

1.0 INTRODUCTION

1.1 PURPOSE OF THE MONITORING PROGRAM

The U.S. Army Corps of Engineers (USACE) manages F.E. Walter Reservoir located in northeastern Pennsylvania within the Delaware River Basin. Foremost, F.E. Walter Reservoir provides flood control and a dependable water supply to downstream communities on the Lehigh River. Additionally, the reservoir provides important habitat for fish, waterfowl, and other wildlife, and recreational opportunities through fishing, and boating. Due to the broad range of uses and demands F.E. Walter Reservoir serves, the USACE monitors water quality and other aspects related to reservoir health primarily to ensure public health safety. Water quality monitoring results are compared to state water quality standards and used to diagnose other problems that commonly effect reservoir health such as nutrient enrichment and toxic loadings. This report summarizes the results of water quality monitoring at F.E. Walter Reservoir from April through October 2001. This report also discusses the relevance of the water quality measures to the ecology of the reservoir and makes recommendations toward future water quality monitoring.

1.2 DESCRIPTION OF F.E. WALTER RESERVOIR

F.E. Walter Reservoir is an integral part of the Lehigh River Flood Control Program. The authorized purpose of this project is flood control. The reservoir project was authorized as a white water project as part of Public Law 100-676, Section 6, dated November 17, 1988. Located about 9 miles southeast of Wilkes-Barre, PA, the reservoir dams a drainage area of 288 square miles. The dam can impound up to 35.8 billion gallons of floodwater. The primary surface water input into the reservoir is the Lehigh River as it flows west between Luzerne and Carbon Counties. Bear Creek, a secondary surface water input, enters the reservoir from the north. Tobyhanna Creek drains an area to the southeast and joins the Lehigh River near the headwaters of the reservoir. The reservoir is approximately 3 miles long and about 50 feet deep at the face of the dam. Average annual discharge from the dam into the Lehigh River is approximately 625 cubic feet per second (USGS 1993).

1.3 ELEMENTS OF THE STUDY

The USACE, Philadelphia District, has been monitoring the water quality of F.E. Walter Reservoir since 1975. Over this time, the yearly monitoring designs have evolved to address newly defined problems such as health of public drinking water and

contamination of sediments. The 2001 monitoring program follows that in recent years and includes the following major elements:

- Monthly water quality and bacteria monitoring from April through October to evaluate compliance with the Pennsylvania state water quality standards;
- In an effort to coordinate concurrent studies, additional parameters were collected and analyzed in conjunction with the Lehigh Water Quality Study. This included the addition of a meteorological station on the dam tower;
- Sediment priority pollutant monitoring of semivolatile organics and metals to evaluate sediment toxicity relative to identified screening concentrations; and
- Drinking water monitoring to ensure public health safety by comparing water quality from a drinking water source to standards determined by the Safe Drinking Water Act (SDWA).

2.0 METHODS

2.1 PHYSICAL STRATIFICATION MONITORING

Physical stratification monitoring of the water column of F.E. Walter Reservoir was conducted seven times during 2001, between April and October (Table 2-1). Physical stratification parameters included temperature, dissolved oxygen (DO), percent of DO saturation (dependent on temperature), pH, and conductivity. Monitoring was conducted at seven fixed stations located throughout the reservoir watershed (Fig. 2-1). Surface water quality was monitored at stations downstream of the reservoir (WA-1), and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Stratification monitoring was conducted at the reservoir-body station WA-2 with water quality measured at the surface to the bottom at 5-ft intervals. Two new stations were added this year on Bear Creek (WA-6) and on Lehigh River (WA-7). All of the water quality monitoring was conducted with a calibrated Hydrolab water quality meter.

In this report, water quality data recorded from stratification monitoring were compared to water quality standards mandated by the Pennsylvania Department of Environmental Protection (PADEP Chapter 93). The standard for DO is a minimum concentration of 5 mg/L, and that for pH is an acceptable range from 6 to 9.

All of the water quality data collected during physical stratification monitoring are summarized in Appendix Table A-1.

2.2 WATER COLUMN CHEMISTRY MONITORING

Water column chemistry monitoring was conducted seven times at F.E. Walter Reservoir between April and October (Table 2-1). Water samples were collected at the seven fixed stations throughout the reservoir drainage area (Fig. 2-1). Surface water samples were collected at stations downstream of the reservoir (WA-1) and upstream on Tobyhanna Creek (WA-3), the Lehigh River (WA-4), and Bear Creek (WA-5). Surface, middle, and bottom water samples were collected at the reservoir-body station WA-2, WA-6, and WA-7. Surface water samples were collected by opening the sample containers approximately 1 foot below the water's surface. Middle and bottom samples were collected with a Van Dorn design horizontal water bottle.

Water samples collected from surface, middle, and bottom depths were analyzed for ammonia, nitrite, nitrate, total Kjeldahl nitrogen (TKN), total phosphorus, total dissolved solids (TDS), total suspended solids (TSS), biochemical oxygen demand (BOD), alkalinity, total organic carbon (TOC), total inorganic carbon (TIC) and chlorophyll *a*. Table 2-2 summarizes the water quality parameters; laboratory method detection limits, state water quality standards, and allowable and achieved maximum hold times for each. Parameters such as BOD went beyond the maximum holding time by one day.

Table 2-1. F.E. Walter Reservoir water quality monitoring schedule for 2001						
Date of Sample Collection	Physical Stratification Monitoring (All Stations)	Water Column Chemistry Monitoring (All Stations)	Trophic State Determination (WA-2)	Coliform Bacteria Monitoring (All Stations)	Sediment Priority Pollutant Monitoring (WA-2)	Drinking Water Monitoring*
24 April	X	X	X	X		
23 May	X	X	X	X		
13 June	X	X	X	X		Sets A and B
21 June						Total Coliform/ E. Coli
18 July	X	X	X	X	X	
9 August	X	X	X	X		Sets A
27 September	X	X	X	X		
23 October	X	X	X	X		
* Set A – comprised analyses of nitrate, nitrite, and coliform bacteria contaminants. Set B – comprised analyses for primary and secondary contaminants.						

