	13.284	13.429	13.575	13.722	13.870	14.020	14.170		
3.2	14.322	14.474	14.628	14.783	14.940	15.097	15.255	15.415	15.576	15.738		
3.3	15.901	16.066	16.231	16.398	16.566	16.735	16.906	17.078	17.250	17.425		
3.4	17.600	17.784	17.969	18.155	18.343	18.533	18.723	18.915	19.109	19.304		
3.5	19.500	19.750	20.003	20.259	20.516	20.777	21.040	21.305	21.573	21.844		
3.6	22.118	22.394	22.672	22.954	23.238	23.524	23.814	24.106	24.401	24.699		
3.7	25.000											

Offset* = 1.00

*Offset is the difference between the staff gage reading and stage at zero flow.

Table D.20 Rating table for the H-flume at Center Seven station (GS17, USGS 03537200) located on Center 7 Creek,
a tributary of Melton Branch

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
0.0	0.000	0.001	0.002	0.004	0.006	0.009	0.012	0.016	0.02	0.025			
0.1	0.030	0.035	0.041	0.047	0.053	0.059	0.067	0.074	0.082	0.091			
0.2	0.099	0.108	0.118	0.128	0.138	0.149	0.16	0.172	0.184	0.196			
0.3	0.209	0.222	0.235	0.249	0.264	0.28	0.296	0.312	0.329	0.346			
0.4	0.364	0.382	0.4	0.419	0.437	0.455	0.477	0.498	0.52	0.542			
0.5	0.565	0.588	0.61	0.634	0.66	0.685	0.71	0.736	0.763	0.791			
0.6	0.819	0.847	0.876	0.905	0.934	0.964	0.995	1.026	1.095	1.095			
0.7	1.13	1.162	1.195	1.229	1.264	1.299	1.338	1.376	1.414	1.452			
0.8	1.49	1.53	1.569	1.611	1.655	1.698	1.741	1.783	1.828	1.874			
0.9	1.921	1.966	2.011	2.059	2.11	2.161	2.21	2.26	2.31	2.361			
1.0	2.412	2.463	2.513	2.567	2.624	2.68	2.737	2.793	2.851	2.91			
1.1	2.97	3.03	3.091	3.151	3.21	3.27	3.333	3.397	3.463	3.532			
1.2	3.602	3.672	3.743	3.806	3.863	3.919	3.99	4.061	4.131	4.202			
1.3	4.273	4.357	4.442	4.52	4.59	4.661	4.746	4.83	4.908	4.979			
1.4	5.049	5.134	5.219	5.304	5.388	5.473	5.558	5.643	5.727	5.812			
1.5	5.897	5.982	6.066	6.158	6.257	6.356	6.455	6.554	6.652	6.751			

Table D.20 (continued)

[illegible]

[illegible]

Table D.22 Rating table for West Seven Tributary station (GS18, USGS 03537300) located on Melton Branch

GAGE HEIGHT (ft)	DISCHARGE (cfs)												
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09			
1			0.000	0.001	0.002	0.003	0.004	0.005	0.006	0.006			0.006
1.1	0.007	0.007	0.008	0.01	0.012	0.015	0.018	0.022	0.025	0.029			0.029
1.2	0.034	0.039	0.045	0.05	0.056	0.063	0.07	0.078	0.086	0.094			0.094
1.3	0.103	0.112	0.123	0.133	0.144	0.155	0.168	0.181	0.194	0.207			0.207
1.4	0.222	0.237	0.253	0.293	0.338	0.39	0.45	0.503	0.562	0.627			0.627
1.5	0.7	0.772	0.85	0.92	0.995	1.075	1.162	1.255	1.354	1.461			1.461
1.6	1.576	1.699	1.83	1.93	2.035	2.144	2.259	2.379	2.505	2.637			2.637
1.7	2.775	2.919	3.07	3.194	3.321	3.453	3.59	3.731	3.877	4.028			4.028
1.8	4.183	4.344	4.51	4.654	4.802	4.954	5.109	5.269	5.432	5.600			5.600
1.9	5.773	5.949	6.13	6.292	6.457	6.626	6.799	6.975	7.154	7.337			7.337
2	7.525	7.715	7.91	8.088	8.27	8.455	8.643	8.834	9.028	9.226			9.226
2.1	9.427	9.632	9.84	10.045	10.254	10.466	10.681	10.9	11.412	11.945			11.945
2.2	12.5	12.86	13.228	13.605	13.991	14.386	14.791	15.205	15.629	16.063			16.063
2.3	16.507	16.961	17.425	17.9	18.386	18.883	19.392	19.911	20.443	20.986			20.986
2.4	21.541	22.109	22.689	23.282	23.887	24.506	25.139	25.785	26.445	27.119			27.119
2.5	27.807	28.51	29.228	29.961	30.71	31.474	32.254	33.05	33.862	34.692			34.692
2.6	35.538	36.402	37.283	38.182	39.099	40.035	40.989	41.962	42.955	43.968			43.968

Table D.22 (continued)

GAGE HEIGHT (ft)	DISCHARGE (cfs)									
	0.00	0.01	0.02	0.03	0.04	0.05	0.06	0.07	0.08	0.09
2.7	45									

Offset* = 1.02

*Offset is the difference between the staff gage reading and stage at zero flow.

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