WATER QUALITY STATUS REPORT NO. 117

East Fork of the South Fork of the Salmon River

Valley County, Idaho

1979 - 1995

Prepared by:

Bruce A. Schuld

Southwest Idaho Regional Office
Idaho Department of Health and Welfare
Division of Environmental Quality
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ACKNOWLEDGMENTS

Monitoring of the East Fork of the South Fork of the Salmon River (EFSFSR) has been the responsibility of many technicians and scientists in the Idaho Division of Environmental Quality (DEQ), Idaho Department of Fish and Game (IDF&G), Idaho Department of Lands (IDL), Idaho Department of Water Resources (IDWR), U.S. Fish and Wildlife Service (USF&WS), Idaho Department of Health and Welfare Bureau of Laboratories, Krassel District of the Payette National Forest (PNF), and the current operators, Hecla Mining Company (HECLA), and Stibnite Mine Incorporated (SMI). Their perserverence to improve monitoring procedure and analyses has resulted in better correlations between data sets, and ultimately in land management practices in the Upper EFSFSR Watershed.

The discussion of analyses contained in other environmental reports is imperative to correlating the various environmental factors present in the watershed. Mere reference of these reports and authors is insufficient to underscore their importance and contributions. This report contains discussion of analyses by; Susan Burch and Bill Mullins of the USF&WS, John Lund, Mary Faurot, and John Gephards of the PNF, and Robert W. Wisseman of Aquatic Biology Associates, Incorporated, without all of whose contributions this report would be inadequate to analyze the ecological status of the watershed.

ABSTRACT

The EFSFSR watershed is located on the western border of the Frank Church River of No Return Wilderness in Valley County, Idaho (Figure 1, JMM). Impacts to the EFSFSR occur due to mining activities at Stibnite and Cinnabar. Although monitoring plans had been focused on the entire length of the EFSFSR, trends in data justified modifications in the plans to focus limited resources and funding on the EFSFSR and two major tributaries, Sugar Creek and Meadow Creek, in proximity to Stibnite.

The EFSFSR has been designated as both a Stream Segment of Concern, and a Special Resource Water. The EFSFSR is particularly notable for its role as a spawning and rearing habitat for salmon, steel head, bull trout and cutthroat trout. Meadow Creek and the EFSFSR have been submitted to the U.S. Environmental Protection Agency for listing under Section 303 (d) of the U.S. Clean Water Act as a "Water Quality Limited Segment" because of: recurring violations of the Idaho "Environmental Protection and Health Act"; a chronically toxic condition in a portion of Meadow Creek; and demonstratable impairment in macroinvertebrate communities near the mouth of Meadow Creek.

In an effort to substantially reduce contaminant loading to surface and ground waters, the PNF, SMI, IDL and the DEQ prescribed a plethora of mitigation measures for historic and contemporaneous mine related disturbances. These measures, described in the Forest Service document "Reasonable and Prudent Alternatives for Commercial Road Use and Mining at the Stibnite Mine", were incorporated as an amendment to SMI's plan of operations.

Intensive water quality and habitat monitoring has been implemented in the EFSFSR in order to assure compliance of current mining operations in the drainage with Idaho's <u>Water Quality Standards and Wastewater Treatment Requirements</u> and to qualify the effects of reclaiming historical mining sites on surface water quality. The monitoring will also become a very important tool as management strategies are developed for "threatened or endangered species".

Water quality monitoring and analyses indicates that there is a general trend towards improvement in water quality, habitat, and aquatic communities. Improvements should not, however, be construed to mean that water quality is good to excellent as is indicated in independent studies on fine sediment deposition and water chemistry. When all analytical indices are considered, it is evident that, the water quality of the EFSFSR is in the good to excellent ranges, while water quality in Meadow Creek is impaired and does not fully support beneficial uses.

Continuing improvements to water quality in the headwaters is completely dependent upon actions by the owner and operators of the Yellow Pine and Stibnite Mines and the PNF. Trend analyse infers that modifications to best management and operating practices would be reflected by continuing improvements in chemical, biological and physical indices.

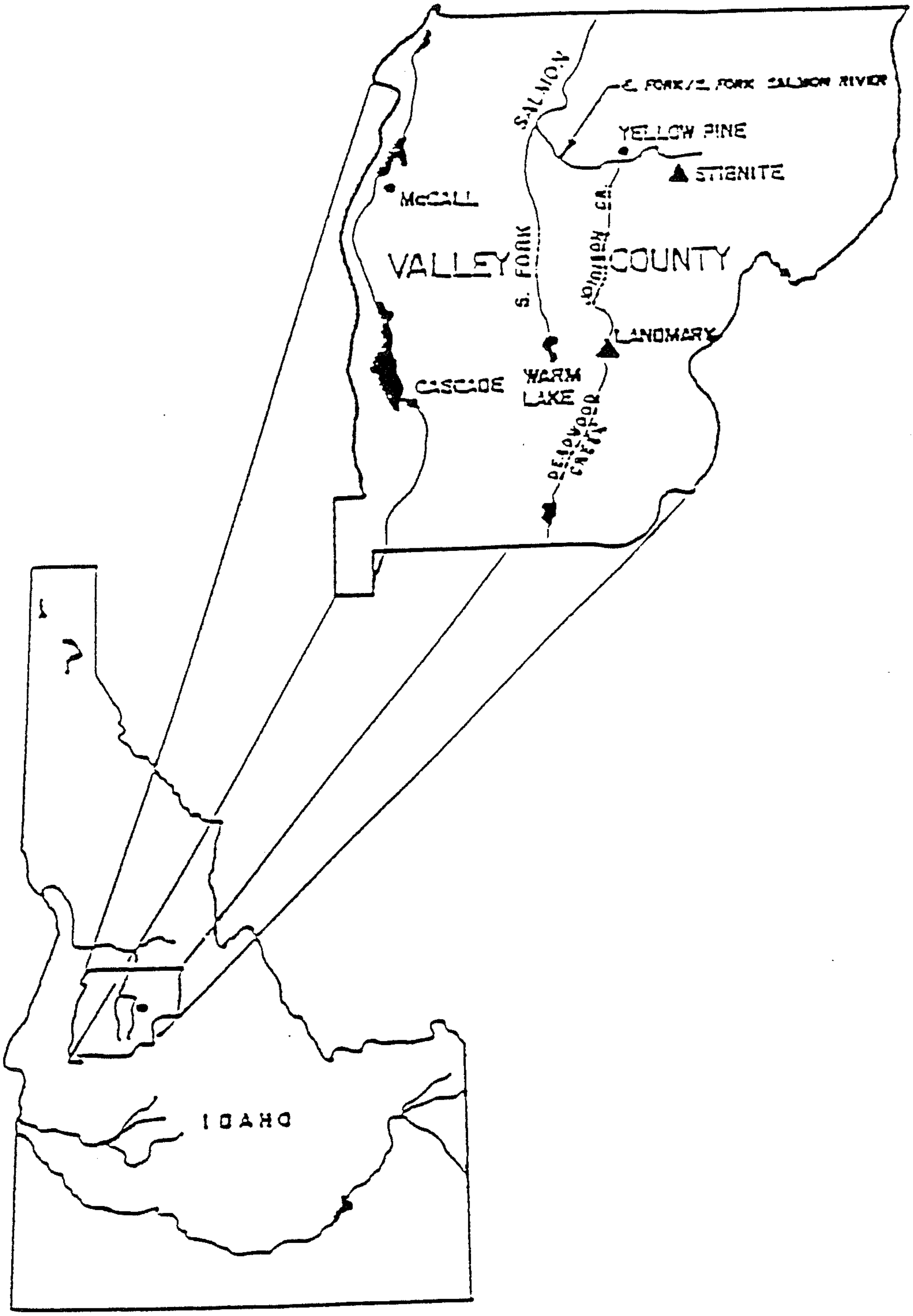


Figure 1. Stibnite Mining Project location map (JMM 1981).

INTRODUCTION

Mining, at the Stibnite and Cinnabar Mines, has played an economically important and colorful role in the development of eastern Valley County, Idaho. The Stibnite and Cinnabar Mines, however, have become shrouded in controversy because of their history of pollution discharges to the EFSFSR, and its tributaries, and the listing of Spring/Summer Snake River Chinook Salmon as Endangered Species. Consequently, surface and ground water quality monitoring has become one of the most important tools of resource managers in the watersheds which influence the EFSFSR.

Analysis of water quality trends at individual stations and along stream segments would be extremely difficult if it were not for the number of stations throughout the watershed with which to compare data. Furthermore, it would be ludicrous to attempt to correlate resource management activities and data analyses from one water quality monitoring approach. It is, therefore, the purpose of this report to utilize the analyses and conclusions drawn from fine sediment deposition surveys, benthic studies, chemical analyses of fine sediment, algae, macroinvertebrate and fish tissue, and water chemistry studies to assess the overall water quality status to the EFSFSR related to mining at Stibnite.

A problem encountered in the development of this report was that there is very little water quality monitoring data from 1986 through 1989. Although data from mine operators' filled the gaps in the data, it is evident that particular attention must be paid to maintaining consistency and frequency of data collection.

Analyses of fine sediment deposition, macroinvertebrate assemblages, contaminants in fine sediment, algae, macroinvertebrate and fish tissue, and water chemistry are correlative and support many conclusions. Sediment and metals loading of surface waters has caused acute and chronic reactions in aquatic communities. Impacts to these communities has however, been reversing itself for approximately the last five to ten years. Data indicates that each of the monitored sections of the upper EFSFSR and its tributaries can reattain high biotic/habitat integrity. Trends show that although rapid changes occurring in mining practices are reflected by improving trends in water and habitat quality, these sections may not achieve that high biotic/habitat integrity until a large portion of the historical mining impacts are mitigated. It would seem logical, therefore, that improving environmental conditions in surface waters in the Upper EFSFSR watershed are directly linked to ongoing mining activities and public lands management.

HISTORY

It would be difficult to understand the significance of water quality data in the EFSFSR without being familiar with historical natural resource uses in the area. Although there are many activities in the area, such as hunting, fishing, and logging, mining has been proven to have the most significant impact on the EFSFSR.

Mining at Stibnite and Cinnabar has played an economically important and colorful role in the development of eastern Valley County, Idaho. The Stibnite and Cinnabar Mines were located and intermittently mined as early as 1900 when gold was discovered there during the Thunder Mountain Gold rush. Significant mineral development did not, however, occur until the early 1930's. In the 1930's the Yellow Pine Open Pit was located in the EFSFSR bed and the entire river flow was diverted around the pit and into a tunnel through a mountain north of the river channel (Klahr, 1987).

The Strategic Mineral Investigations Enabling Act in 1939 triggered the listing of antimony and tungsten as strategic metals and essential to national defense (Trainor, 1993). After the discovery of high grade antimony and tungsten-bearing ore that same year, intensive mining and milling began. Antimony and tungsten became the primary minerals produced in this area during World War II, supplying nearly 95% of the nations's antimony for the war effort. With the collapse of the antimony market in 1952 and problems with the smelter, the mine was closed and dismantled.

The Bradley Mining Company began expansion of its Stibnite operations in 1939 with the location of strategic mineral reserves. This expansion led to the construction of a mining, milling and smelting operation which supported a local population of approximately 1,500 persons (Trainor 1993). The subsequent collapse of the antimony market proved to be a temporary demise of the town.

When mining was discontinued in the early 1950s, Meadow Creek was allowed to return to its natural channel, which was blocked by the old Bradley Mill tailings (JMM 1994). The result of this rechannelization was the beginning of the Meadow Creek Pond. Subsequent to the formation of the pond, the old mill tailings were destabilized and washed downstream to the EFSFSR.

Increasing gold prices in the 1970s partially revived the local economy, and by 1978 engineering plans were being drafted for cyanidation of the oxide gold ores from West End and Midnight Creek pits. In 1982 full scale mining of the West End pits began, and cyanidation and spent ore disposal facilities were constructed on top of mill and smelter tailings in the Meadow Creek drainage.

Hecla secured the lease on an adjacent property, and a low-grade oxide ore stockpile which was loaded in the 1940's. Hecla developed an open-pit mine and one-time heap leach pad. The mine ceased operations in 1991, and reclamation is ongoing.

An estimated 4.2 million tons tailings from the Bradley Mill were encapsulated by cyanidation spent ore disposal facilities which incorporated the use of a retaining structure known as the Meadow Creek Keyway (JMM 1994). The ultimate disposition of the Bradley Mill tailings has been the subject of many debates in the modern history of the mine facilities. Among the many proposed actions to resolve water quality problems associated with the tailings are; complete burial, stream stabilization, and removal.

The Cinnabar Mine was discovered about 1902 during the Thunder Mountain Gold Rush (Pioneer Technical Services, 1992). Claims around the lode and mill sites were patented in the late 1920's and are currently held by the J.J. Oberbillig Estate. The United Mercury Mines Company began development of lodes which become known as the Hermes Mine. Prior to 1930 only minor or sporadic development occurred. In 1942, Bonanza Mining Inc. took over the mine facilities and report some development and production. Major mine development was recorded under the management of Holly Minerals. Originally ore was roasted to liberate free vapor mercury and sulphur dioxide. Mercury was collected after cooling gases in flue condensers. The roasting systems burned to the ground in 1956 and were replaced with a floatation and electrowhining process. Activities were suspended in 1958, but periodic exploration of the lodes have been pursued in hopes of reopening production.

The Cinnabar Mine Site has been investigated many times from 1983 through 1993 in response to complaints or queries regarding water quality, petroleum, and hazardous materials. In 1984 DEQ and Central District Health visited the site in an attempt to characterize threats to human health, safety, or the environment (Clark and Lappin, 1984). Many barrels, storage tanks, transformers and other containers of potentially hazardous materials were located and identified. Characterization of these materials is incomplete. In May of 1988 DEQ was notified of an oil spill resulting from damage or vandalism to a 100,000 gallon fuel storage tank at the Cinnabar Mine. Coordinated efforts with Pioneer Metals Corporation resolved water quality problems resulting from the spill. In 1992 the USDA Forest Service contracted a Preliminary Assessment of the site, which has resulted in EPA's contracting of a Site Investigation, which will begin during the summer of 1994.

In 1983 and 1984 several water quality problems were noted at the Stibnite Mine and processing facilities which involved cyanide and turbidity. The PNF, IDL and DEQ entered into discussions with Superior Mining Company to resolve the problems. Of these problems, sediment production and delivery from the West End Pit, old mine workings, and the haul roads were, perhaps, the most obvious. The operator developed a comprehensive water management plan and implemented an extensive network of best management practices to control discharges.

In 1985 the DEQ - Hazardous Materials Bureau compiled an initial investigation of the historical mining facilities at Stibnite (Harr 1985). Although a "Preliminary Assessment" was completed, no actions were instigated towards a site removal or cleanup.

In 1985 a Consent Order for violations of turbidity standards was entered into by Superior Mining Company and DEQ. This Consent Order established compliance points and a standard of 5 Nephelometric Turbidity Units (NTUs) over background for discharges from West End Creek and the sediment basin at the Box Culvert.

In 1986 through 1987, turbidity violations and a spill of cyanide leach solution occurred. These events led to an investigation and subsequent issuance of a Notice of Violation by the DEQ on December 12, 1986. Pioneer Metals, the successor to Superior Mining Company, and the DEQ entered into a Consent Order, to mitigate for violations, on May 12, 1987.

On October 6, 1987, the DEQ issued a separate Notice of Violation concerning sediment delivery to the EFSFSR. The issue was resolved through the compliance schedule of the existing Consent Order.

In 1988, a truck containing Ammonium Nitrate/Fuel Oil (AN/FO) went off of a mine road upstream from the confluence of Sugar Creek and the EFSFSR. Apparently, none of the AN/FO entered the water, and there were no apparent natural resource damages attributed to this incident.

In 1989 and 1990, the DEQ and the PNF issued Pioneer Metals a Notice of Violation and Notice of Noncompliance, respectively. These citations were issued for the discharge of acute concentrations (EPA 1986) of cyanide (0.022 mg/l total) to the Meadow Creek Pond and Channel adjacent to Pioneer Metals' spent ore disposal area, and diesel fuel in the ground water beneath the ore processing facility.

During the winter of 1990-1991, MinVen Corporation began negotiations and successfully purchased the Stibnite Mine from Pioneer Metals. On August 1, 1991 SMI (aka MinVen Corporation aka Dakota Mining Company) entered into a Consent Order amending and superseding previous consent orders and incorporating monitoring and clean up protocols for diesel, cyanide, and turbidity.

On April 4, 1992, discharges from SMI's land application site was documented by DEQ. DEQ and SMI entered into negotiations for modification of land application procedures. SMI relocated its land application site and modified procedures later in 1992.

In July of 1992, a diesel spill was identified by SMI in the processing facility. SMI notified DEQ of the incident and implemented immediate cleanup actions. DEQ responded to the site and documented a significant area of soils and ground water contamination. The contaminants of particular concern included diesel, cyanide, chloroform, and nitrates.

On January 26, 1993, DEQ issued SMI a Notice of Violation for violations of Idaho's Water Quality Standards and Waste Water Treatment and Rules, Regulations and Standards for Hazardous Waste. The Notice of Violation was for contamination of ground water due to diesel and nitrates, and improper storage and handling of materials (IDHW 1993) regulated under Subtitle C of the Resource Conservation and Recovery Act as supplemented by the Idaho Hazardous Waste Management Act of 1983 (HWMA). The RCRA issues were resolved after SMI and DEQ entered into a Consent Order regarding the hazardous materials on May 5, 1993.

In April and May of 1993, DEQ documented disposal of spent ore, containing cyanide, immediately adjacent to Meadow Creek. Because of good faith negotiations regarding diesel and cyanide contamination, modification of the ore processing facilities, and permitting of the cyanidation facility, and SMI's immediate removal of the spent ore, an administration action was not pursued.

On October 20, 1993 SMI and DEQ entered into two consent orders requiring the ore processing facility to be permitted prior to any operation after the 1993 operating season, and for ground water pollution assessment and cleanup. As of November 1995 all of the technical actions required of SMI under the outstanding consent orders have been completed. Procurement of a finalized Permit to Construct and Operate a Facility in accordance with the "Rules Governing: Ore Processing by Cyanidation" is the only outstanding requirement of those consent orders. Because of an appeal by local and out-of -state environmental advocacy groups a formal hearing will be held in 1996 to make a final determination of the validity of the permit issued by the DEQ in June of 1995.