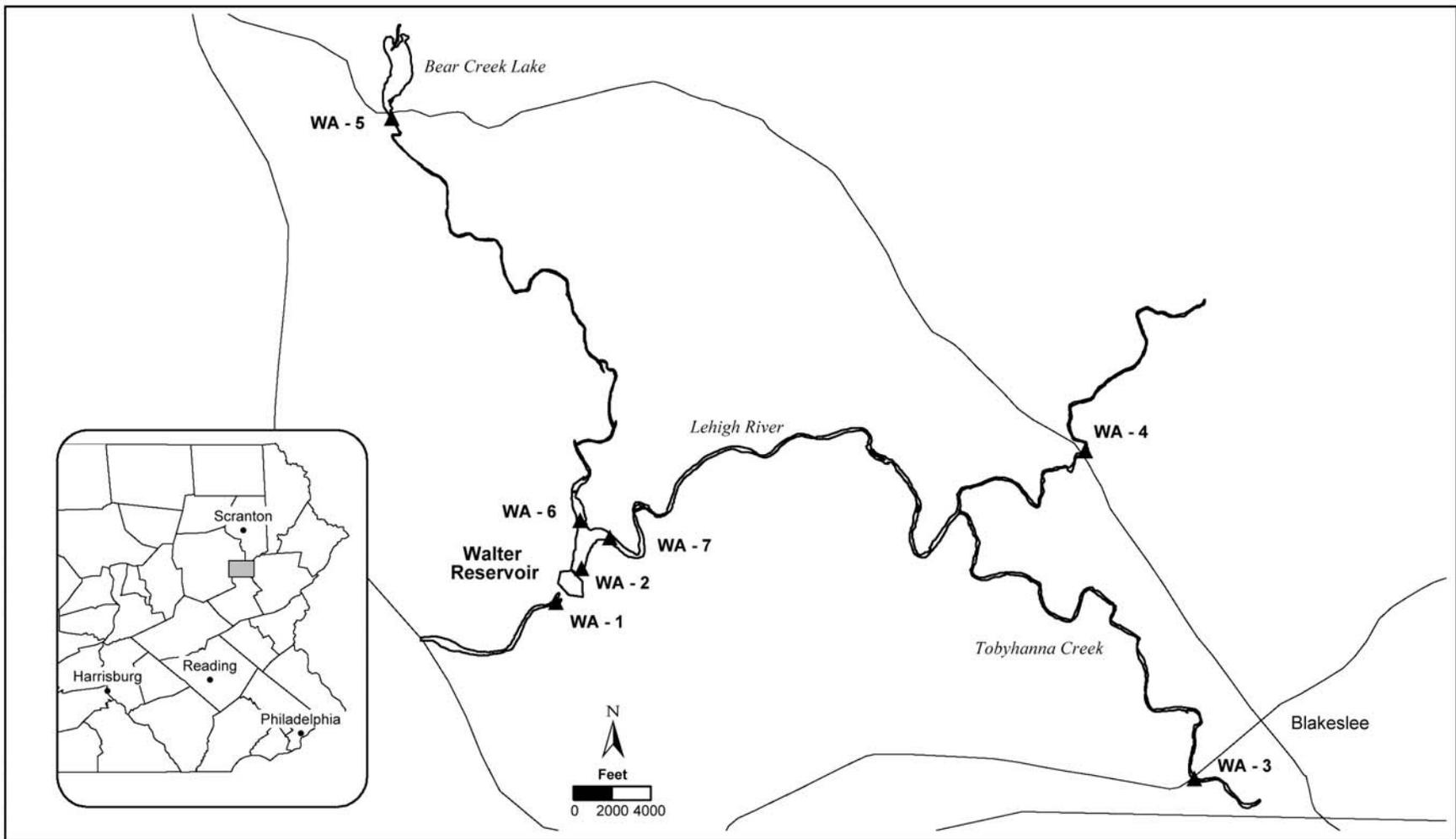


Figure 2-1 Location map for F.E. Walter Reservoir and water quality monitoring stations in 2001

Table 2-2. Water quality test methods, detection limits, state regulatory criteria, and sample holding times for water quality parameters monitored at F.E. Walter Reservoir in 2001					
Parameter	EPA Method	Detection Limit	PADEP Surface Water Quality Criteria	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Alkalinity	310.3	1 mg/L	minimum 20 mg/L CaCO ₃	14	13
Biochemical Oxygen Demand (BOD)	SM5210B	3 mg/L	None	2	3
Total Phosphorus	365.2	0.05 mg/L	None	28	9
Dissolved Phosphorus	365.2	0.05mg/L	None	28	13
Dissolved Phosphate	365.2	0.05 mg/L	None	28	13
Total Organic Carbon	415.1	5 mg/L	None	28	21
Total Inorganic Carbon	415.1	5 mg/L	None	28	21
* Chlorophyll <i>a</i>	445.0	0-mg/m ³	None	90	60
Total Kjeldahl Nitrogen	351.3	0.20 mg/L	None	28	15
Ammonia	350.3	0.1 mg/L	Temperature and pH dependent	28	14
Nitrate	300	0.5 mg/L	Maximum 10 mg/L (nitrate + nitrite)	2	2
Nitrite	300	0.5 mg/L		2	2
Total Dissolved Solids	160.1	10 mg/L	Maximum 500 mg/L	7	7
Total Suspended Solids	160.2	1 mg/L	None	7	7
* Chlorophyll <i>a</i> samples were allowed this holding time when wrapped tightly in the dark at – 20 °C					

2.3 TROPHIC STATE DETERMINATION

The trophic state of F.E. Walter Reservoir was determined by methods outlined by Carlson (1977). In general, this method calculates trophic state indices (TSIs) independently for total phosphorus and chlorophyll *a* concentrations, and secchi disk depth. Surface water measures of total phosphorus and chlorophyll *a* from chemistry monitoring were averaged in determining monthly TSI values. Secchi disk depth was measured only in surface waters at the reservoir-body station (WA-2). Trophic state determinations were made using criteria defined by Carlson (1977) and EPA (1983).

2.4 RESERVOIR BACTERIA MONITORING

Monitoring for coliform bacteria contaminants was conducted seven times between April and October at F.E. Walter Reservoir. Surface water samples were collected in the same manner as for chemical parameter samples, and analyzed for total and fecal coliform bacteria contamination. Table 2-3 presents the test methods, detection limits, PADEP standards, and sample holding times for the bacteria parameters monitored at F.E. Walter Reservoir in 2001. The bacteria analytical method was based on a membrane filtration technique. All of the samples were analyzed within their maximum allowable hold times. At the end of the monitoring period, streamflow data (CFS) collected from USGS gauging stations in the region (Blakeslee and Stoddartsville) and precipitation data collected at the dam were used to correlate rainfall patterns with measured bacteria levels (see Section 2.5).