In November of 1994, the U.S. Department of Commerce National Marine Fisheries Service (NMFS) issued a biological opinion that an expansion of the mining operations at Stibnite, and continuation of the hauling of fuel, lubricants and other deleterious materials for that mine expansion would result in adverse effects to the endangered salmon. Subsequent to the release of NMFS's opinion, the interagency coordination group which jointly administers the mine convened to outline the major concerns for the site and possible mitigation measures which were intended to improve water quality and fisheries habitat. In March of 1995, the PNF released the document "Reasonable and Prudent Alternatives to Commercial Road Use and Mine Expansion for the Stibnite Mine". This document specified mitigation which would be incorporated in the mine's operating plan and administered by the PNF in ongoing consultation with NMFS. Implementation of mitigation measures began in the operating season of 1995 and will continue over the course of the next twelve years. Intensive monitoring has also been implemented which is intended to measure the success of mitigation on an annual basis in order to make, where necessary, modifications to the mitigation plans.

SMI has made major modification in the ore processing facilities which have been designed to increase protection of surface and ground waters in accordance with the "Rules and Regulations Governing Ore Processing by Cyanidation". SMI and the PNF are also preparing a Environmental Impact Statement (EIS), under regulation of National Environmental Protection Act, for mine expansion.

In compliance with a CERCLA 106 Removal Action Order, SMI has implemented a corrective action plan which has been designed to stabilize historic mine and mill tailings in the Meadow Creek drainage. These measures are also intended to reduce the transportation of total suspended solids, dissolved solids, and dissolved metals. The U.S. Forest Service has also prepared a Preliminary Assessment/Site Investigation for listing of the mine under the Comprehensive Environmental Response and Liabilities Act (CERCLA). This document has precipitated negotiations for corrective actions to mitigate for impaired water quality and aquatic habitat conditions which are related to historic and contemporaneous mining activities.

ISSUES

Primary issues which necessitate ongoing monitoring of the EFSFSR is the extensive use by the public, and native populations of terrestrial and aquatic fauna. Designated beneficial uses identified for the watershed include domestic water supplies, cold water biota, salmonid spawning, and primary and secondary contact recreation. The EFSFSR is critical habitat for Summer and Spring Chinook Salmon, which have been listed as endangered, and Bull Trout, West Slope Cutthroat Trout and Steelhead Trout, which have been listed as Species of Special Concern. Therefore, monitoring of the watershed is particularly important to assure effectiveness of best management practices and engineering design implementation for water pollution abatement.

Many solid or chemical waste products, which result from multiple use of public resources, are of concern to regulators, the mine operators, and the public. These include sediment, chlorine, cyanide, arsenic, nitrates, petroleum products, and solvents. All of these products are closely monitored in proximity to the Stibnite and Yellow Pine mines, but only a few have been shown to be discharged at concentrations which threaten or have damaged designated beneficial uses. These include sediment, cyanide, arsenic, trace metals, petroleum, and nitrates. Additionally, however, catastrophic spills of any of the substances used in normal operations of the mines may have a divesting effect on the aquatic community.

Sediment produced on public access routes and in historically developed areas make up a significant portion of sediment loads in the watershed. Maintenance and rehabilitation of these areas will be a critical factor in sediment reduction and aquatic habitat enhancement.

DESCRIPTION OF STUDY AREA

The EFSFSR is a tributary of the South Fork of the Salmon which in turn is a major tributary to the Main Salmon. As described in its name, it is an important drainage for salmonid spawning and rearing, particularly summer chinook, steelhead trout, bull trout, and Westslope cutthroat trout. Both the EFSFSR and the South Fork of the Salmon River are Special Resource Waters, and listed as such in Idaho's Water Quality Standards and Waste Water Treatment Requirements (Klahr 1987). The drainage is deeply incised and heavily wooded with conifers. The upper reaches of the EFSFSR, and its tributaries Meadow Creek and Sugar Creek are bordered by roads, mine workings, and mill and smelter tailings (Figure 2). The drainage has been developed for both recreational and mining activities. Both mine operators and the U.S. Forest Service have begun closure and reclamation of historical and recent mine disturbances.

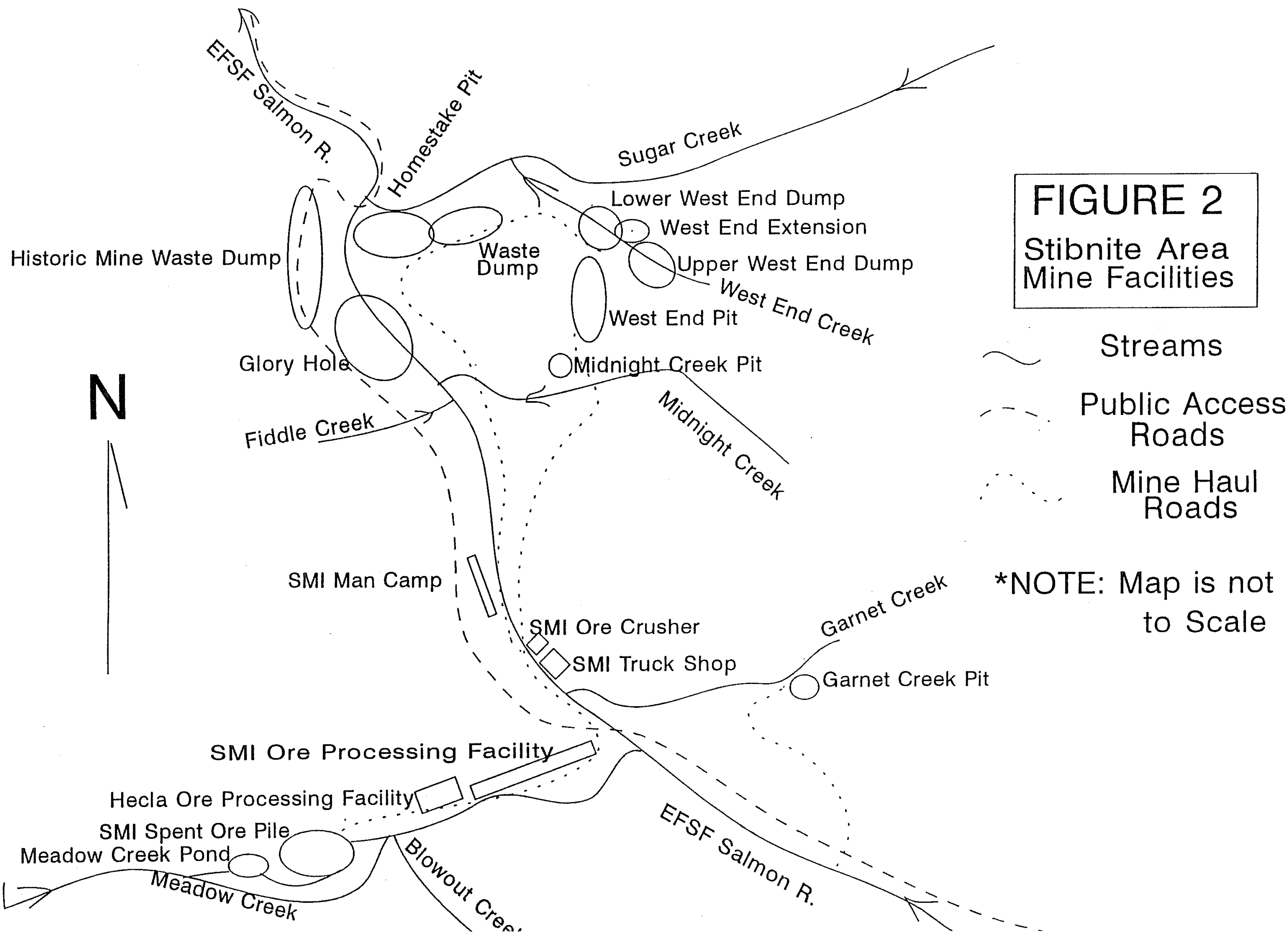


FIGURE 2
Stibnite Area Mine Facilities
EFSF Salmon R.
Homestake Pit
Sugar Creek
Lower West End Dump
West End Extension
Upper West End Dump
West End Creek
Historic Mine Waste Dump
Waste Dump
West End Pit
Glory Hole
Midnight Creek Pit
Midnight Creek
Fiddle Creek
N
Streams
Public Access Roads
Mine Haul Roads
SMI Man Camp
*NOTE: Map is not to Scale
SMI Ore Crusher
SMI Truck Shop
Garnet Creek
Garnet Creek Pit
SMI Ore Processing Facility
Hecla Ore Processing Facility
SMI Spent Ore Pile
Meadow Creek Pond
Meadow Creek
Blowout Creek
EFSF Salmon R.

WATER QUALITY MONITORING
MATERIALS AND METHODS

OBJECTIVES

Monitoring water quality in EFSFSR has been designed to improve the efficiency of water management systems, assure compliance with Idaho law, and qualify the status of support for the beneficial uses of water in the drainage. Specifically, the study addresses:

1) Monitoring effectiveness of best management practices used at the Stibnite and Yellow Pine Mine;

2) Monitoring the mine operators' compliance with Idaho's Water Quality Standards and Waste Water Treatment Requirements, permits, and consent orders; and

3) Qualifying the extent to which designated beneficial uses are supported in the EFSFSR and its tributaries

COORDINATION

Monitoring and analyses is coordinated annually by state and federal agencies (Clark 1990). These agencies include the DEQ, IDL, IDF&G, USF&WS and Payette National Forest. Coordination meetings are held in the spring and late summer in the field with local mine operators.

An initial coordination meeting will be held by the regulatory agencies each winter. The primary objective of the meetings is to discuss the results and analyses of the previous monitoring season, the feedback loop process, effectiveness and modifications of best management practices, changes, if any, in designated beneficial use status, possible revisions to the NPS Water Quality Monitoring Plan, and the roles of each agency. Secondary objectives for the winter coordination meeting will be to introduce new staff, review monitoring techniques, and to establish tentative dates for field coordination meetings and interagency monitoring agenda.

Field coordination meetings will be held twice each year. These coordination meetings will be attended by state and federal regulatory agencies, local operators, and possibly community leaders. The primary objective of these meetings is to discuss the results and analyses of the previous monitoring season, the feedback loop process, effectiveness and modifications of best management practices, changes, if any, in designated beneficial use status, revisions to the NPS Water Quality Monitoring Plan, and the roles of each agency, the operators, and the community. Secondary objectives for field coordination meeting will be to introduce new staff and review monitoring techniques.

Text and data from reports by the PNF and USF&WS have been included in this report in order to correlate data from the upper reaches of the EFSFSR. For additional discussion or information contained in the reports compiled by the PNF or the USF&WS the reader is referred to their final reports. DEQ appreciates the cooperation of those agencies and their permission to summarize their reports in this report. Parameters for environmental monitoring and analyses are included in but not limited to those listed in Table 1. Environmental monitoring stations are listed in Table 2.

FLOW MEASUREMENT

Flow has been monitored on the EFSFSR in proximity to Stibnite since 1982 when the U. S. Geological Survey (USGS) implemented its initial survey and installed a gaging station near the ore processing facilities. This location has since been identified with the STORET Station #2040313. The USGS , in coordination with the IDWR maintains the station and electronic data base in which the flow measurements are stored. Routine maintenance of the gaging station takes place every month to six weeks during which time the USGS takes a stream flow measurement using a pygmy meter, which is used to recalibrate the station. DEQ has supplemented this data by collecting stream flow measurements on the EFSFSR and its tributaries and interpolating flows for the EFSFSR at other locations and on its tributaries. These measurements are of particular importance for identifying annual and storm runoff events, calculations of contaminant loading, and designing water management systems.

TABLE 1. Sample Parameters for Trend Monitoring Stations.

PARAMETER		UNITS	STORET #
1.	Arsenic, total	ug/l	01002
2.	Antimony, total	ug/l	00720
3.	Cadmium, total	ug/l	01045
4.	Copper, total	ug/l	00530
5.	Iron, total	ug/l	00403
6.	Lead, total	ug/l	00095
7.	Mercury, total	ug/l	00076
8.	Selenium, total	ug/l	01055
9.	Zinc, total	ug/l	01097
10.	Cyanide, Wad and Total	mg/l	
11.	Nitrates as (NO_2 + NO_3)	mg/l	
12.	Suspended Solids, total	mg/l	
13.	pH	S.U.	
14.	Turbidity	NTU	
15.	Flow	cubic feet per second (cfs)	
16.	Free Matrix	%	
17.	Cobble Embeddedness	% weighted embeddedness	
18.	Macroinvertebrates	multiple indices	

TABLE 2. **Water Quality Status: Monitoring Stations Analyzed**

STORET Number	Station Location
1. 2040307	Sugar Creek below the confluence with West End Creek. (trend and compliance)
2. 2040308	EFSFSR Below Glory Hole (trend)
3. 2040309	Sugar Creek above the confluence with West End Creek. (trend, and compliance)
4. 2040310	EFSFSR at Below Garnet Creek (trend)
5. 2040313	EFSFSR At USGS Gaging Station (trend)
6. 2040314	EFSFSR below Sugar Creek. (trend and compliance)
7. 2040315	EFSFSR above Meadow Creek. (trend)
8. 2040316	Sugar Creek at Bridge. (trend).
9. 2040317	West End Creek above Sugar Creek. (trend)
10. 2040318	Lower Garnet Creek (trend)
11. 2040319	Meadow Creek above confluence with EFSFSR. (trend)
12. 2040320	Meadow Creek above Diversion. (trend)
13. 2040321	Midnight Creek above EFSFSR (trend)
14. 2040322	Meadow Creek below diversion. (trend)
15. 2040323	Upper Garnet Creek (trend)
16. 2040365	EFSFSR above Box Culvert. (trend and compliance)
17. 2040368	Meadow Creek below keyway. (trend)
18. 2040369	EFSFSR below Midnight Creek (trend)
19. 2040584	Meadow Creek Pond next to Spent Ore Pile. (trend and compliance)
20. 2040585	Old Meadow Creek Channel adjacent to the Spent Ore (trend)
21. 2040580	Sugar Creek above confluence with Cinnabar Creek (trend)
22. 2040581	Sugar Creek below confluence with Cinnabar Creek (trend)
23. 2040582	Cinnabar Creek above confluence with Sugar Creek (trend)

FINE SEDIMENT, ALGAE, AND FISH SAMPLE COLLECTION

One composite sediment sample was collected from each of three sites. Composite samples consisted of two to four grab samples each 6 to 8 inches deep using a stainless steel hand corer with a lexan tube (Burch and Mullins 1994). Individual grab samples were thoroughly mixed in a stainless steel tray with a stainless steel spoon before placing in a clean sample jar.

One algae sample was collected at approximately Mile Post 8 of the EFSFSR road. The collection site for the algae sample was selected by availability, as algae was not seen at other locations within the EFSFSR (Burch and Mullins 1994).

Whole fish samples were collected using electro fishing techniques. Steel head trout smolts and mountain whitefish adults were collected at the confluence of Profile Creek, at Mile Post 8 of the EFSFSR road, and below Sugar Creek (Burch and Mullins 1994). Individual length and weight measurements and estimated year class were recorded.

Sediment and algae samples were placed in clean sample jars (Burch and Mullins 1994). Each fish sample was wrapped in aluminum foil and placed into a zip lock bag. All samples were placed on ice immediately after collection and frozen upon return to the laboratory (within 12 hours). Samples were analyzed within 6 months of collection.

CHEMICAL ANALYSIS OF SEDIMENT, ALGAE, AND FISH TISSUE

All samples were analyzed for trace elements by the USF&WS Patuxent Analytical Control Facility (PACF). Arsenic and selenium were analyzed by the graphite furnace atomic-absorption method, and mercury was analyzed by the cold-vapor atomic absorption method (Burch and Mullins 1994). All other trace elements were analyzed by an ICP (inductively coupled plasma) scan. All trace element concentrations in this document are reported in dry weight unless otherwise noted. Fish tissue concentrations are discussed in wet weight when compared to National Contaminant Biomonitoring Program results for purposes of comparison (Burch and Mullins 1994).

Quality assurance and quality control (QA/QC) of analytical data were reviewed by the PACF (Burch and Mullins 1994). Acceptable performance (recovery variation averaged $<20\%$ for all constituents measured) on spikes, blanks, and duplicates were documented in laboratory quality control reports.

MACROINVERTEBRATE TISSUE COLLECTION AND ANALYSES

Approximately ten (10) grams, wet weight, of macroinvertebrates were collected from ten (10) stations for metals tissue concentration analyses on September 19 and October 2, 1995. Originally samples were to be collected at the time that Macroinvertebrate samples were collected for population and diversity analyses. Time constraints, however, made a second date for collecting tissue samples necessary.

Macroinvertebrates for tissue analyses were collected using Hess samplers, plastic trays, and stainless forceps. Although the Hess samplers are generally used to collect sample sets from specifically sized target areas of substrate, it was necessary to collect and composite Macro invertebrate samples from as many as forty locations in proximity to the sample station in order to get between seven and ten grams of macroinvertebrates.

Macroinvertebrates, sediment and plant debris collected in the Hess samplers were placed in plastic tubs in order to separate the macroinvertebrates from the sediment and plant debris. After separation, macroinvertebrates were placed in one liter containers with fresh stream water. Macroinvertebrates were allow to purge themselves of gut contents for a period of approximately twenty-four plus hours. After this period, the macroinvertebrates were rinsed with distilled water to remove materials clinging to their exoskeleton, and influence by metals contaminants in the stream waters. Samples were then submitted to the Idaho Bureau of Laboratories for analyses. Prior to digestion and analyses in accordance with protocols specified by the U.S. Geological Survey's laboratory, the samples were again rinsed in distilled waters to remove any residual contaminants which may bias tissue analyses.

WATER CHEMISTRY SAMPLE COLLECTION PROTOCOLS

Sampling methodology within the scope of the study on the EFSFSR Study are governed by those protocols developed for streams in Idaho by the USDA Forest Service, USDOI Bureau of Land Management, U.S. Geological Survey, and DEQ. The protocols are contained in nine publications which are periodically reviewed and modified to meet with nationally accepted standards.

Whenever samples are collected for trend, storm event, or compliance monitoring, samplers should treat the samples as legal samples (Burr 1986). Field notes, sample submittal forms, and chain-of-custody paper work must accompany sample submittals and be sent to each participating agency. Consistent well documented procedures, therefore, will enable regulatory agencies to maintain legally acceptable and scientifically reproducible data interpretations. Sampling procedures will include sample collection, preservation, transportation, chain-of-custody protocol, and analysis.