Table 2-3. Water quality test methods, detection limits, PADEP water quality standards, and sample holding times for bacteria parameters monitored at F.E. Walter Reservoir in 2001		
Parameter	Total coliform	Fecal coliform
Test method	SM 9222B	SM9222D
Detection limit	10 clns/100-mls	10 clns/100-ml
PADEP standard	-	Geometric mean less than 200 clns/100-ml (application of this standard is conservative because swimming is not permitted in the reservoir)
Maximum allowable holding time	30 hours	30 hours
Achieved holding time	< 30 hours	< 30 hours

Monthly coliform bacteria counts were compared to the PADEP water quality standard for bacteria. The standard is defined as a maximum geometric mean of 200 colonies/100-ml based on five samples collected on different days. Given our logistical limitations (all monthly sampling conducted on one day), we calculated the geometric mean based on all of the surface samples collected for each month. Although our sampling design does not fully meet PADEP guidelines, we feel that this interpretation of the coliform data meets the intent of the PADEP water quality standard for evaluating F.E. Walter Reservoir bacteria levels. Additionally, application of this standard is conservative because swimming and other human/water contact recreation is prohibited in the reservoir.

2.5 STREAMFLOW AND PRECIPITATION DATA

Streamflow and precipitation data for the principal monitoring months from April to October were compiled from USACE records (Figs. 2-2 through 2-8). Streamflow data were collected from the USGS stations located in Blakeslee and Stoddartsville and reflect rainfall patterns throughout the F.E. Walter Reservoir watershed. Precipitation data was collected by F.E. Walter Reservoir personnel and reflects a more local condition of rainfall pattern.

In April through the middle of May, stream flow slowly decreased from over 1,000-cfs to 300-cfs until two small precipitation events took place at the end of May (Fig. 2-2 and Fig. 2-8). These rain events increased the flow to 600-cfs. After the May rain events, stream flow decreased again to 300-cfs until the middle of June when there was another rain event of over 3 inches. Monthly monitoring in all three months took place when stream flow ranged from 200 to 600-cfs. In the later part of the summer the stream flow decreased to approximately 200-cfs. Monthly monitoring was done at 200-cfs during July and August. Towards the end of September there was a storm event that exceeded 2.0 inches of rain. Monthly monitoring was conducted at a stream flow of approximately 300-cfs on September 25.

2.6 SEDIMENT PRIORITY POLLUTANT MONITORING

Sediment from F.E. Walter Reservoir was monitored for priority pollutant contaminants, Group 2 – metals and semivolatiles. Sediment was collected on 18 July at station WA-2 with a petite ponar grab-sampler. Sediment from the grab-sampler was emptied into a stainless steel mixing bowl and homogenized with a stainless steel spoon. Sediments were contained in appropriately labeled sample jars and stored on ice until shipment to the analytical laboratory. All field equipment used during the handling of reservoir sediments was decontaminated prior to sampling. Decontamination procedures were as follows: detergent wash, first deionized water rinse, 10% nitric acid rinse, second deionized water rinse, hexane rinse, and third deionized water rinse. Table 2-4 summarizes the parameters monitored, method detection limits, sample hold times, and the laboratory methods used in the analyses.

All sediment contaminant concentrations were reported on a dry weight basis, and were calculated as follows:

$$\text{Dry weight concentration (mg/kg)} = \frac{\text{Wet weight concentration (mg/kg)} \times 100}{\% \text{ solid of sample}}$$

Sample-specific detection limits were calculated for the sediment tests because of matrix interference and the conversion from wet weight to dry weight.