Sample collection is the initial, and perhaps, simplest step in water quality monitoring. It may, however become overly routine, and therefore, proper care must be taken to be consistent with established procedures. Planning and preparation will eliminate sampling mistakes. Field personnel should have and maintain small inventory of basic equipment. There is some variation in this inventory based on personal.

Sample submittal forms, Chain-of-Custody reports, and sample containers should be marked in advance of sample collection. Submittal forms and reports which list the samples to be collected can serve as a checklist to ensure all of the sample are collected. Properly marking samples with the STORET number, type of sample, preservatives or spikes added, and date prior to sample collection will reduce the numbers of samples lost because of illegible markings.

MONITORING TECHNIQUES AND RESULTS

Monitoring data from trend and compliance surveys, as well as special studies, were analyzed conjunctively in order to evaluate the overall health of the EFSFSR, Meadow Creek, and Sugar Creek. Initial screening of parameters and monitoring stations, however, was done to reduce the data into a manageable format. Additional water quality data was incorporated from data sets compiled by the operators of the Stibnite and Yellow Pine Mine. Incorporation of this data was justified because of the convention the operators used established stations, analytical techniques, and Quality Assurance/Quality Control (QA/QC) protocols.

FLOW

Flows at the USGS gaging station near SMI's ore processing facility varied from 6 to 348 cubic feet per second (cfs). The large fluctuations in flows are directly attributable to seasonable precipitation and runoff events and localized storm events. Base flows are, however, attributed to the limited retention capacity of the thin soil system, colluvium, and fractured intrusive and metamorphic geologic units.

The highest peak annual flows between 1982 and 1995 occurred in June of 1986 where levels reached approximately 348 cfs (Figure 2 - 6). The lowest peak annual flows were approximately 77 cfs in June of 1987.

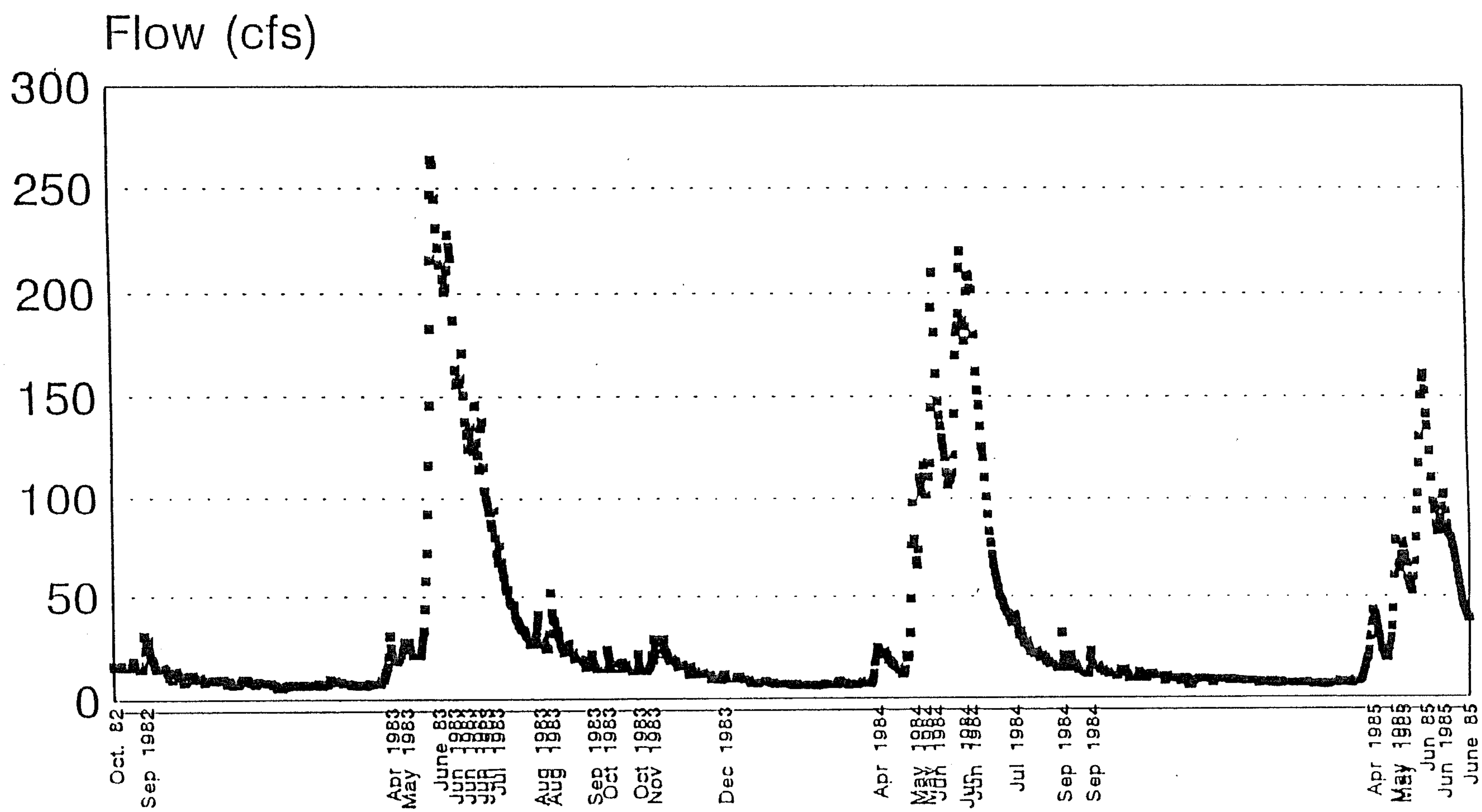
Storm and rapid runoff events, which are due to unseasonably warm weather, have resulted in daily fluctuations in flow of between five (5) and fourteen (14) cfs). Storm and rapid runoff events are particularly notable from December through May when flows are at their baseline, but may also be noted throughout the year. The most notable of such events occurred during the winter of 1994 and 1995 when data indicated that flows increased by ten (10) to forty-five (45) cfs in five (5) separate events. Other more significant events, however, occurred during 1983 and 1984 when large quantities of suspended sediment were delivered from tributaries to EFSFSR and historic mining dumps located adjacent to the EFSFSR.

Annual base flows are between six (6) and eleven (11) cfs. The former is probably due to the severe drought conditions of the last decade, whilst the latter is probably due to cooler springs and summers.

Data from the USGS gaging station, which is adjacent to water quality monitoring station #2040313, was interpolated for application at other water quality monitoring stations. Interpolation was based on weighted averages calculated from flow data that was collected using Marsh-McBirney digital flow meters at each station during water sample collection. A margin of error is incorporated in analyses of annual data for the monitoring sites other than 2040313 because frequent localize storm events occur within several different subwatersheds which may

EFSFSR Hydrograph

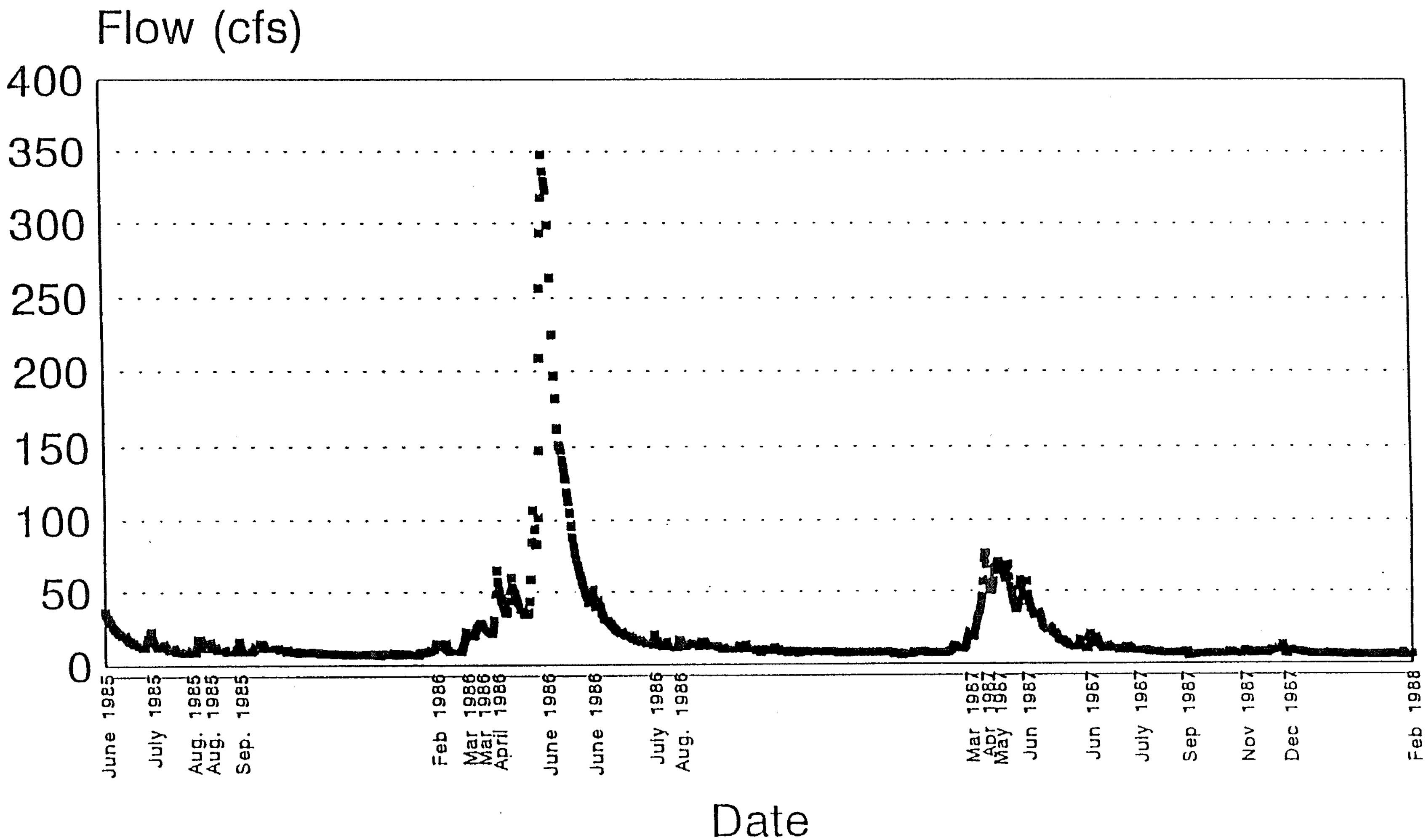
Stibnite Mining Area



October 1982 - June 1985

EFSFSR Hydrograph

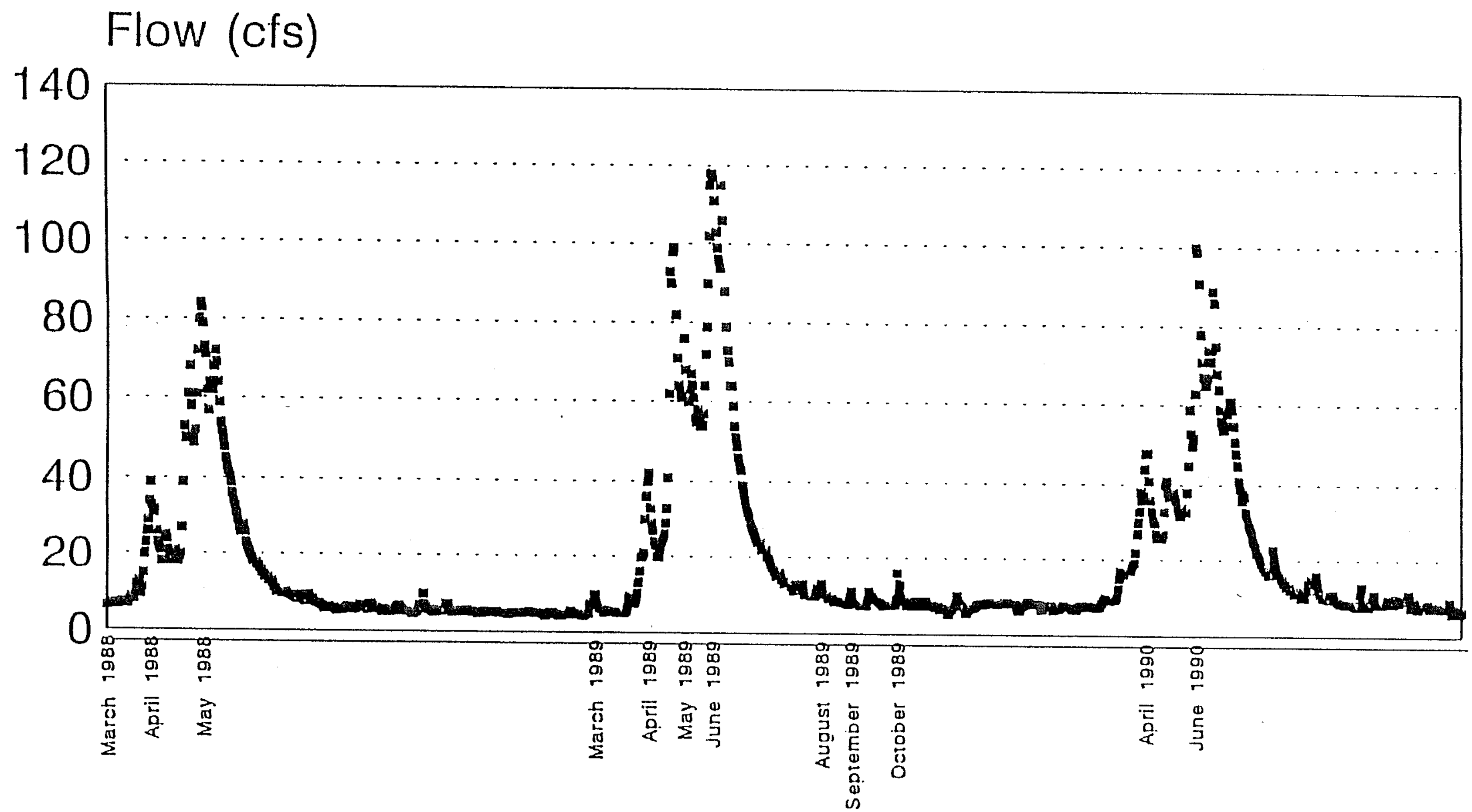
Stibnite Mining Area



June 1985 - February 1988

EFSFSR Hydrograph

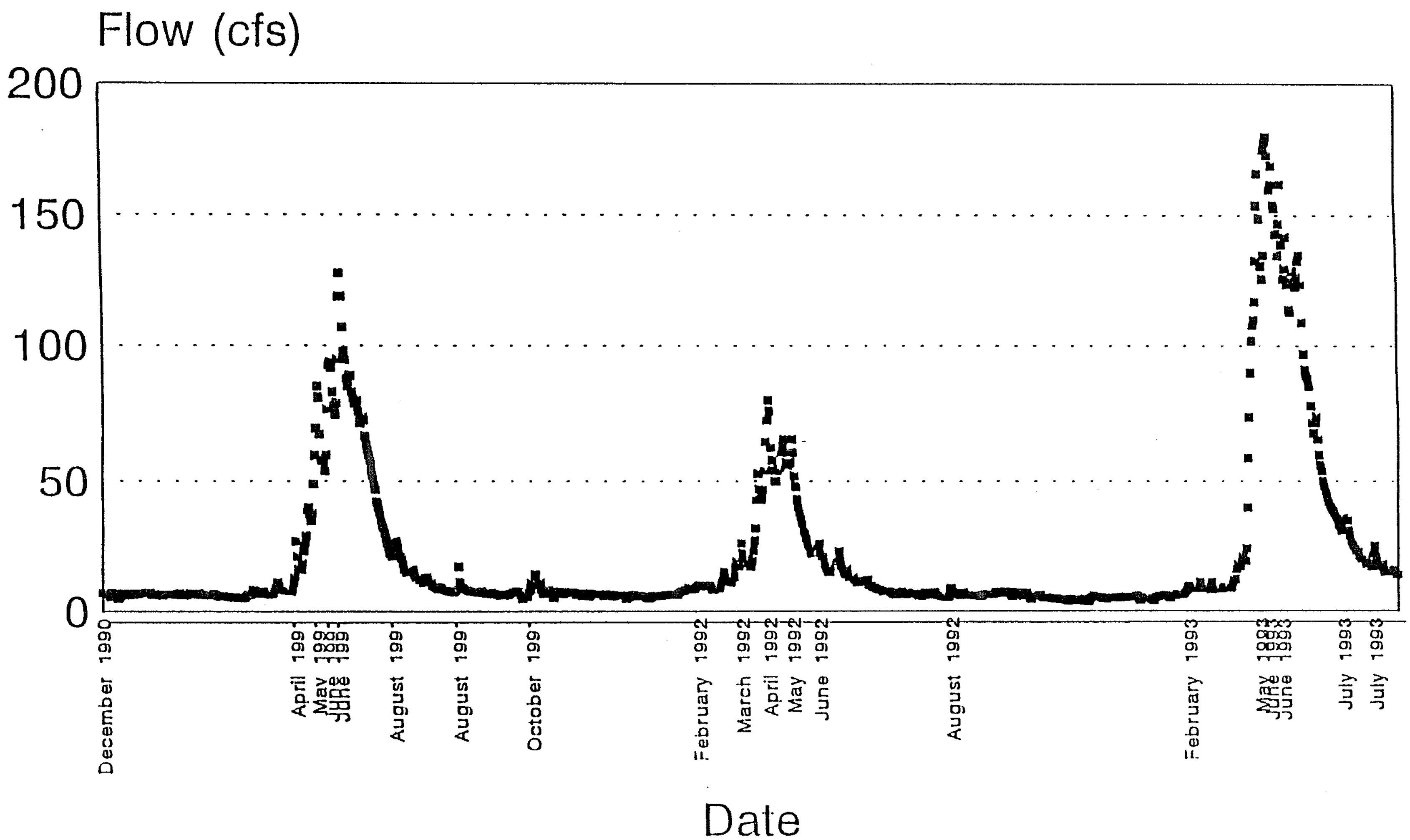
Stibnite Mining Area



March 1988 - December 1990

EFSFSR Hydrograph

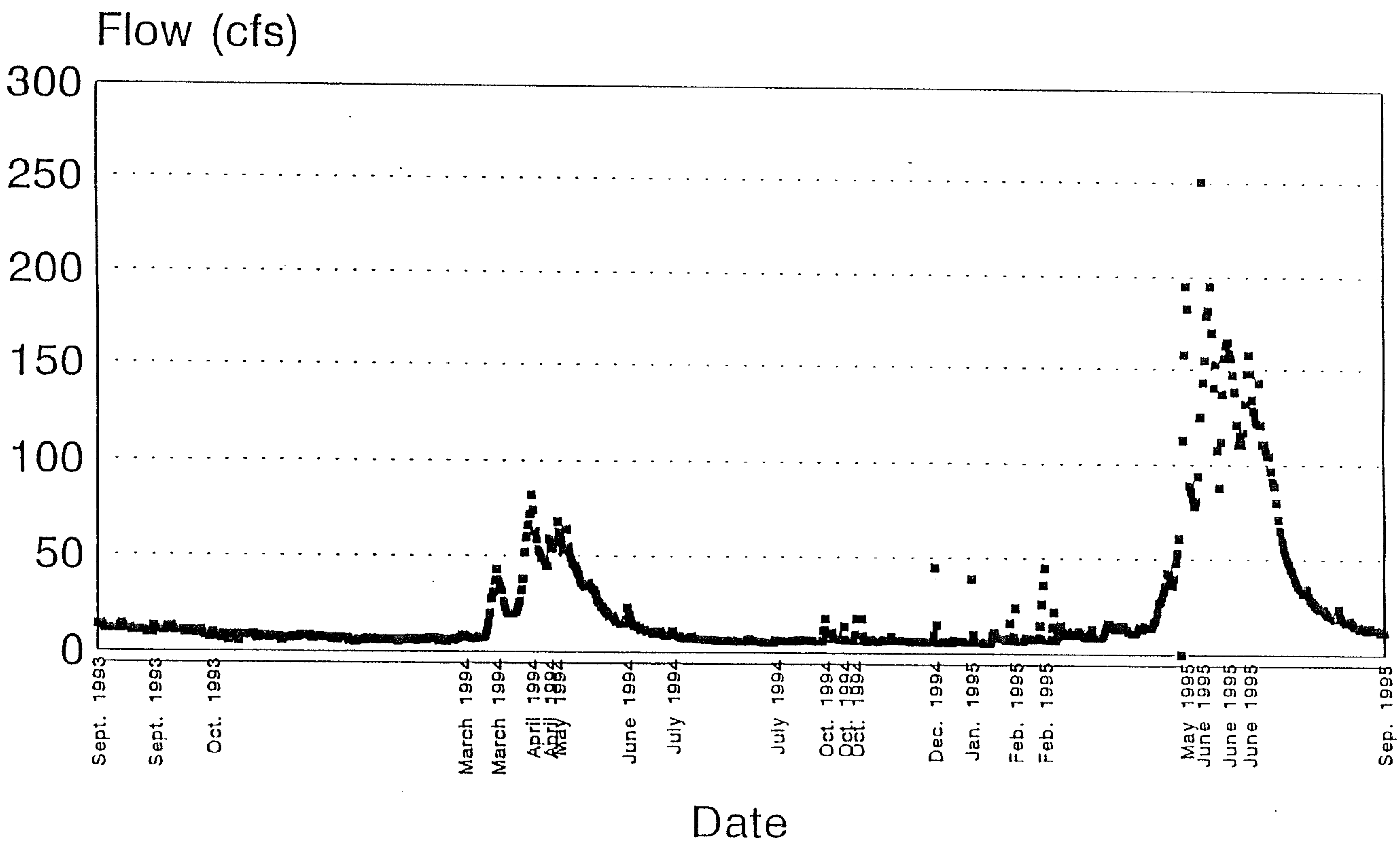
Stibnite Mining Area



December 1990 - August 1993

EFSFSR Hydrograph

Stibnite Mining Area



September 1993 - September 1995

or may not be reflected in the electronic data for the USGS gaging station. That margin of error, however, has been significantly reduced when analyses was broadened to consider data over the fifteen year period since there is a statistical likelihood that localized storm events occur as frequently in each of the subwatersheds, and therefore, would be cumulatively predicted through the interpolation.

Data interpolation of flows may be used to model contaminant loading from point and nonpoint source activities and tributaries of the EFSFSR. Modeling will become an integral method of evaluating the effectiveness of major mitigation plans and best management practices implemented by the mines' operators and owners, and the PNF. As such, flow monitoring is crucial to continued operations at Stibnite.

FINE SEDIMENT DEPOSITION

This portion of the water quality status report is a synapsed version of the Payette National Forest's Fine Sediment Deposition in Selected Tributaries to the Salmon River in the Payette National Forest, Report of Monitoring Results 1989- 1990 (Ries et al 1991) in the sections which discussed the EFSFSR, Sugar Creek and Meadow Creek. The synopsis is provided to familiarize the reader with sediment monitoring, and conclusions drawn by sediment data analyses, and to allow the reader to follow cumulative impact correlations drawn between sediment and water chemistry data. Beginning in 1996 quantification and qualification of fine sediment deposits will not be restricted to mass and particle size. Due to the possible toxic character of metals contained in the sediments, fine sediment (-45 mesh) will be analyzed for total metals concentrations for the analytes arsenic, antimony, cadmium, copper, iron, lead, mercury, selenium and zinc.

In the upper reaches of the EFSFSR, sources for sediment production and delivery include the Cinnabar Mine, the Stibnite Mine, the Yellow Pine Mine (Ries et al 1991), the ore processing facilities along Meadow Creek and the extensive roadways to, through and around the mined lands. Areas exhibiting the most significant land disturbance include the West End Pit, the Midnight Pit, the Homestake Pit and Waste Dump (reclaimed), and the spent ore disposal site on Meadow Creek.

Fine sediment deposition was measured using cobble embeddedness and free matrix sampling techniques described in Ries et al (1991). A Mann-Whitney U Test was used to compare cobble embeddedness and the percentage of free matrix particles in developed and undeveloped watersheds (Ries et al 1991).

Tamarack Creek near its confluence with the EFSFSR has been used as a reference site. Data from this site was used to compare background and man-caused sediment loading of the EFSFSR. Tamarack Creek has generally exhibited considerable stability in metals and sediment loads, except for an unusually high value in 1990. The level of embeddedness at the two EFSFSR of the Salmon locations and at Sugar Creek above West End Creek remained somewhat constant. In Sugar Creek below West End Creek, there has been a trend of significantly decreasing embeddedness, which indicates a reduction in sediment coming from West End Creek.

In general, cobble embeddedness and free matrix indices in stream reaches affected by mining in the early 1980's have improved, while indices in unaffected areas have remained fairly stable (Ries et al 1991). Several factors may account for the improvements. These factors include: 1) Increased use of best management practices that specifically prohibit sediment production and delivery; 2) Stabilization and reclamation of abandoned mined lands around the glory hole and Meadow Creek Mill Site; 3) Stabilization and reclamation of the Homestake pit and waste dump; and 4) Drought conditions observed over the last ten years.

MACROINVERTEBRATE TAXONOMIC

In 1994 the water quality status report for the EFSFSR was a synapsed version of the Payette National Forest's Aquatic Ecosystem Inventory by Magnum (1993), and Biological Assessment by Faurot and Gebhards (1993). The synopsis was provided to familiarize the reader to macroinvertebrate monitoring and conclusions drawn by macroinvertebrate data analyses, and to allow the reader to follow correlations made in water chemistry analyses and conclusions. At that same time Bob Wisseman of Aquatic Biology Associates, Incorporated was contracted to perform a comprehensive review of the historical macroinvertebrate data in order to ascertain whether or not trends could be noted in the data, and whether or not that data was of a quality that would lend itself to more contemporary analytical techniques.

Wisseman standardized and reanalyzed the historic data. He noted that a multimetric bioassessment had to be constructed for the data sets since the level of taxonomic effort used on the original samples was too coarse. Wisseman further notes that "due to inadequacies in historic data sets, trend and impact analyses in both watersheds (EFSFSR and Big Creek) was found to be difficult". Wisseman did, however, observe that benthic invertebrate communities found at all monitoring sites could generally be characterized as:

> Typical of mid-order western montane streams;
>
> Composed of taxa that are widespread and common in western North America;
>
> Taxa richness is generally moderate;

Ephemeroptera+ Plecoptera+Trichoptera (EPT) Taxa richness is moderate to high;

Richness of cold adapted taxa is moderate to high; and

Highly tolerant taxa are generally rare or absent.

In 1994 the biotic integrity of sites in the EFSFSR watershed were rated as: High (2 sites); Moderate (7 sites); and very low (1 site)(Wisseman 1995). Furthermore, although Wisseman's comparison of the 1983-1984 data to the 1994 data indicates a sharp contrast (highly impacted versus moderate to high biotic/habitat integrity) he also noted that historic data was inconsistent and unreliable.

In spite of the pervasity of low efficacy in historic data acquisition and analyses, Wisseman has made many extraordinary and sound conclusions. His findings are summarized for each of the ten (10) macroinvertebrate monitoring sites in the upper EFSFSR watershed.

Although metals concentrations reach levels which would be expected to cause a chronic effects in cold water biota at the macroinvertebrate Station 2040314 on the EFSFSR below Sugar Creek, bioassessment scores demonstrate an erratic but show a dramatic improvement from 1983 through 1994 (Wisseman 1995). This in part can be explained by a significantly decreasing trend in total metals concentrations at that point in the EFSFSR.

At Station 2040308, on the EFSFSR above the confluence with Sugar Creek, but below the Glory Hole, biomonitoring was limited to four (4) years (1989-1994). Total bioassessment scores, however, varied between 50% and 63% (low-moderate/biotic habitat integrity)(Wisseman 1995). These scores, which are somewhat depressed in 1990 and 1992, may reflect the impacts of relatively higher concentrations of metals in the EFSFSR during those years. In 1994, however, the bioassessment score reached 70% and both cold water taxa and metals sensitive taxa were present (Wisseman 1995). If this stream segment was at or near its natural potential, then it is expected that the bioassessment scores would probably be in the 80-90% range (Wisseman 1995).

Biomonitoring trends at Station 2040310, on the EFSFSR below Garnet Creek are similar to those found in the EFSFSR below the Glory Hole. Biomonitoring indicates that severely impacted communities in 1983-1984 recovered to attain moderate biotic/habitat status in 1989, and has remained somewhat constant through 1994 with depression noted for 1990 and 1992. It is important to note that Total bioassessment scores below Garnet Creek are about 10% lower than those found at the next site on the EFSFSR above Garnet Creek. This may be attributed the relatively high background levels of metals, particularly arsenic, in Garnet Creek which would influence the communities immediately downstream.

Limited data for the Station 2040365, located on the EFSFSR above Garnet Creek excludes any possibility of trend analyses. Total bioassessment scores of 78% and 77%, however, approach what is believed to be the natural potential of the stream which would be approximately 80%-90% (Wisseman 1995).

Station 2040315 was established as a reference site on the EFSFSR above the confluence with Meadow Creek. This section of the EFSFSR is, however, significantly different than that below the confluence with Meadow Creek in that there is a much lower flow volume, higher in gradient, and much colder than the lower sections of the EFSFSR. Furthermore, this site is probably not totally unaffected by sediment and metals contaminants as the Thunder Mountain Road and some smaller mineral exploration and development are up gradient from the site. Biomonitoring for this site is available from 1989 through 1994 and bioassessment scores range from 55.6% (low biotic/habitat integrity) to 84% in 1994 (Wisseman 1995). The variation and depression seen in the Total scores are likely to be relics of low efficacy sampling and laboratory processing (Wisseman 1995). Bioassessment scores of 80%-84% are most likely the norm for the site which indicates a high biotic/habitat integrity (Wisseman 1995). In addition, Total and EPT taxa richness are moderate (2680/m^2), negative indicators taxa are virtually absent, and cold-adapted intolerant taxa dominate the benthic community (Wisseman 1995). This site is probably at its natural potential.

Biomonitoring data for Station 2040319, on Meadow Creek near its confluence with the EFSFSR, is available from 1983 through 1994. Although historic data, particularly prior to 1989, is inconsistent and perhaps unreliable, trend analyses indicates that a sustained but occasionally interrupted recovery has occurred since 1983 (Wisseman 1995). Total scores have gone from 22.2% (severely impacted) in 1983 to 70% (moderate biotic/habitat integrity) in 1994. This trend is consistent with trends noted in water chemistry at the same site for the period 1983 through 1994, and is indicative that overall water quality is improving in this section of Meadow Creek with, however, occasional depressions which may be due either to corresponding increases in metals concentrations or pulses in sediment delivery from Blowout Creek (Schuld 1994). Meadow Creek has the potential to display Total bioassessment scores in the 80%-90% range if contamination from mine effected runoff can be significantly reduced and the physical aquatic and riparian habitat is improved (Wisseman 1995).

Station 2040368 was established as a biomonitoring site in the Old Meadow Creek Channel below the Keyway in 1994, and data has been collected in both 1994 and 1995. Because of substantial differences between the aquatic and riparian environment of this section relative to other sites in Meadow Creek with which comparisons would normally be made, and the reconstruction which will occur in this stream section due to EPA's and the Forest Service's Joint 106 Removal action, it is unlikely that biomonitoring at this site will continue. The accumulated data and analyses, however, warrant discussion.

The Total bioassessment score for this Station 2040368 was 28% in 1994, which indicates a severely impacted condition. Habitat limitations undoubtedly account for the severe impact (Wisseman 1995). These habitat limitations include low flow and gradient, especially the lack of ability for the stream to flush itself, and the lack of diverse riparian structures and communities such as large organic debris and woody vegetation which would act as canopy. Given the habitat conditions and the long history of high metals concentrations, it is not unexpected to have found that the benthic community is dominated by moderately to highly tolerant taxa (Wisseman 1995).

Station 2040320 was established as a reference site on Meadow Creek above the Diversion. Although water chemistry data was collected as early as 1978, biomonitoring data only exists for 1990 through 1994. Total bioassessment scores for this site range from 51.9% to 78%. Wisseman accounts for the lower scores as probably due to the lower efficacy of sampling and laboratory analyses in the first few years of monitoring. Wisseman continues to qualify his conclusions by stating "Total bioassessment score of 77% and 78% are most certainly more representative of the site" (Wisseman 1995). This site is almost certainly at or near it natural potential.

Biomonitoring data for Station 2040307, on Sugar Creek below West End Creek, has been accumulated and analyzed from 1989 through 1994. Although trend analyses for this site was performed, Wisseman concluded that it was rather unreliable. Total bioassessment scores ranged from 44.4% (low biotic/habitat integrity) in 1989 to 88.9% (high biotic/habitat integrity) in 1991 (Wisseman 1995). Wisseman attributed a significant portion of the variation to differences and low efficacy in sampling and laboratory analytical techniques. Despite those problems in the data base Wisseman concluded that recovery from impacts which had occurred in Sugar Creek prior to 1989 from the West End or Cinnabar mines was occurring. Total scores of 78% to 81% are probably representative of this site, and therefore, this site is probably at or near its natural potential (Wisseman 1995).

Biomonitoring data has also been collected at Station 2040309 on Sugar Creek above West End Creek from 1989 through 1994. The results, trends and conclusions from this monitoring near perfectly mirrors that of the site below West End Creek. It may be concluded, therefore, that there has been no substantial impacts to the benthic community which were direct results of discharges from West End Creek. As with Station 2040307, the aquatic community at Station 2040309 is at or near its natural potential for biotic/habitat integrity (Wisseman 1995).

FINE SEDIMENT, ALGAE, AND FISH TISSUE ANALYSES

In September 1992, sediment, algae, and fish samples were collected from the EFSFSR below the influence of Stibnite Mine, and analyzed for trace elements. Results of analyses indicate elevated concentrations of arsenic, chromium, and mercury in sediment samples collected below the influence of mining activities (Burch and Mullins 1994). The one algae sample collected had an elevated level of arsenic, and trace element concentrations in whole steel head trout smolts and adult mountain whitefish samples had elevated arsenic, cadmium, copper, lead, mercury, and selenium concentrations when compared to National Contaminant Biomonitoring Program (NCBP) data (Burch and Mullins 1994). The results of these analyses indicate there are elevated trace elements in fish and their habitats in the EFSFSR system (Burch and Mullins 1994).

The objective of the study plan was to measure concentrations of trace elements in sediment, algae, and fish in the EFSFSR to determine if there are elevated levels which could potentially affect anadromous and resident fish or their habitat, and to establish baseline conditions in the event of a potential future catastrophic release of toxic material into the EFSFSR (Burch and Mullins 1994). Collection sites were selected upstream of the currently operating Stibnite Mine, and downstream of the Stibnite Mine complex.

In October, 1991, the USF&WS in cooperation with the DEQ collected water, sediment, and algae samples from Meadow Creek for trace element analysis (Burch and Mullins 1993). Elevated concentrations of arsenic, barium, copper, iron, lead, manganese, and mercury were detected in sediments, and elevated levels of arsenic, barium, boron, copper, iron, lead, and mercury were detected in algae samples (Burch and Mullins 1994). This information was summarized in conversations with Susan Burch and Bill Mullins regarding their study of trace element concentrations in sediment and algae collected from Meadow Creek.

Sediments collected from the EFSFSR contained detectable concentrations of aluminum, arsenic, barium, beryllium, chromium, iron, magnesium, manganese, mercury, nickel, strontium, vanadium, and zinc (see Table 1 from Burch and Mullins 1994). Two sediment samples from Sugar Creek and Profile Creek, had detectable concentrations of copper, lead, and selenium. Sediments from Sugar Creek and the Control Station (EFSFSR above Stibnite Mine) contained detectable levels of boron (Burch and Mullins 1994).