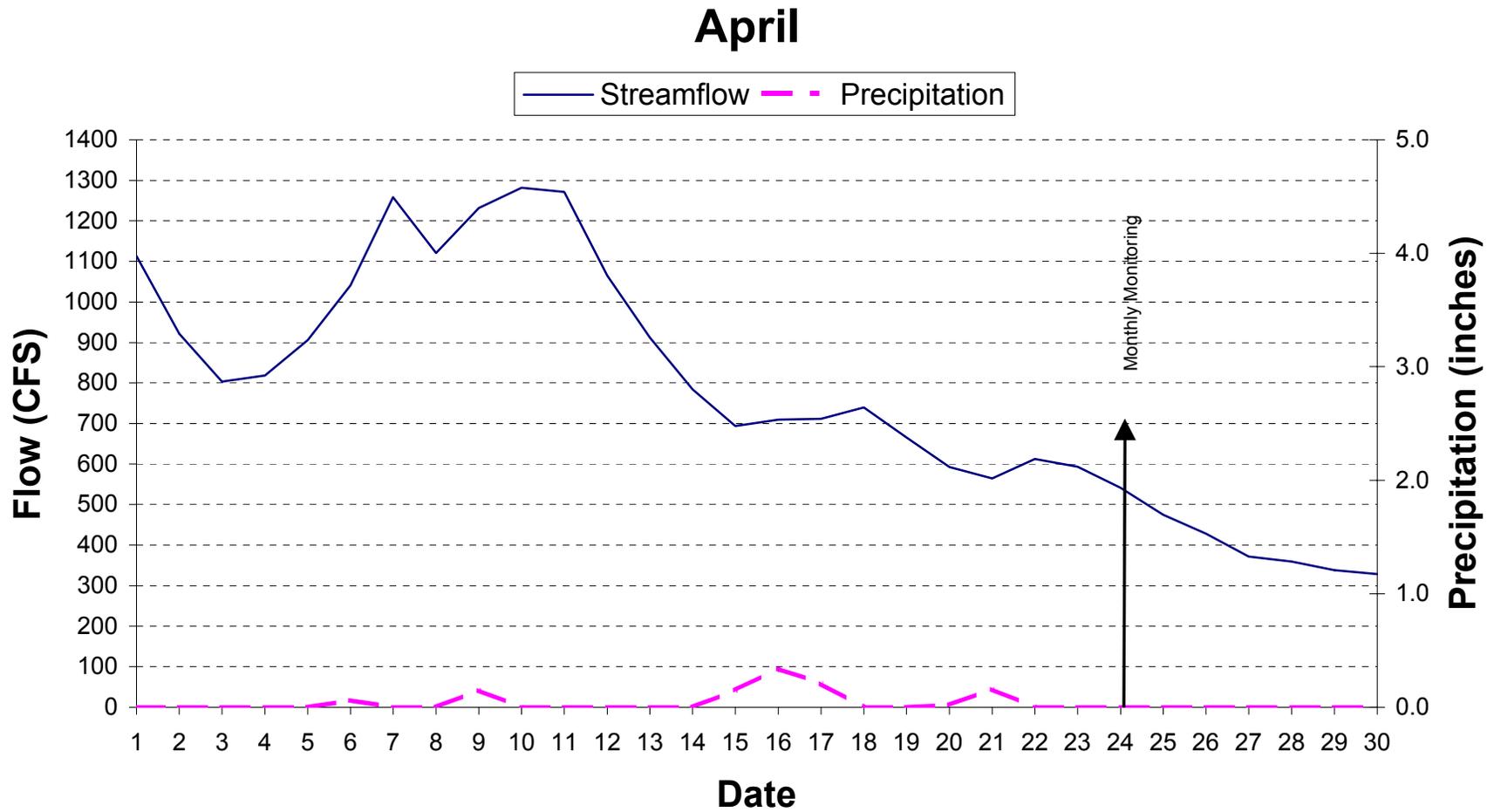


Figure 2-2. April streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2001

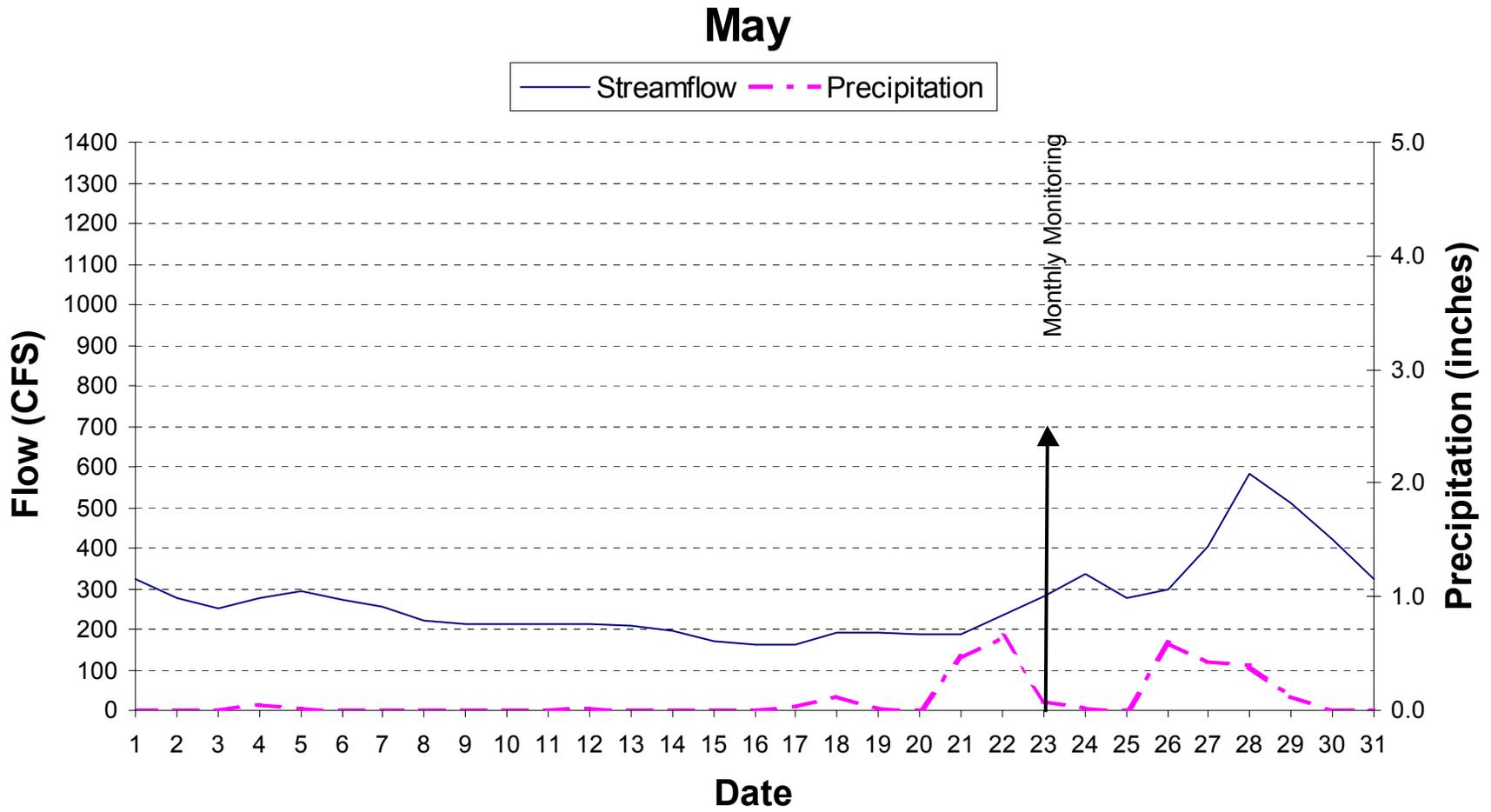


Figure 2-3. May streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2001

June

2-9

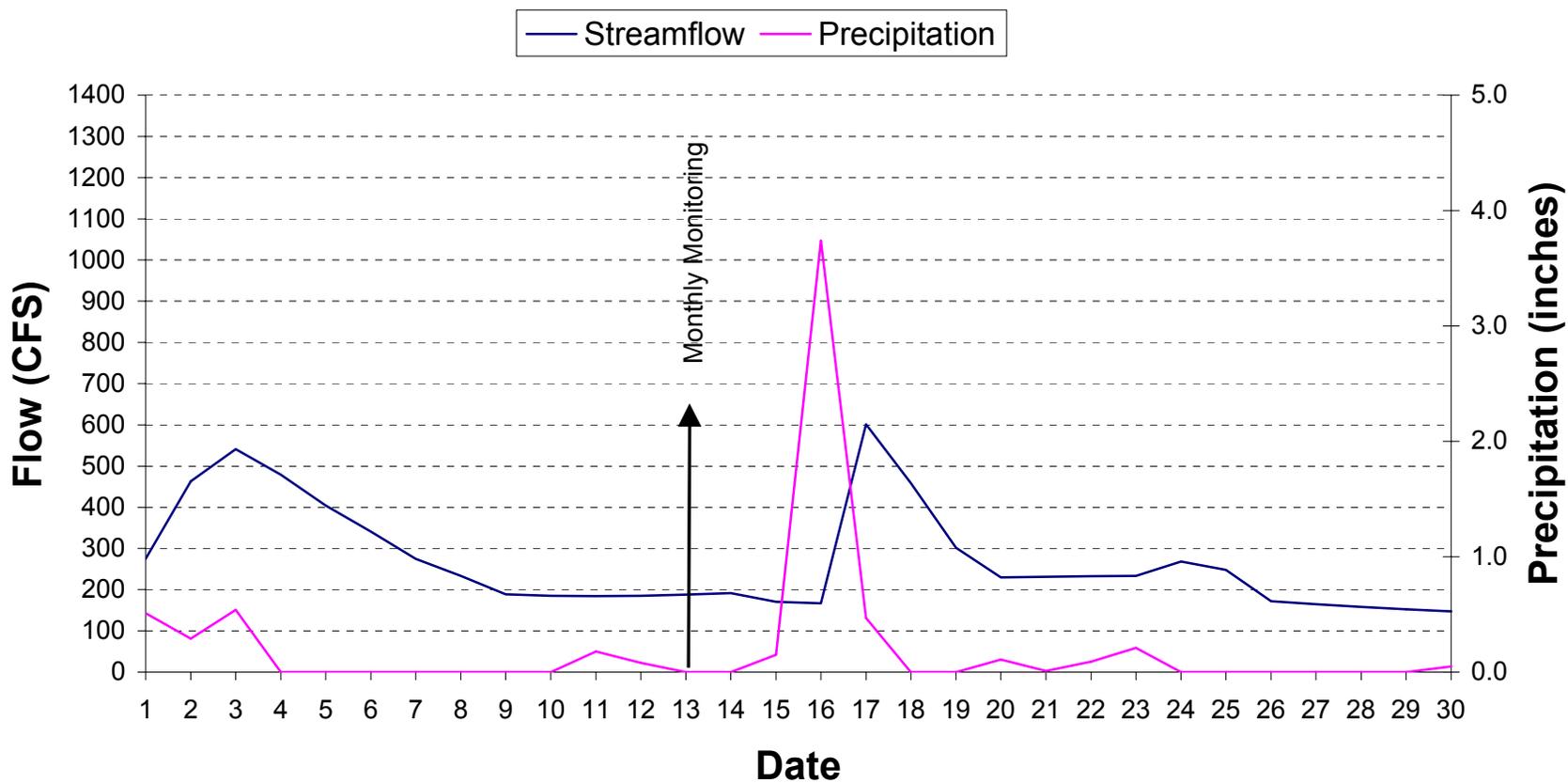


Figure 2-4. June streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2001

July

2-10

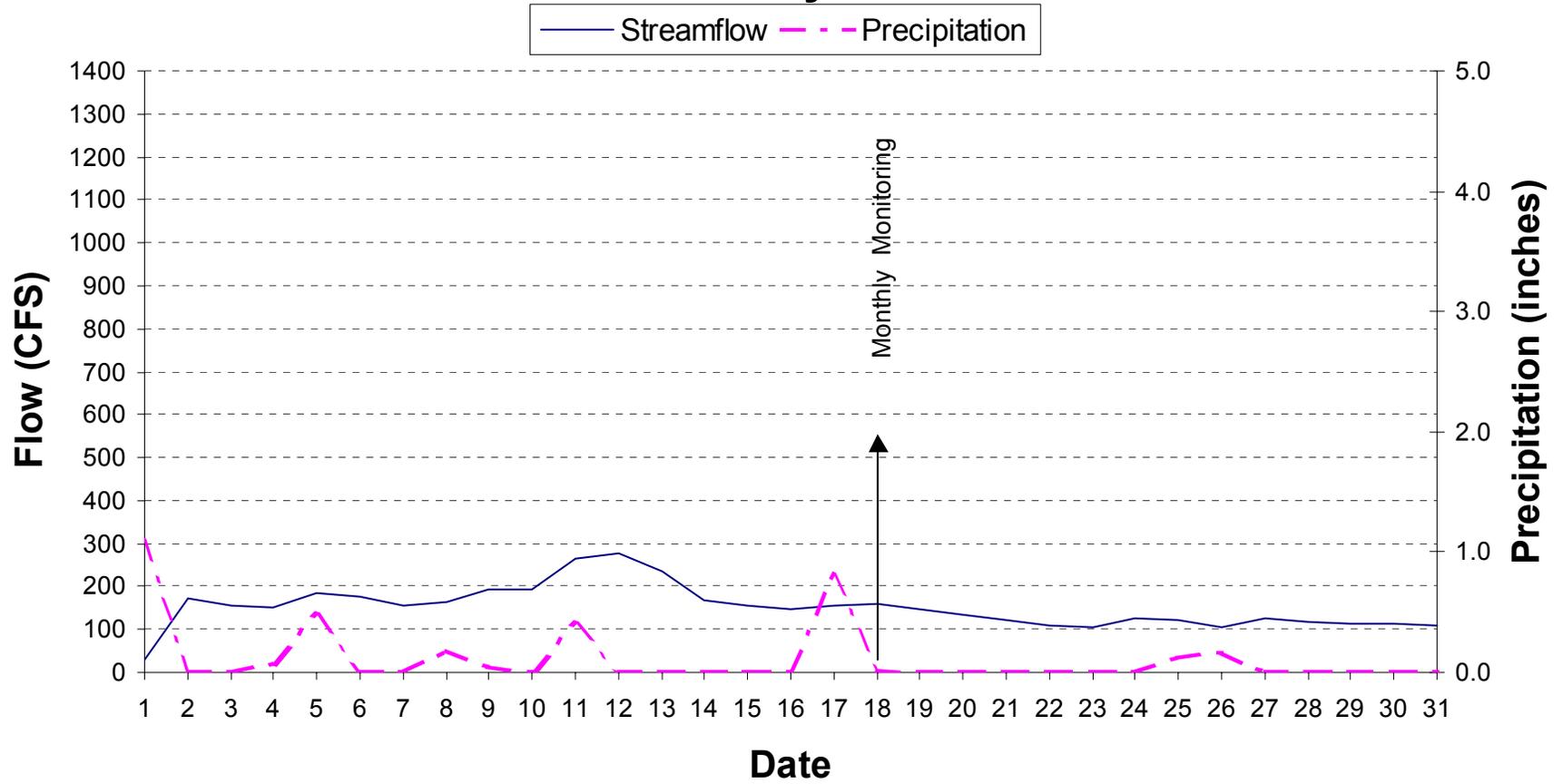