Mountain whitefish and steel head trout were the two species of fish collected using electro fishing techniques in the EFSFSR (See Table 3, Burch and Mullins 1994). Aluminum, arsenic, barium, chromium, copper, iron, magnesium, manganese, mercury, selenium, strontium, and zinc were detected in all fish samples collected from all three sites. At present, it appears that aluminum, barium, boron, iron, magnesium, manganese, nickel, strontium, and zinc are not at

TABLE 3. Trace Element Concentrations in Sediment, Algae, and Fish Collected from the EFSFSR South Fork Salmon River, Idaho, August 1992. (From Burch and Mullins 1994)
[Concentrations in micrograms per gram, (μg/g), dry weight]

Sample/Location	Age[a]	Aluminum	Arsenic	Barium	Beryllium	Boron	Cadmium	Chromium	Copper	Iron	Lead
Sediment Below Sugar Creek		5,820.00	779.70	73.40	0.78	5.53	<0.20	64.39	7.31	14,140	12.19
Sediment At Profile Creek		7,545.00	216.90	88.53	0.33	<4.96	<0.20	102.80	10.93	13,550	7.33
Sediment Control (EFSFSR above Stibnite mine)		5,945.00	54.80	66.73	0.39	5.15	<0.20	52.20	<4.97	10,830	<4.97
Algae Mile Post 8		1,470.00	244.70	102.20	<0.48	<2.40	<0.48	3.40	6.42	4,270	<2.40
Steel head Trout (2)[b] Profile Creek	1+	42.57	1.69	1.89	0.21	1.11	0.29	5.13	3.28	90.62	1.01
Mountain Whitefish (1) Profile Creek	3-4	81.78	2.21	1.60	<0.10	0.65	<0.10	17.63	2.45	210.60	<0.49
Steel head Trout (2) At Mile Post 8	1+	37.69	2.87	1.25	<0.10	<0.49	<0.10	1.48	5.51	49.99	<0.49
Mountain Whitefish (1) At Mile Post 8	3-4	47.82	2.82	1.71	0.11	2.13	0.13	5.30	2.21	90.82	0.59
Steel head Trout (1) Below Sugar Creek	2+	39.00	5.52	1.06	0.14	2.85	<0.10	4.02	5.66	86.12	0.49
Steel head Trout (3) Below Sugar Creek	1+	39.47	6.38	1.28	<0.10	<0.49	<0.10	1.58	4.35	77.56	<0.49
Mountain Whitefish (2) Below Sugar Creek	3-5	85.40	4.96	1.50	<0.10	0.96	<0.10	11.35	3.83	243.70	<0.50

[a] Estimated age in years.
[b] Number of fish in composite sample.

TABLE 3.(cont) **Trace Element Concentrations in Sediment, Algae, and Fish Collected from the EFSFSR South Fork Salmon River, Idaho, August 1992. (From Burch and Mullins 1994) Concentrations in micrograms per gram, ($\mu g/g$), dry weight]**

Sample/Location	Magnesium	Manganese	Mercury	Molybdenum	Nickel	Selenium	Strontium	Vanadium	Zinc
Sediment Below Sugar Creek	2,640.00	326.40	5.14	<4.93	9.70	0.53	18.22	11.32	32.98
Sediment At Profile Creek	2,940.00	623.60	1.66	<4.96	11.93	0.55	21.64	14.25	31.69
Sediment Control -	2,721.00	184.00	0.28	<4.97	5.06	<0.50	12.64	14.52	26.60
Algae At Mile Post 8	2,267.00	313.90	1.67	<2.40	<2.40	<1.84	34.58	3.06	24.55
Steel head Trout Profile Creek	754.50	9.89	0.31	<0.48	1.33	2.69	15.74	<0.48	54.11
Mountain Whitefish Profile Creek	786.60	8.20	0.34	<0.49	0.60	3.18	23.35	<0.49	49.50
Steel head Trout At Mile Post 8	760.60	9.37	0.32	<0.49	<0.49	2.84	17.80	<0.49	56.64
Mountain Whitefish At Mile Post 8	1,034.00	18.84	0.60	<0.49	0.89	6.82	35.17	<0.49	54.21
Steel head Trout Below Sugar Creek	635.50	5.51	0.59	<0.48	0.85	2.77	11.35	<0.48	52.44
Steel head Trout Below Sugar Creek	726.00	11.51	0.39	<0.49	<0.49	2.96	14.88	<0.49	54.06
Mountain Whitefish Below Sugar Creek	693.80	15.56	0.87	<0.50	0.68	4.91	18.63	<0.50	41.83

concentrations which are harmful to fish (Burch and Mullins 1994). Arsenic concentrations of fish tissue ranged from 1.69 ppm (0.51 ppm wet weight) in steel head trout collected from Profile Creek to 6.38 ppm (1.88 ppm wet weight) in steel head collected from the Sugar sampling site (Burch and Mullins 1994). The potential for bioaccumulation or bioconcentration of cadmium is high to very high for mammals, birds, fish, mosses, lichens, algae, mollusks, crustacea, lower animals, and higher plants (Jenkins, 1981).

In whole fish collected from the EFSFSR, copper concentrations ranged from 2.45 ppm (0.75 ppm wet weight) in mountain whitefish collected near Mile Post 8, to 5.66 ppm (1.78 ppm wet weight) in steel head trout collected from the Sugar Creek site (Burch and Mullins 1994). The steel head samples collected at sites Mile Post 8 and Sugar Creek (total of three samples: 5.51 ppm, 5.66 ppm, and 4.35 ppm wet weight), and mountain whitefish taken from Sugar Creek (3.83 ppm wet weight).

One steel head trout collected from Profile Creek, one of two steel head samples collected from Sugar Creek, and mountain whitefish collected at Mile Post 8 had detectable concentrations of lead. The fish were found to contain 1.01 ppm (0.30 ppm wet weight), 0.49 ppm (0.15 ppm wet weight), and 0.59 ppm (0.17 ppm wet weight), respectively (Burch and Mullins 1994).

Elevated concentrations of selenium were also found in fish. Selenium concentrations in fish tissue collected from the EFSFSR ranged from 2.69 ppm (0.80 ppm wet weight) in steel head trout at the Profile Creek site to 6.89 ppm (2.32 ppm wet weight) in mountain whitefish from Mile Post 8 (Burch and Mullins 1994).

MACROINVERTEBRATE TISSUE ANALYSES

Approximately seven (7) to ten (10) wet weight grams of macroinvertebrates were collected from each of ten (10) water quality monitoring sites (see Table 4). The samples were hand picked and cleaned to eliminate the influence of gut content, fines which were attached to the exoskeleton, and stream water. Because of the intensity of labor involved in collecting the necessary weight of tissue for each sample, the more massive individuals were collected. There was, therefore a dominance by the family plecoptera particularly the cold water taxa *Leuctridae, Doroneuria, Cultus, Kogotus, Megarcys* and/or *Yoraperia.* Of secondary importance or dominance in these sets were Tricoptera dominated by *Parapsyche* and *Arctopsyche.* Although these taxa are considered cold water and intolerant species, they contributed more readily to the collection of the mass needed for analyses.

Three samples were collected at reference sites including the EFSFSR above Meadow Creek (Station 2040315), Meadow Creek above the Diversion (Station 2040320), and on Sugar Creek above West End Creek (Station 2040309). These stations were selected because they already

TABLE 4.

EFSFSR	Macroinvertebrate	Tissue	Metals	Concentrations		9/22/95				
	STATION	Arsenic ug/g	Antimony ug/g	Cadmium ug/g	Copper ug/g	Iron ug/g	Lead ug/g	Mercury ug/g	Selenium ug/g	Zinc ug/g
Below Mine	2040314	43.8	4.58	0.169	13.7	1244	1.59	0.8	2.09	145
Blw Glry Hc	2040308	319.8	21	0.21	16.8	4048	4.5	NS	3	157
Mid Point	2040310	49.7	14.4	0.149	16	849	4.47	0.4	2.29	130
Blw CN Fac	2040365	129.8	57.4	0.21	22.8	2086	17.5	NS	2.7	172
Ref. Sta.	2040315	7.95	1.59	0.238	18.6	402	0.79	0.25	0.99	180

Sugar	Creek	Macroinvertebrate	Tissue	Metals	Concentrations		9/22/95			
	STATION	Arsenic ug/g	Antimony ug/g	Cadmium ug/g	Copper ug/g	Iron ug/g	Lead ug/g	Mercury ug/g	Selenium ug/g	Zinc ug/g
Blw Min	2040314	43.8	4.58	0.169	13.7	1244	1.59	0.8	2.09	145
Blw W.E.	2040316	47.1	1.59	0.179	14.6	569	1.19	1.09	1.88	157
Above W.E	2040309	5.97	0.7	0.239	16.3	407	0.7	1.05	1.1	165

Meadow	Creek	Macroinvertebrate	Tissue	Metals	Concentrations		9/22/95			
	STATION	Arsenic ug/g	Antimony ug/g	Cadmium ug/g	Copper ug/g	Iron ug/g	Lead ug/g	Mercury ug/g	Selenium ug/g	Zinc ug/g
At Mouth	2040319	209.1	36.8	0.119	18.9	3236	6.47	0.59	3.78	132
Blw Divr.	2040322	104.7	11	0.17	18.9	2533	2.99	0.44	3.79	139
Ref. Sta.	2040320	2.1	0.5	0.24	16.7	758	1.2	0.23	1.9	191

had an extensive historical data base for water chemistry and macroinvertebrate taxonomy, and because that data suggest that these sites are at or close to their natural potential for biologic integrity. The analyses compared well to metals analyses of tissue samples collected in the Upper Snake River Basin, which were dominated by Tricoptera *Hydropsyche* and *Arctopsyche* (Maret 1995). The metals concentration of the EFSFSR samples were somewhat higher than those in the Snake River samples which is not unusual particularly when considering the mineralogic nature of the Upper EFSFSR watershed. The most outstanding divergence noted in comparing the data from the reference sites to data from the Upper Snake data was in mercury concentrations found in the sample collected on Sugar Creek. Indeed, relative to the other samples collected in the Upper EFSFSR, the Sugar Creek samples showed elevated mercury which is almost certainly attributable to the cinnabar ore deposits located on Cinnabar Creek, which is a tributary to Sugar Creek above the reference sites.

Macroinvertebrate tissue was collected at Station 2040365 on the EFSFSR below the confluence of the EFSFSR and Meadow Creek. This sample location is also immediately downgradient, hydrological, from the ore processing facilities. Copper, cadmium, selenium and zinc concentrations were consistent with data from the Upper Snake and reference stations in the watershed. Arsenic, antimony, iron and lead, however, were five (5) to thirty-six (36) times higher than that at the reference site on the upper EFSFSR. This indicates a substantial contribution of metals from a localized source(s). Metals data on Meadow Creek above the confluence with the EFSFSR and approximately 300 feet up gradient from this station also indicates the influence of a heavy metals source(s) up gradient from the station. This station has been historically impacted by Bradley Mill tailings which were washed from the mill and smelter site between 1950 and 1995. Therefore, effects due to heavy metal ladened fine sediment or elevated concentrations of heavy metals in the water column may be reflected in the tissue analyses.

Analyses of tissue collected at Station 2040310 on the EFSFSR at Adkins Flat, immediately below Garnet Creek shows a substantial difference in metals concentrations compared to those found at the reference Station 2040315 and Station 2040313 immediately upstream on the EFSFSR. Relative to Station 2040315, concentrations of arsenic, antimony, iron and selenium indicate the influence of heavy metal source(s) up gradient from Station 2040310. Lower concentrations of all metals, when compared to those at Station 2040365 immediately upstream, would suggest that the aquatic community is further removed or significantly less effected by the heavy metals sources. This was not expected particularly since analyses of the effluent from Garnet Creek indicates a significant source or arsenic and antimony in that subwatershed. Never-the-less, the lower metals concentrations may correlate to significant concentrations in the water column and lack or fine sediment and tailings found in proximity to the station.

Macroinvertebrates were collected for tissue analyses at Station 2040308 on the EFSFSR below the Glory Hole.Once again, concentrations of cadmium, copper and zinc were consistent with the reference site data and data from the Upper Snake. Antimony, lead and selenium concentrations were notably higher than those found at the reference site, but similar to those found at Stations 2040365 and 2040310 above the Glory Hole. Arsenic and iron concentrations, however, were far higher than any found in or outside of the watershed. Unfortunately, the quantity of tissue available for analyses was too small to analyze for mercury. It appears that arsenic and iron concentrations may have a correlation in both bioaccumulation and to localized source(s). Extremely high concentrations of arsenic and iron is most certainly indicative of heavy metals in the water column whose source(s) is located in the sulfide mineral zones exposed in the Glory Hole or sulfide waste dumps on its periphery.

Tissue analyses for metals concentrations was done for macroinvertebrates collected from Station 2040314 on the EFSFSR below Sugar Creek which is the furthest downstream station in the mine monitoring plan. As with upstream stations, concentrations of cadmium, copper, lead, selenium and zinc were comparable to those found at reference sites in the watershed and in the Upper Snake data. Concentrations of arsenic, antimony, iron, and mercury, although significantly higher than those at reference sites, were significantly lower than concentrations found at the three up gradient stations (2040365, 2040310, 2040308) within the mining site. These concentrations are almost certainly lower than at the upstream stations because of a dilution of the EFSFSR by the influence of Sugar Creek immediately upstream from Station 2040314. There is, however, a significant increase in the concentration of mercury in the macroinvertebrate tissue which is expected due to the influence of Cinnabar Creek on Sugar Creek and thence upon the EFSFSR.

As stated previously, tissue data for the reference site on Meadow Creek above the Diversion, Station 2040320, is comparable to the other reference sites in the EFSFSR watershed and those stations monitored in the Upper Snake River when the differences in mineralogic setting are noted. Arsenic, antimony and mercury concentrations are slightly lower whilst concentrations of cadmium, copper, lead, selenium and zinc are slightly higher at this station than at either of the other two reference sites. These differences may be attributed to slight differences in the species collected, residual contamination of stream water or residual gut content, but are never-the-less relatively insignificant.

Metals concentrations in tissue collected at Station 2040322 on Meadow Creek below the Diversion are significantly higher than those found at Station 2040320 for every analyte except cadmium, copper and zinc. Elevated concentrations of arsenic, antimony, iron, lead, mercury, and selenium are consistent with analyses of water samples collected from Station 2040322, and are what would be expected of samples collected in proximity to the Bradley Mill and Smelter site where sulfide materials were processed and sulfide waste was left.

Macroinvertebrate tissue samples were also collected at Station 2040319 on Meadow Creek above the confluence with the EFSFSR. All metals concentrations in the tissue, except cadmium and zinc, were significantly higher than concentrations found in tissue collected at either of the two upstream sites on Meadow Creek. Concentrations of two (2) times in selenium to one hundred (100) times in arsenic over background were noted. These concentrations and those found at the upper sites may be indicative of cumulative effects from multiple sources in Meadow Creek from the Meadow Creek Pond downward through the confluence with the EFSFSR, these effects are most likely reflected in the data on the EFSFSR below the confluence.

A reference site for macroinvertebrate tissue analyses was also established at Station 2040309 on Sugar Creek above West End Creek. Metals concentrations at Station 2040309 are similar to those found at the other two reference sites, and is comparable to sites located in the Upper Snake River Basin except for mercury. Mercury at Stations 2040309 and 2040307, above and below West End Creek respectively, exhibit the highest concentrations of mercury found in tissue samples taken in the watershed, and far exceed those found in the Upper Snake data. This indicates that although the station may be used as a reference site for most of the metallic analytes, influences from the Cinnabar Creek subwatershed negate this site as an optimum reference site for the entire watershed.

Tissue analyses of macroinvertebrates collected at Station 2040316, on Sugar Creek at the Bridge to the mines, were significantly higher in metals concentrations than those collected upstream at Station 2040309. Although cadmium, copper and zinc were somewhat less, and lead, iron, mercury and selenium were slightly higher, concentrations of arsenic and antimony were significantly higher than concentrations found at Station 2040309. This would indicate that there are significant sources of arsenic and antimony somewhere in between. These sources may include but are not limited to West End Creek, the Bailey Tunnel, natural seeps and springs, and the historic Bradley Mine Dump which contains sulfide waste. As yet these sources are uncharacterised except West End Creek whose effluent water quality has been monitored since 1988. Water quality monitoring indicates that there are elevated concentrations of arsenic and antimony occur in West End Creek, which confirms this subwatershed as a source of some metals contamination. Water quality monitoring, however, also indicates that there are substantial contributions of arsenic and antimony to the water column from sources which discharge to Sugar Creek downstream of West End Creek.

Concentrations of arsenic, cadmium, copper, selenium, lead, mercury, selenium and zinc are anomalous within the area influenced by mine development. Until additional tissue data is collected, conclusions relating total metals concentrations and impairment of communities or to cumulative effects of different metals in macroinvertebrates would be statistically unfounded. There is, however, a significant number of studies which support the hypothesis that metals toxicity is at least partially responsible for impairment of communities. There can be no doubt that as toxicity analyses of these metals continues nationwide, tissues analyses of macroinvertebrates and fish in industry areas will be invaluable.

WATER CHEMISTRY

Water chemistry data has been compiled for the EFSFSR, in proximity to the Stibnite Mine, since 1978. Study of water quality in the area was instigated by proposals to reopen the historical mines at Stibnite. The data has been included in the planning and evaluation process for the West End, Midnight, Homestake, and Garnet Creek Pits. The data has also been included in various water quality status reports produced by Hecla, Pioneer Metals, and SMI and the DEQ. Water quality data from both trend and compliance monitoring, as well as that compiled by the operators, has been considered in this analysis. For the purposes of trend analyses, graphics of arsenic and antimony concentrations versus time have been utilized because; arsenic and antimony graphics most dramatically depict the trends in metals loading in the watershed, and trends in other metals closely parallel to those of arsenic and antimony (except when compared to analyte concentrations expected to cause chronic or acute effects in cold water biota). In other words, arsenic and antimony are without exception the metals contaminants of greatest concern.

Although there are in excess of forty (40) water quality monitoring stations and thirty (30) analytical parameters, rudimentary screening of stations and analytes was done for this report. Screening resulted in analyses for: 1) Surface water stations; 2) Stations which were reference sites, above or below major stream reaches or contaminant sources; 3) Parameters, which concentrations may cause chronic or acute effects in cold water biota; and 4) Parameters which, although they exhibit no toxic effects to human health or aquatic communities, occurred in such high concentrations as to possibly identify trends in metals loading. Stations listed in TABLE 2, and the parameters; Total Arsenic, Total Antimony, Total Cadmium, Total Copper, Total Iron, Total Mercury, Total Selenium and Total Zinc were included in the study. Screening should not be construed as indicating usefulness, or lack there of, for monitoring stations not analyzed. Nor should the screening be construed as an elimination for analytical parameters from subsequent monitoring. Furthermore, it should be noted that although total metals has been the basis for analyses, this does not reflect bioavailability of those metals. Additionally, laboratory detection limits are often much higher than concentrations of metals which may bioaccumulate, particularly in the case of mercury.

Water quality monitoring has been performed in accordance with established protocols for sample collection, transportation, chain-of-custody, and Field and Laboratory QA/QC (Bauer 1986 and Franson A. ed 1985). The protocols for data collection and analysis are contained in Appendix A of this report. Results from laboratory analysis are contained in the Tables of Appendix B.

Station 3040315 (EFSFSR above Meadow Creek Figure 8.) is the reference site on the EFSFSR. Metals concentrations at the station trend close to the detection limits. Exceptions to this trend occurred during the high flow periods in 1983, 1984, and 1992. Most likely these spikes occurred as the direct result of erosion along the Thunder Mountain Road which parallels the EFSFSR for several miles above Stibnite. Hardness and pH at Station 2040315 average 31.2 mg/l (as $CaCO_3$) and 7.5 s.u, respectively.

The water quality monitoring Station 2040365 (EFSFSR above the Box Culvert Figure 9) was established in 1978 for baseline analyses when a proposed plan of operations for reopening the mine was submitted to the PNF. Subsequent to that time, Station 2040365 became a critical compliance monitoring site. Higher concentrations of metals, particularly arsenic and antimony, have been noted to coincide with major precipitation and runoff events. From 1983 through 1985 repeated spikes in metals, which exceeded those concentrations which would be expected to cause both chronic and acute reactions in aquatic organisms, were documented. Sources for the contaminants were presumed to include the haul road and ore processing facility upstream from Station 2040365. Although no direct natural resource damages were documented, the mine operator was served with a Notice of Violation by the Idaho Division of Environment. Subsequent to that violation, an extensive system of best management practices were implemented to eliminate sediment production and delivery to the EFSFSR above the Box Culvert. Implementation of these best management practices and significantly lower precipitation and runoff events during the interim of 1987 through 1990 are probably responsible with a corresponding decrease in metals concentration. Analyses for total cadmium, total copper, total mercury and total selenium began in 1991 and demonstrates that those metals concentrations are at or below detection limits. Hardness and pH at Station 2040365 average 39.6 mg/l (as $CaCO_3$) and 7.5, respectively. The higher hardness, relative to Station 2040315, may be indicative of Meadow Creek adding some buffering capacity to the EFSFSR, which is confirmed by hardness data collected at Station 2040319 on Meadow Creek above the confluence with the EFSFSR.

Metals concentrations at Station 2040313 on the EFSFSR above Garnet Creek are consistent with concentrations at Station 2040365 and with trends at the reference Station 2040315 on the upper EFSFSR. The data also correlates well with Station 3040319 near the mouth of Meadow Creek (Figure 16 and 17). Specifically, during high runoff in 1991 total arsenic and antimony concentrations peaked. Concentrations of arsenic and antimony would not, however, be expected to have caused chronic effects in cold water biota. Concentrations of total cadmium, total copper, total mercury, total selenium and total zinc were at or below detection limits. Trends in data for Station 2040313 coincide which those of 2040365 and 2040319 and confirm an influence from the Meadow Creek Drainage. Subsequently lower total arsenic concentrations may, however, indicate that implementing and modifying best management practices on haul and access roads in the vicinity of the Box Culvert and ore processing area and draught have reduced metals loading. Hardness and ph were similar to those found at Station 2040365, and averaged 36.8 mg/l (as $CaCO_3$) and 7.4 s.u., respectively.

Arsenic and Antimony Concentrations

EFSF Salmon River Above Meadow Creek

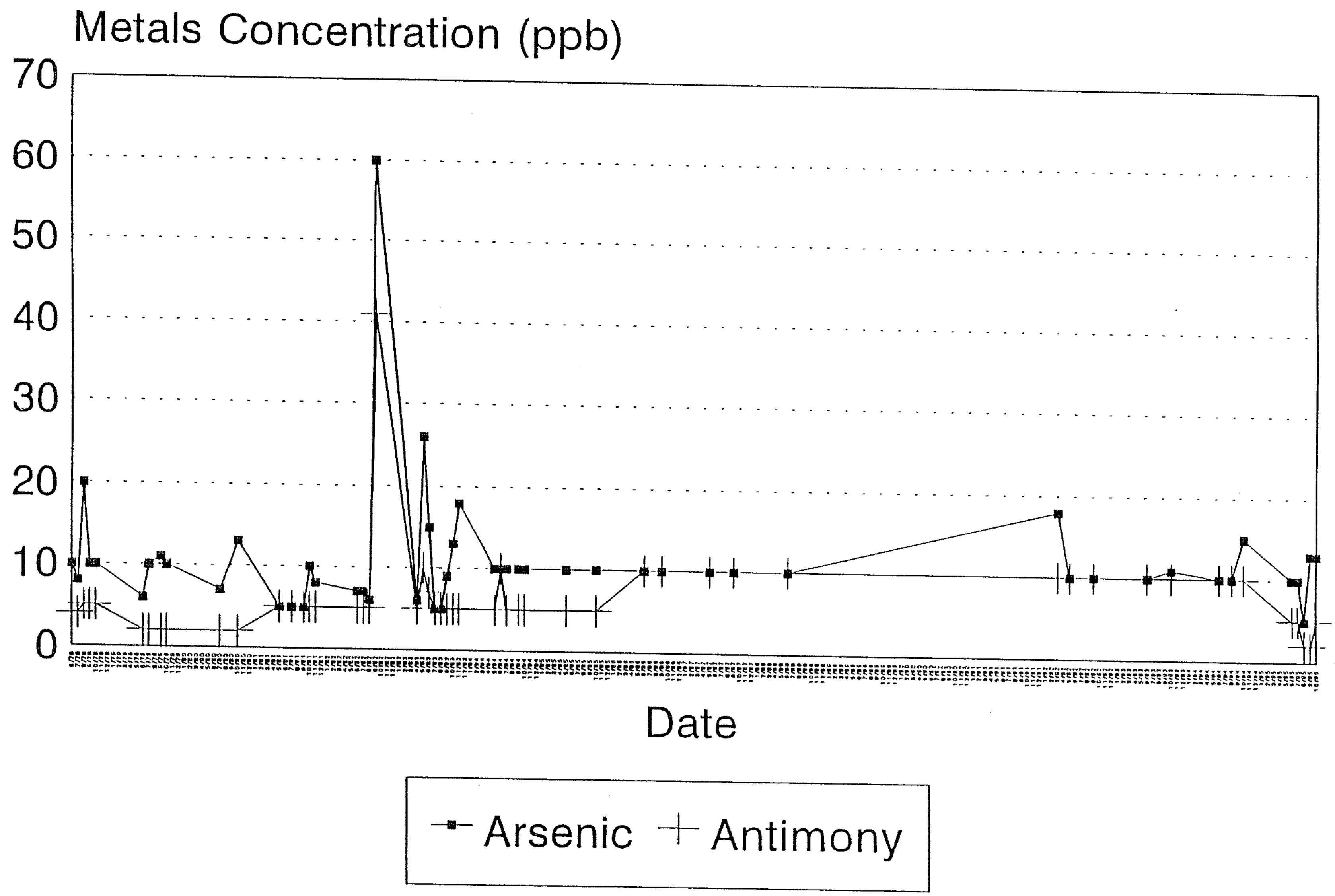


Figure 8

Arsenic and Antimony Concentrations

EFSF Salmon River Above Box Culvert

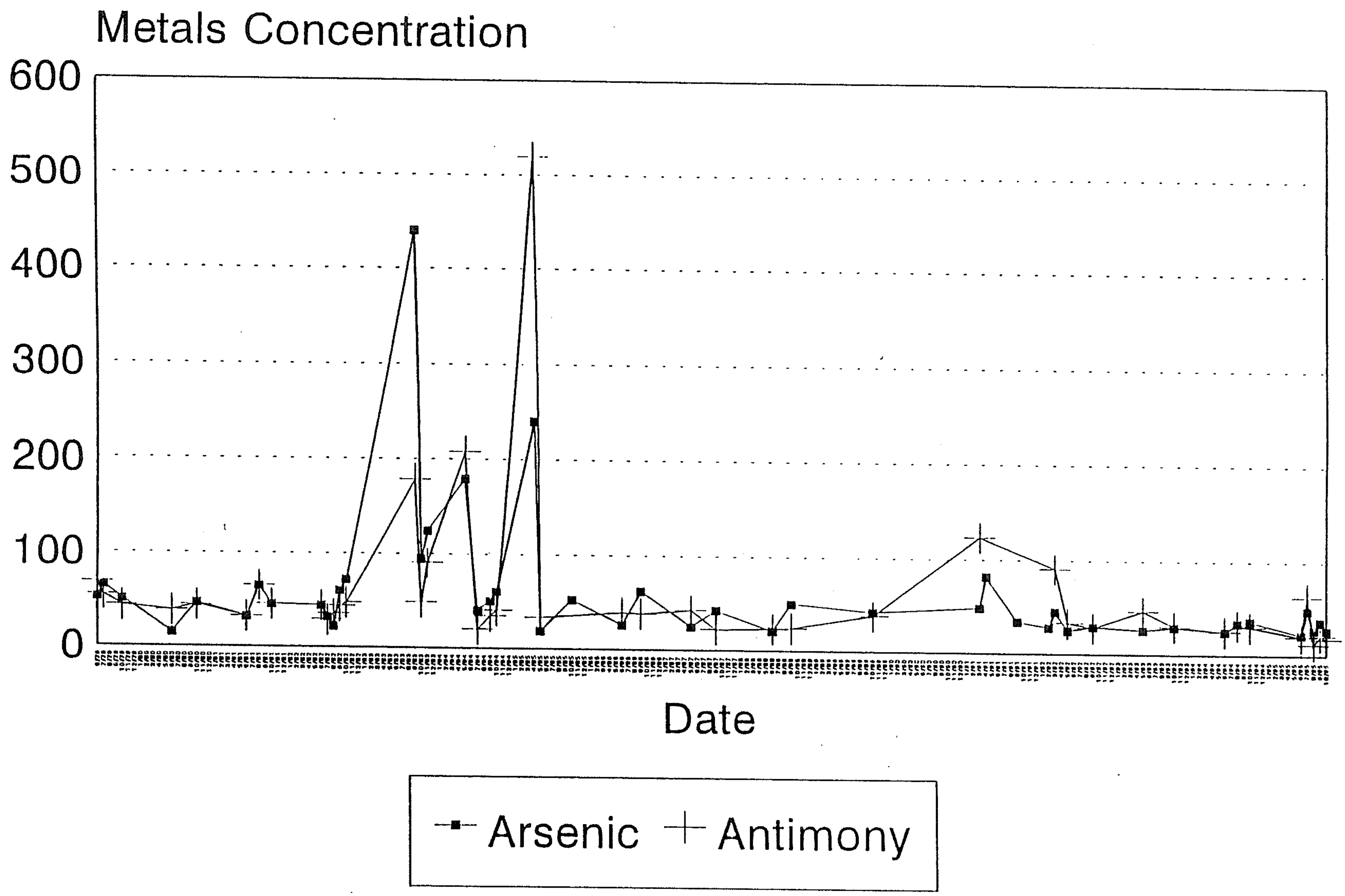


Figure 9

Arsenic and Antimony Cocentrations

EFSF Salmon River Above Garnet Creek

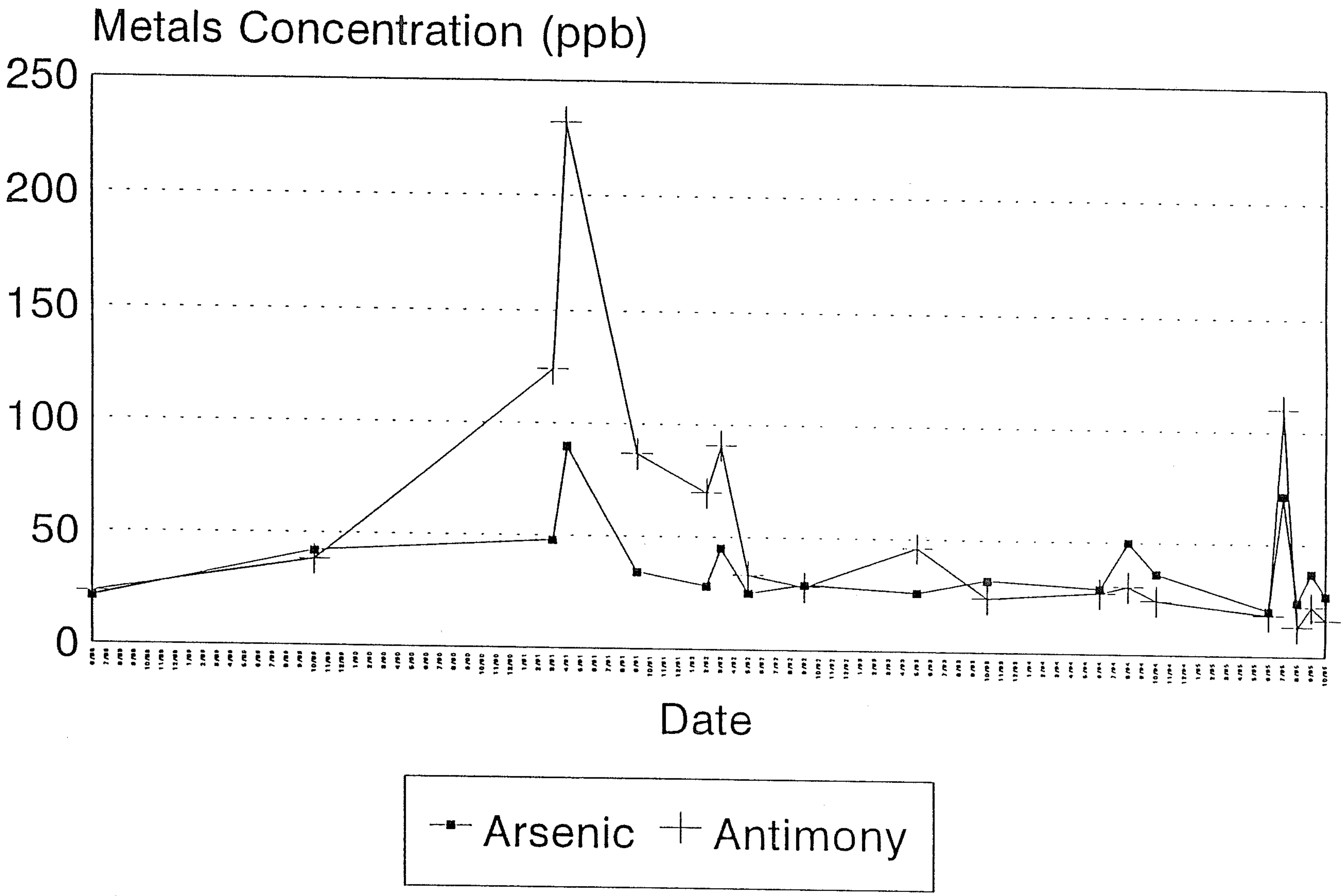


Figure 10

Arsenic and Antimony Concentrations

EFSF Salmon River Below Garnet Creek

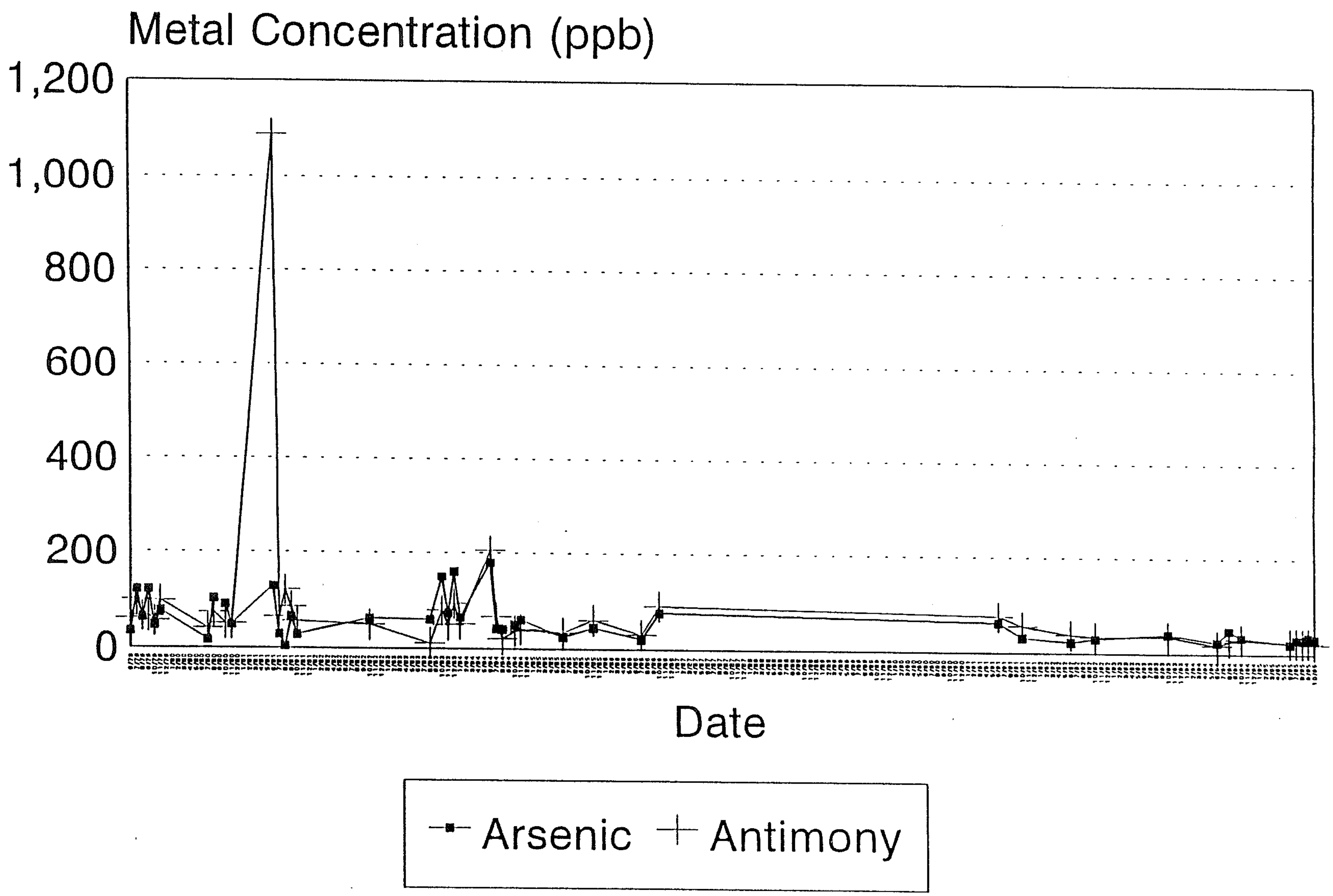


Figure 11

Total metals concentrations at Station 2040310 on the EFSFSR below Garnet Creek appear to have decreased since 1984. The decrease in total metals coincides with concentrations seen above Garnet Creek. This was most likely due to modifications of best management practices at the Stibnite Mine after 1984, and the lack of mineral development in proximity to Garnet Creek. Total arsenic, total antimony and total iron concentrations are somewhat higher at Station 2040310 than were seen at Station 2040313 immediately upstream. This increase in metals concentration is a direct influence of Garnet Creek which has historically had very high concentrations of heavy metals and other trace elements. Analyses for total cadmium, total copper, total mercury and total selenium began in 1991 and demonstrates that those metals concentrations are at or below detection limits. Similar to the slightly higher arsenic and antimony concentrations, hardness was also slightly higher at Station 2040310 than at Station 2040313. Hardness and pH averaged 48.4 mg/l (as $CaCO_3$) and 7.5 s.u., respectively.