Figure 2-5. July streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2001

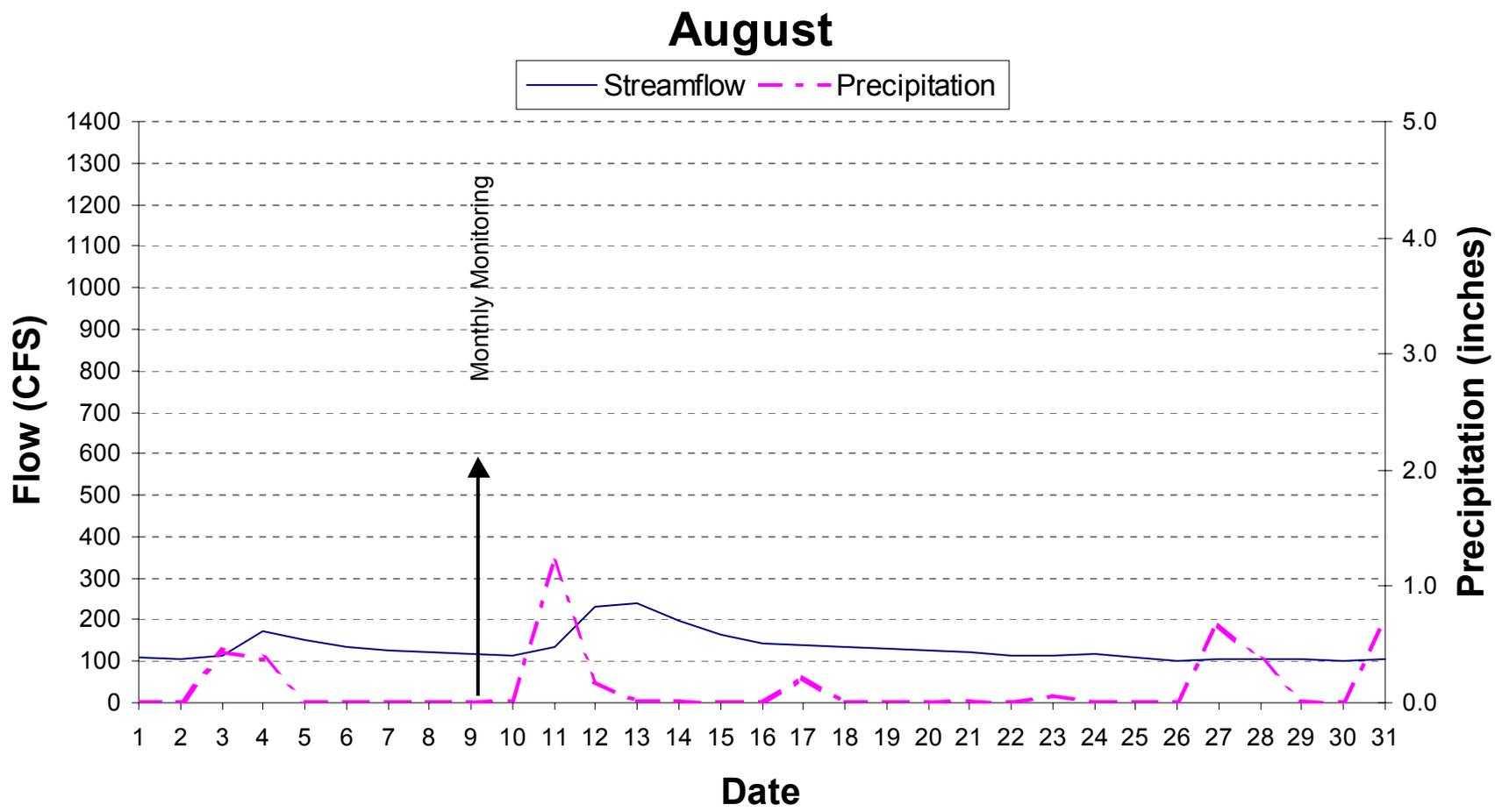


Figure 2-6. August streamflow and precipitation in the vicinity of F.E. Walter Reservoir during August 2001