Station 2040369 (EFSFSR below Midnight Creek Figure 12) has only been consistently monitored since 1992. Metals concentrations at Station 2040369 are slightly higher than those found at Station 2040310. Graphics of metals concentrations do exhibit some of the same peaks as found at Station 2040310, and have a similar trend of declination. The slightly higher metals concentrations are most likely indicative of the influence from Midnight Creek, which like Garnet Creek exhibits very high concentrations of arsenic and antimony (60 to 110 ppb). Hardness and pH at Station 2040369 averaged 42.1 mg/l (as $CaCO_3$) and 7.9, respectively.

Station 2040308 on the EFSFSR below the Glory Hole has not been monitored on a regular basis. Consequently no trend analyses is available. The limited data does, however, indicate that elevated concentrations of metals, particularly arsenic and antimony, are higher than those seen in the EFSFSR above the Glory Hole. The limited water chemistry data and macroinvertebrate tissue analyses indicate that the Glory Hole is a significant source of metals to the EFSFSR and that Station 2040308 has been added to the monitoring stations targeted for intensive monitoring.

Total metals concentrations at Station 2040314 (EFSFSR below Sugar Creek Figure 13) are significantly higher than metals concentrations at Station 2040369 on the EFSFSR below Midnight Creek or Station 2040316 on Sugar Creek at the bridge to the mines. Although the metals concentrations do not appear to approach those that might be expected to cause chronic reactions in aquatic organisms, does support the conclusion that the Glory Hole is or contains significant sources of metals which effect the EFSFSR. Metals concentrations at Station 2040314 appear to have peaked during 1983 and 1984. The trend in metals concentrations appears to be somewhat in decline as peaks in metals concentrations are lower. This trend correlates with trends seen above the Glory Hole. Trends also coincide with modifications of best management practices at the Stibnite Mine and Yellow Pine Mine after 1984, closure and reclamation of the Yellow Pine Mine, and lower than normal flow due to drought.

Arsenic and Antimony Concentrations

EFSF Salmon River Below Midnight Creek

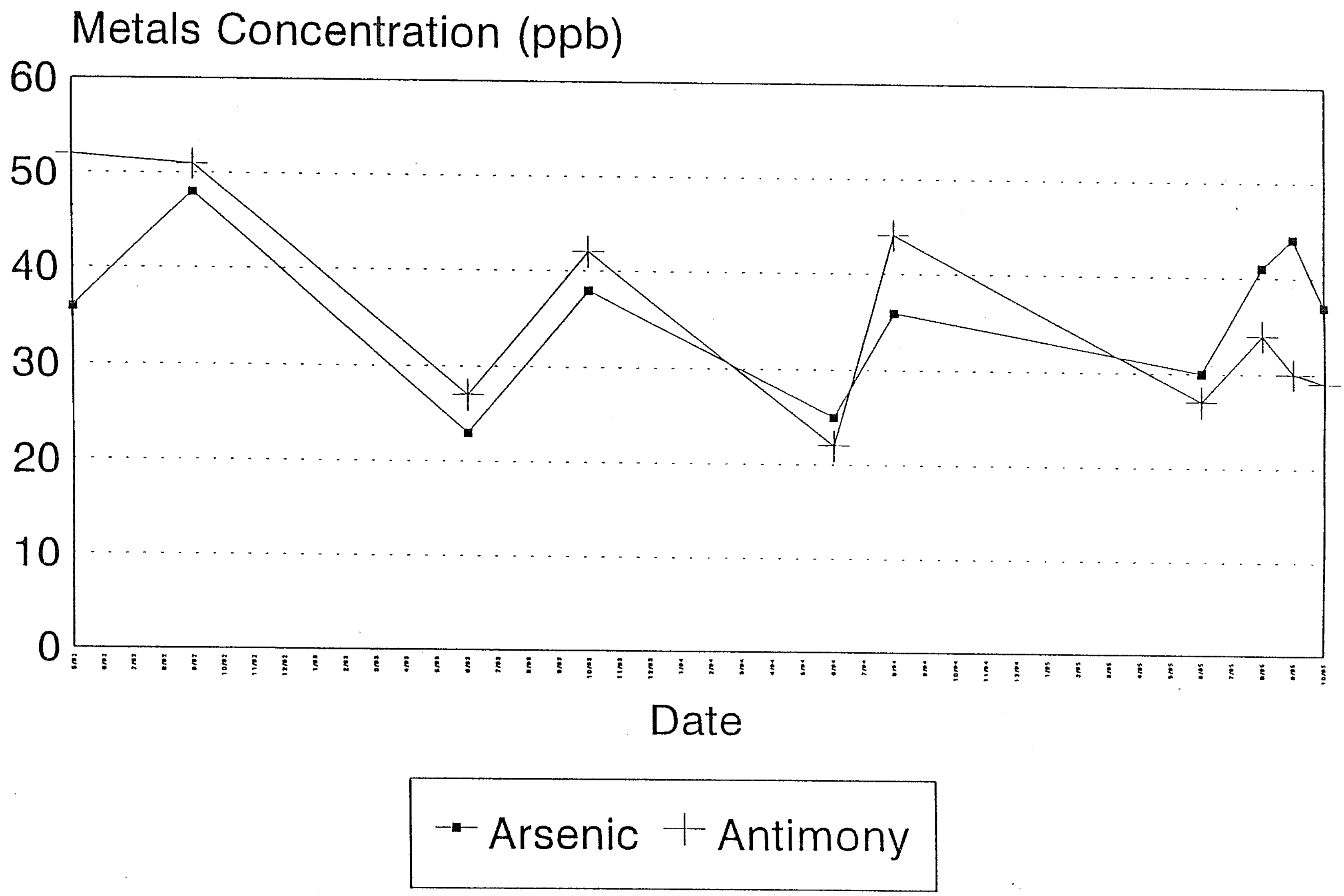


Figure 12

Arsenic and Antimony Concentrations

EFSF Salmon River Below Sugar Creek

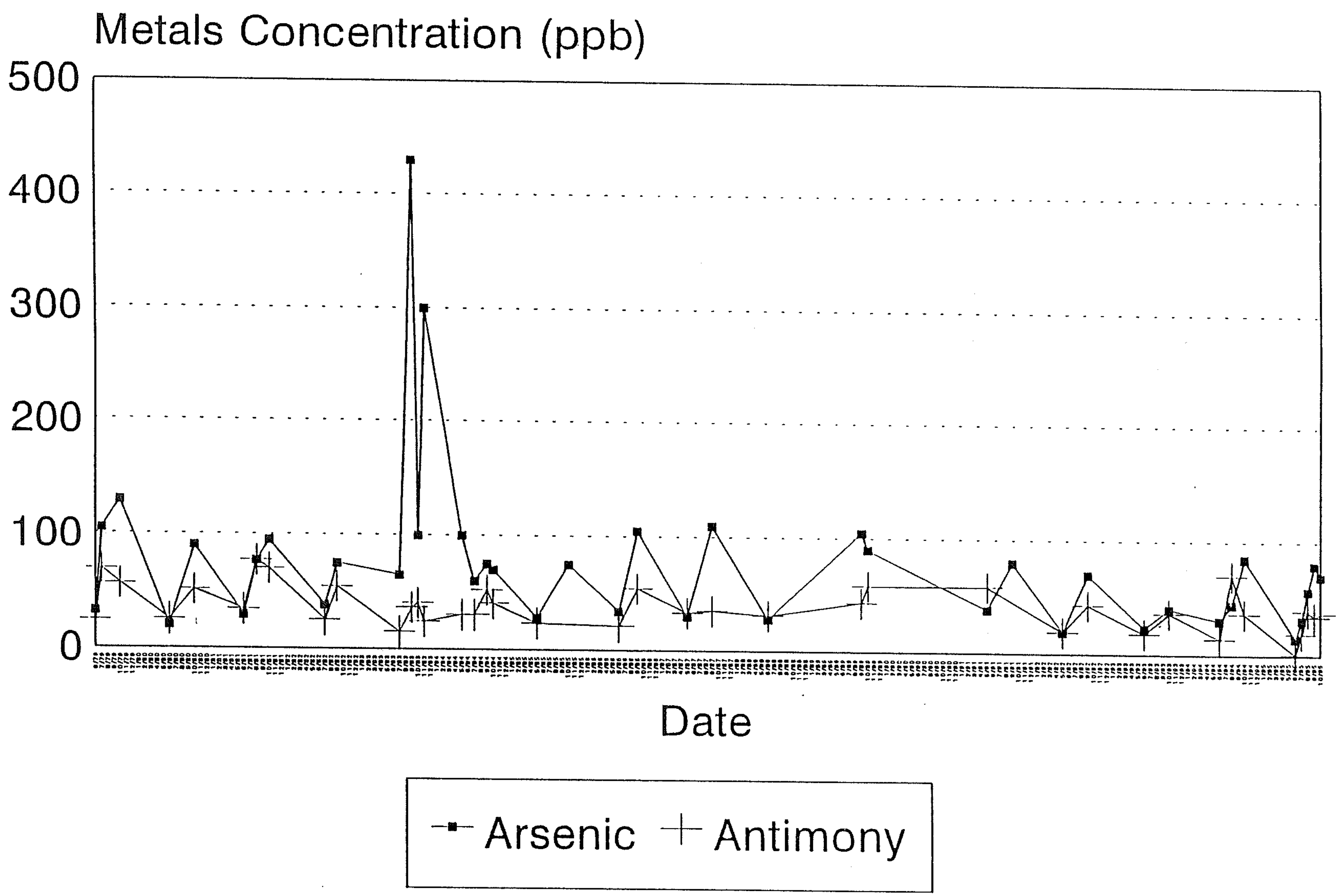


Figure 13

Total arsenic concentrations on the EFSFSR, although not high enough to cause chronic effects in cold water biota, were ten (10) to sixty (60) times higher than background concentrations. Total arsenic concentrations consistently increase towards the downstream stations which indicates a cumulative effect of various activities from the headwaters of the EFSFSR and Meadow Creek through Station 2040314 immediately below the mines. Never-the-less, it appears that the trend in total arsenic concentrations has decreased since 1984. This decrease may be the direct result of several factors: 1) Increased use and modifications of best management practices has reduced arsenic laden sediment production and delivery; 2) Reclamation of the Homestake Pit and Dump, Bradley Pit and Dump, old smelter

Most metal concentrations at reference Station 2040320 (Meadow Creek above Diversion Figure 14) hovered at or below the detection limits. The exceptions to this were iron and zinc. Iron varied widely, exhibited three extraordinary spikes in 1982 through 1984, and had an average value of about 100 ug/l. Zinc did not vary greatly but exhibited spikes in 1983 and 1984 which coincided with those spikes in iron. The cause for the spikes was most likely due to flushing of iron and zinc oxides which accumulated on rocks and in sediment above the mean water marked during the high flow period. These spikes are consistent with spikes found at other stations during the same periods. Overall, background concentrations of metals at the Meadow Creek reference station are well below concentrations which cause chronic effects in aquatic biota. Hardness and pH, at Station 2030320, averaged 31.5 mg/l as $CaCO_3$ and 7.7 s.u. respectively, which are consistent with that which would be expected of waters passing through the slightly basic granodiorites of the Meadow Creek headwaters.

Water quality Stations 2040584 on the Meadow Creek Pond next to Spent Ore Pile and Station 2040585 in the old Meadow Creek channel adjacent to the Spent Ore Pile were established to monitor the influence of the Bradley Tailings and spent ore on Meadow Creek. Subsequent to implementation of the 106 Removal Action, Station 2040584 has been moved headward in the valley above the restraining dike, whilst Station 2040585 has been moved downstream in the old channel. Analyses focused on arsenic, antimony, iron and cyanide (both total and WAD). These contaminants have historically reached concentrations which will cause chronic effects in cold water biota, and have intermittently reached concentrations which will cause acute effects in cold water biota. Spikes in 1991 and 1993 may be indicative of longer periods of acute concentrations of cyanide and arsenic in the Meadow Creek Pond and Old Channel. The cause of these concentration was almost certainly the leaching of the historic Bradley Mill and Smelter tailings as precipitation, process waste water and spring water came into contact with the tailings in the Meadow Creek Drainage. Curtailment of land application processes and below normal amounts of precipitation in 1994 and 1995 may be what has caused significant decreases in contaminant concentrations of metals in the Meadow Creek Pond. In September of 1995, however, arsenic levels spiked sharply which was most likely a result of significant land moving and site reconstruction, for the 106 Removal Action, which resuspended some of the Bradley tailings. This spike was not reflected in downstream stations.