September

2-12

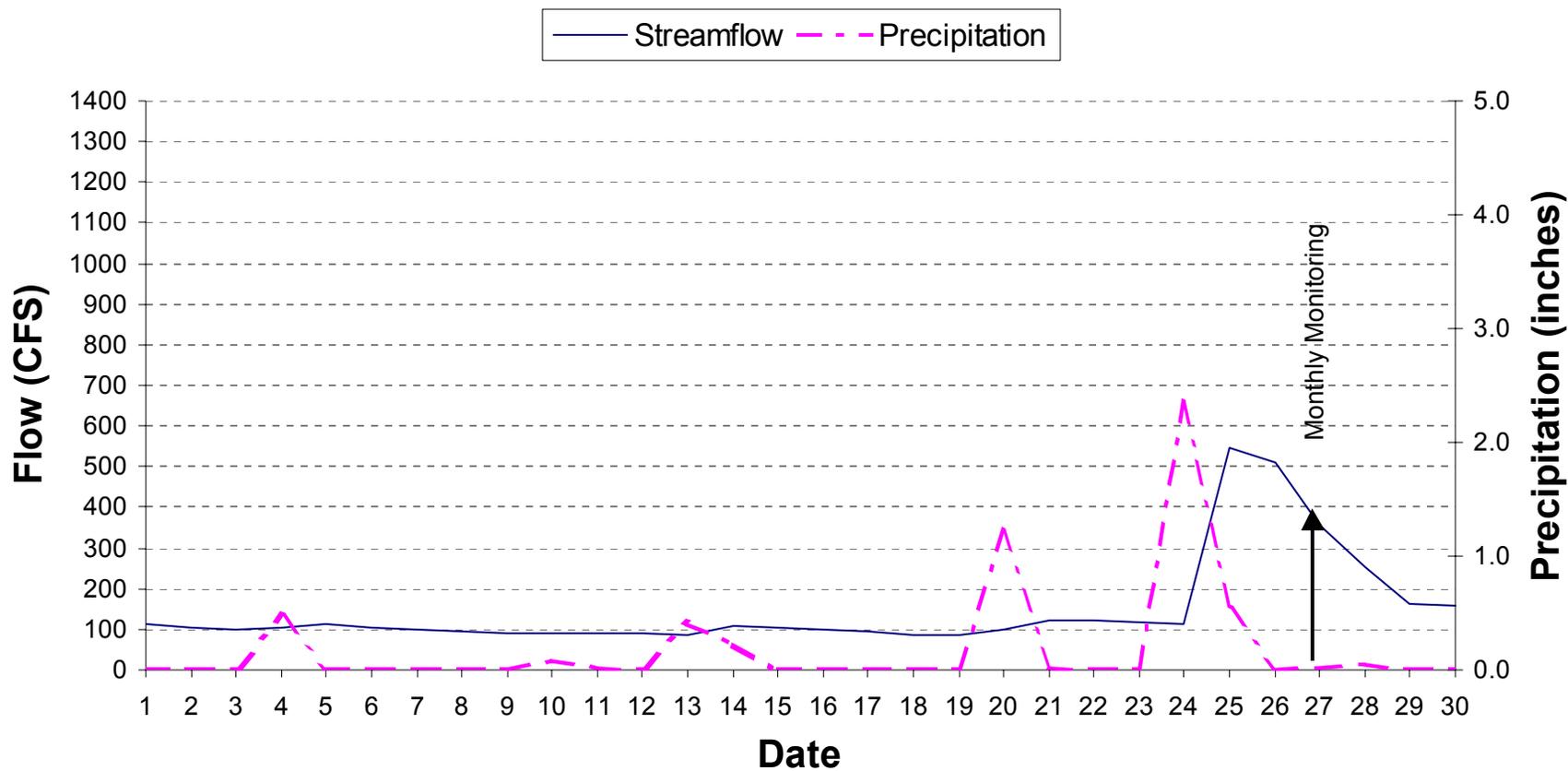


Figure 2-7. September streamflow and precipitation in the vicinity of F.E. Walter Reservoir during September 2001

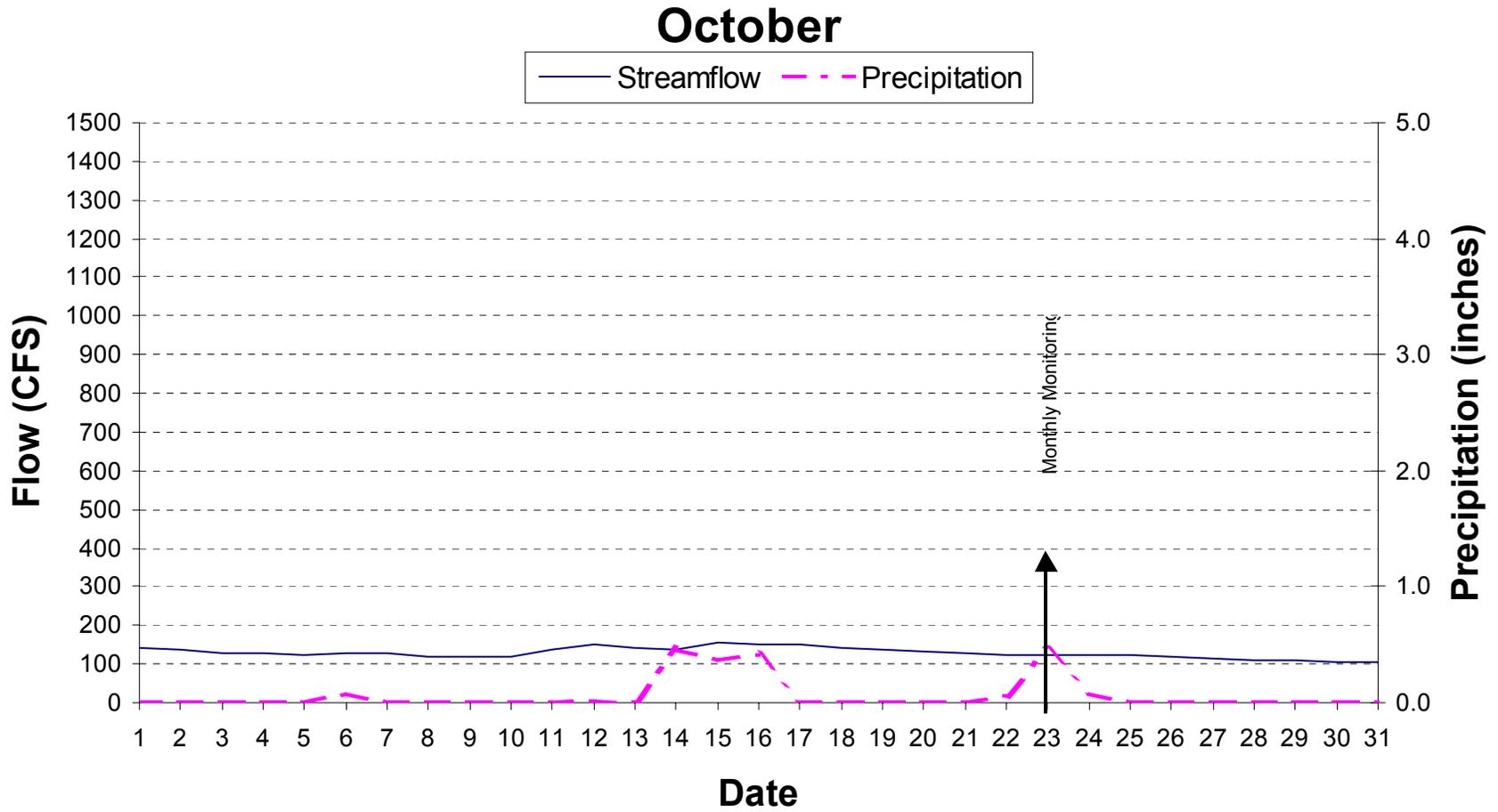


Figure 2-8. October streamflow and precipitation in the vicinity of F.E. Walter Reservoir in 2001

Table 2-4. Analytical methods, detection limits, and sample hold times for sediment priority pollutant metals and semivolatiles (SVOCs) monitored at F.E. Walter in 2001.				
Parameter	EPA Method	Method Detection Limit (mg/kg)	Allowable Hold Time (days)	Max. Hold Time Achieved (days)
<i>CONVENTIONALS</i>				
Percent Solids	STM D2974	0.1		0
<i>METALS</i>				
Aluminum	6010B	80.2	180	12
Antimony	6010B	1.6	180	7
Arsenic	6010B	4	180	7
Barium	6010B	0.4	180	7
Beryllium	6010B	0.4	180	7
Cadmium	6010B	0.4	180	7
Calcium	6010B	1.6	180	7
Chromium	6010B	0.4	180	7
Cobalt	6010B	1.6	180	7
Copper	6010B	0.4	180	7
Iron	6010B	20	180	12
Lead	6010B	1.6	180	7
Magnesium	6010B	1.6	180	7
Manganese	6010B	0.4	180	7
Mercury	6010B	0.07	28	12
Nickel	6010B	0.4	180	7
Potassium	6010B	1.6	180	7
Selenium	6010B	3.0	180	7
Sodium	6010B	1.6	180	7
Vanadium	6010B	1.6	180	7
Zinc	6010B	0.4	180	7
<i>SVOC (mg/kg)</i>				
2,4,5-Trichlorophenol	8270C	397	40	7
2,4,6-Trichlorophenol	8270C	397	40	7
2,4-Dichlorophenol	8270C	397	40	7
2,4-Dimethylphenol	8270C	397	40	7
2,4-Dinitrophenol	8270C	397	40	7
2-Chlorophenol	8270C	397	40	7
2-Methylphenol	8270C	397	40	7
2-Nitrophenol	8270C	397	40	7
3-Methylphenol	8270C	397	40	7
4,6-Dinitro-2-methylphenol	8270C	397	40	7
4-Chloro-3-methylphenol	8270C	397	40	7
4-Methylphenol	8270C	397	40	7
4-Nitrophenol	8270C	397	40	7
Benzoic acid	8270C	397	40	7
Benzyl alcohol	8270C	397	40	7
Pentachlorophenol	8270C	397	40	7
Phenol	8270C	397	40	7

2.7 TREND ANALYSIS METHODS

Annual water quality, sediment contaminant, and drinking water monitoring have been conducted at F.E. Walter Reservoir since 1975. Data collected over these years were compiled in to an electronic database by the USACE (Versar 1996). The compilation of historical data enables the use of statistical trend analysis, an important tool in determining if the water quality at F.E. Walter Reservoir is changing. A number of different trend analysis methods are available, some more complicated than others. For the purpose of this report, we employed two general methods, regression analysis and the Mann-Kendall, or Seasonal Kendall, test.

2.7.1 Regression Analysis

The spatial and temporal distributions of the historical data were examined to determine which parameters had a sufficient time series to warrant meaningful trend analysis. Among the stations monitored for the major water quality parameters (e.g., nutrients, dissolved oxygen, total dissolved solids), downstream station WA-1 and reservoir station WA-2 were consistently sampled over the entire 23-year time series. Water quality trend analyses were limited to the spring (April through June) and summer (July through 15 October) periods. The "spring season" analyses were conceptualized as representing long-term trends associated with inputs to the reservoir during snow melt periods. The "summer season" analyses depicted conditions during periods of maximum productivity and greatest low DO stress. Trends at station WA-1 were analyzed separately to evaluate conditions in the Lehigh River downstream of the reservoir. Regression analyses were used to determine if significant change in parameter concentrations occurred over the past two decades. The slope of the regression line was used to estimate the yearly rate of change. For this report, regression analysis was applied to the water quality parameters: total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and fecal coliform bacteria.

2.7.2 Mann-Kendall Analysis

In addition to regression analysis, the non-parametric Mann-Kendall test was used to determine trends for individual stations over the time span of historical monitoring at F.E. Walter Reservoir. The Mann-Kendall (or Seasonal Kendall) test scores all combinations of yearly change for the tested parameter with a +1 or -1 depending on whether parameter increased or decreased over the time interval. All of the scores are then summed and compared to the chi-square distribution to determine if the parameter has a significant trend (increasing or decreasing) over the time series. For this report, the Mann-Kendall test was applied to the water quality parameters: dissolved oxygen, ammonia, total nitrogen, total phosphorus, total dissolved solids, biochemical oxygen demand, and total and fecal coliform bacteria.

2.8 DRINKING WATER MONITORING

Drinking water was monitored in the operations building of F.E. Walter Reservoir (Table 2-1). Drinking water parameters were divided into two sets, A and B. Set A comprised bacteria parameters, total and fecal coliform (for analytical methods, see section 2.4), and nitrate and nitrite. Set A samples were collected 13 June and 9 August. Set B samples were analyzed for primary and secondary contaminants and were monitored 13 June. An extra coliform sampling was collected on 21 June. Table 2-5 summarizes the analytical methods, method detection limits, and sample hold times for each set B parameter. All of the drinking water quality parameters were analyzed within their respective maximum allowable hold times during 2001.

Table 2-5. Analytical methods, method detection limits, and sample hold times for drinking water monitored at F.E. Walter Reservoir in 2001				
Parameter	Detection Limits	EPA Method	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Aluminum	0.02	200.7	180	12
Antimony	0.05	200.8	180	12
Arsenic	0.05	200.7	180	12
Barium	0.005	200.7	180	12
Beryllium	0.005	200.7	183	12
Cadmium	0.005	200.7	180	12
Chromium	0.005	200.7	180	12
Copper	0.005	200.7	180	12
Iron	0.005	200.7	180	12
Lead	0.001	200.8	N/A	6
Magnesium	0.02	200.7	180	12
Manganese	0.005	200.7	180	12
Mercury	0.0002	245.1	28	12
Nickel	0.005	200.7	180	12
Selenium	1.0	200.8	183	26

Table 2-5. (Continued)				
Parameter	Detection Limits	EPA Method	Allowable Hold Times (Days)	Maximum Hold Time Achieved (Days)
Silver	0.005	200.7	180	12
Sodium	0.02	200.7	180	12
Thallium	0.05	200.8	180	12
Zinc	0.005	200.7	180	12
Alkalinity as CaCO ₃	2.0	SM 2320B	183	2
Chloride	1	300.0	28	12
Cyanide	0.007	SM 4500CN-C&E	14	12
Fluoride	0.1	SM 4500F-B	28	11
Hardness as CaCO ₃	2.0	SM 3500-Ca-D	14	14
Foaming Agents	0.05	SM 5540C	2	1
Nitrate as N	1	SM4500	2	1
Nitrite as N	0.005	SM4500	2	1
Sulfate	5.0	300.0	28	7
Total Dissolved Solids	10.0	SM 2540C	7	5
pH	+/-0.01	150.1	N/A	1
N/A – Not applicable				