Arsenic and Antimony Concentrations

Meadow Creek Above Diversion

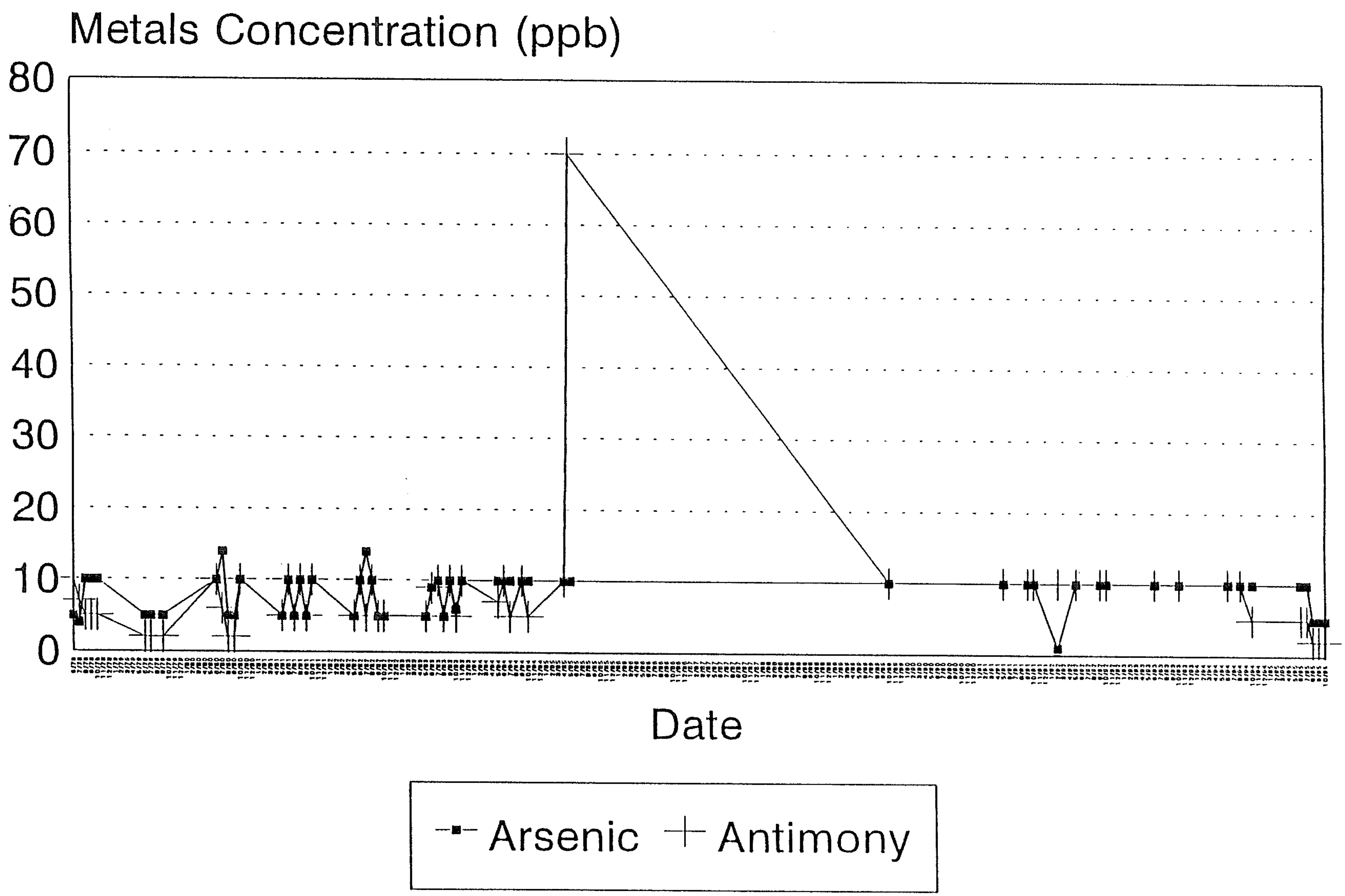


Figure 14

Arsenic and Antimony Concentrations

Meadow Creek Below Keyway

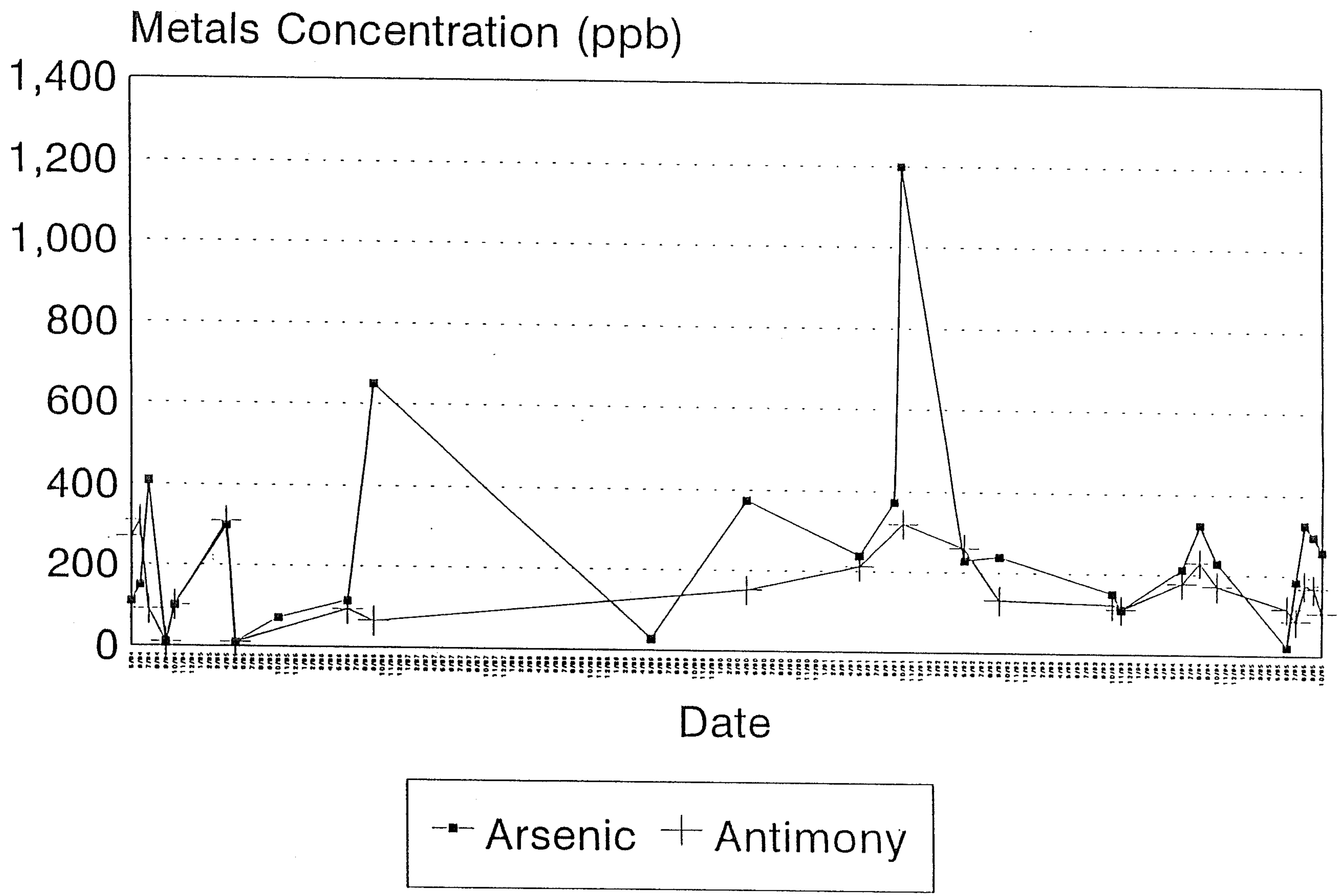


Figure 15

With the exception of the years 1987 and 1988 Station 2040368 (Meadow Creek channel below Keyway (Figure 15) has been continuously monitored. Although concentrations of cyanide have periodically reached levels which may cause chronic effects in cold water biota only arsenic is consistently present in concentrations which would be expected to cause chronic or acute reactions in cold water biota (EPA 1986). Designs are being completed for biological reduction of metals concentrated in effluent from the waste disposal site. It is anticipated that major modifications in water management and attenuation of metals through biologic reduction will result in substantial reduction in the net loading of metals and total suspended solids from the area that drains through the old Meadow Creek channel into the diverted uncontaminated Meadow Creek.

At Station 2040322, on Meadow Creek below the Diversion (Figure 16), both total arsenic and cyanide concentrations peaked in 1983, 1984, 1990 and 1991 at concentrations which could be expected to cause chronic or acute effects in cold water biota. Since 1991, however, contaminant concentrations, particularly for arsenic and antimony, have been substantially reduced to below concentrations which could be expected to cause chronic or acute effects in cold water biota. Arsenic and cyanide concentrations at Station 2040322 although two to seven times those of the reference site, Station 2040320, are well below those at Station 2040368 below the Keyway. These lower concentrations are most likely due to dilution of the contaminated flow from the Old Meadow Creek Channel by the uncontaminated flow through the Meadow Creek Diversion. Hardness and pH at Station 2040322 averaged 54.9 mg/l (as $CaCO_3$) and 7.6 s.u., respectively.

At Station 2040319 (Meadow Creek at Mouth Figure 17) total arsenic concentrations were usually below that which would be expected to cause chronic effects in cold water biota, but have peaked above concentrations which would be expected to cause chronic effects in cold water biota standard in 1993. Furthermore, it should be noted that total arsenic concentrations at 2040319 are nearly twice those at 2040322. Never-the-less, data indicates that there are substantial reductions in metals concentrations over the last ten (10) years. This may indicate that although modifications of ore processing facilities along the lower section of Meadow Creek have resulted in a reduction of metals concentrations, metals loading from historical mine wastes continues and results in a cumulative effect on cold water biota in the lower Meadow Creek area. Hardness and ph at Station 2040319 averaged 35.2 mg/l (as $CaCO_3$) and 7.7 s.u., respectively.

Historically, Garnet Creek has had very high concentrations of metals, particularly arsenic and antimony. Since 1988 Station 2040318 on Garnet Creek above the confluence with the EFSFSR and Station 2040323 on Garnet Creek above the contemporaneous workings were monitored. With the development of the Garnet Creek Pit in 1995, a third station was added to monitor Garnet Creek above the Garnet Creek Pit. Trends in the data for the two lower sites indicate very high arsenic concentrations which averaged between 100 and 150 ppb. This contrasts sharply with data from the upper site where concentrations average 32 ppb arsenic. Although there is a very limited data set for the upper site, the data sets indicate that the high metals

Arsenic and Antimony Concentrations

Meadow Creek Below Diversion

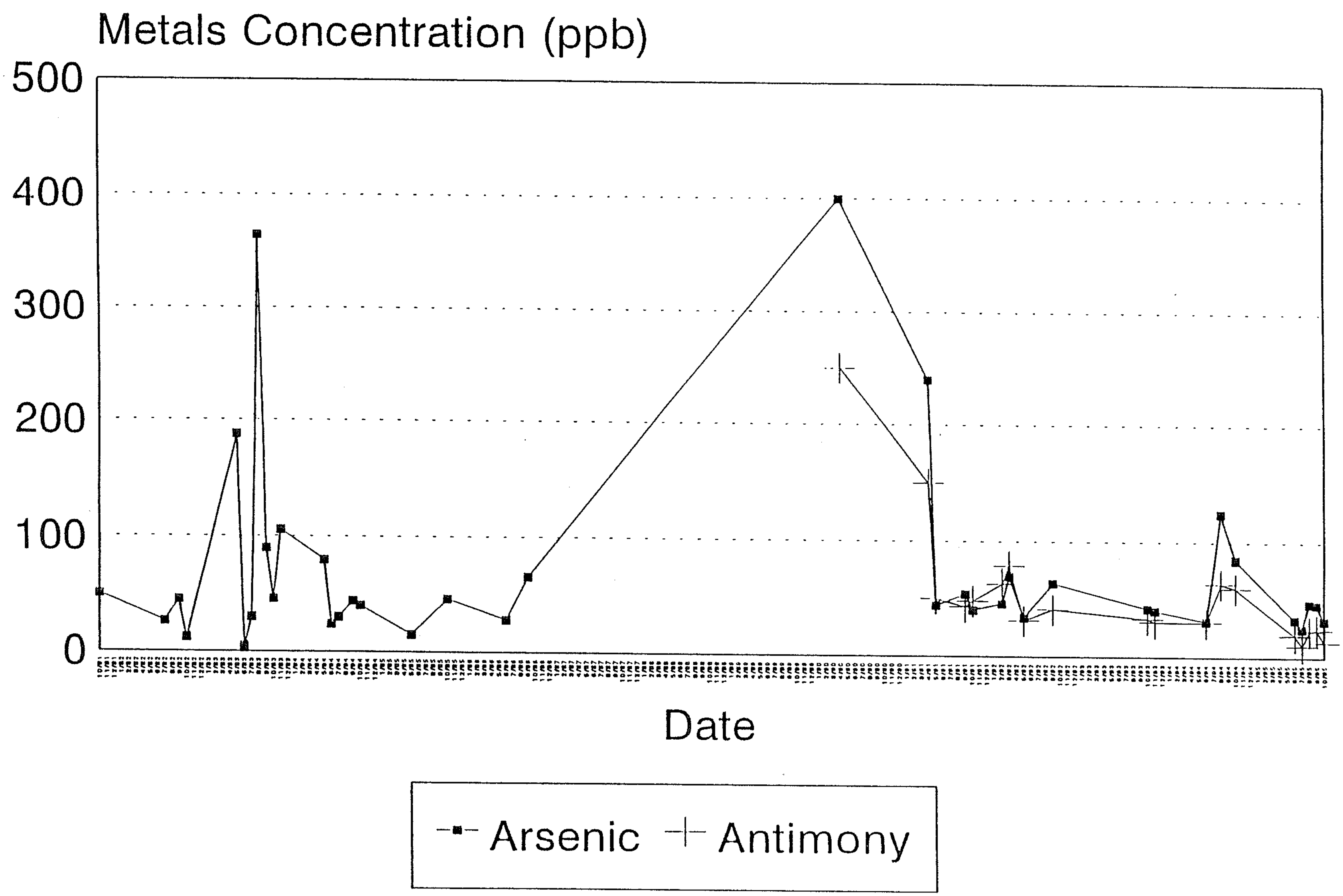


Figure 16

Arsenic and Antimony Concentrations

Meadow Creek at Mouth

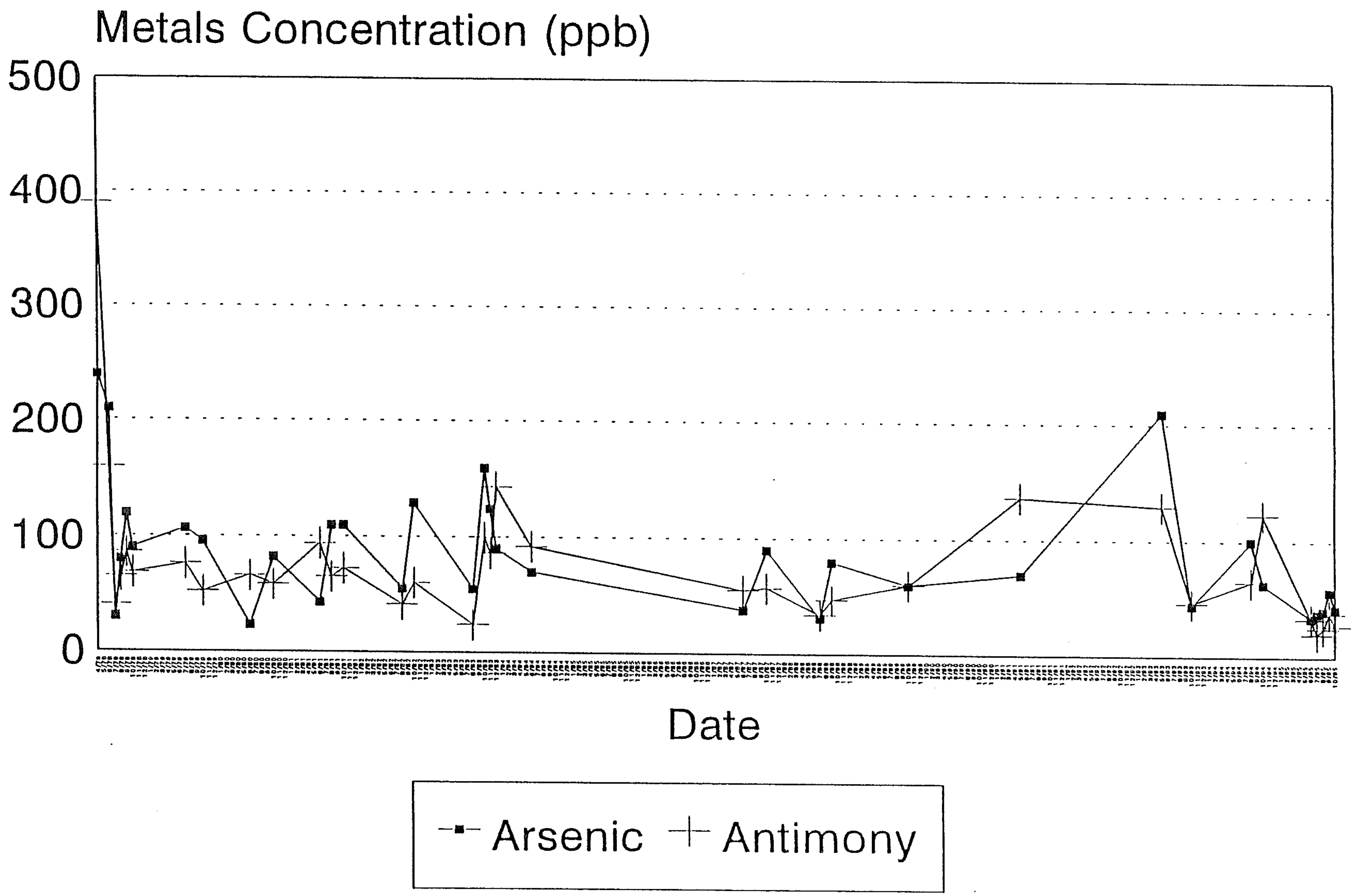


Figure 17

Arsenic and Antimony Concentrations

Lower Garnet Creek

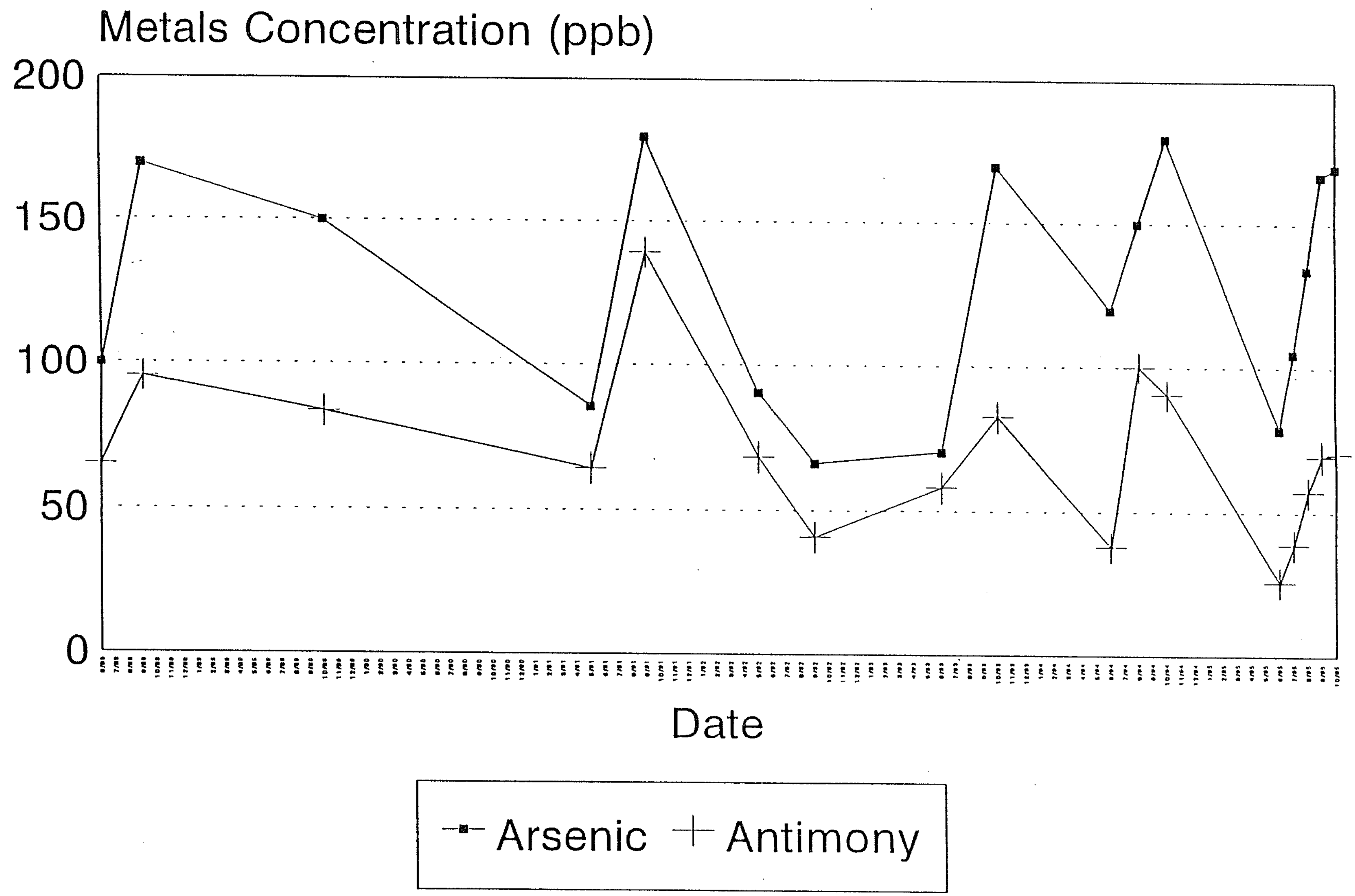


Figure 18

concentrations are directly related to the mineral zone through which Garnet Creek flows and which is perhaps more heavily mineralized with arsenic compounds below the upper site than above. Because of the aerial and volumetric extent of the mineral zone, it is likely that Garnet Creek has and will continue to be a major natural source of arsenic and antimony for the EFSFSR.

Data has been collected from Station 2040321 on Lower Midnight Creek (Figure 19) above the confluence with the EFSFSR since 1988. Although significantly lower than Garnet Creek, metals concentrations, particularly arsenic and antimony, are very high when compared to either those at the reference sites on the EFSFSR, Meadow Creek or Sugar Creek. This data would indicate, therefore, that like Garnet Creek, Midnight Creek flows through a mineralized area that contains high concentrations of arsenic and antimony compounds. The Midnight Creek Pit was developed and constructed in 1992, it was subsequently reclaimed in 1992 (Mitchell, 1992). Coincidental to the development of the Midnight Pit was a peak in arsenic concentrations which were only slightly higher than previous data. Subsequently, arsenic levels dropped below average concentrations and again rose sharply. Due to the dramatic fluctuations in metals concentrations from 1992 to 1995 a trend analysis may be pointless. Arsenic and antimony concentrations are anticipated, however, to continue to fluctuate but remain well below concentrations which would be expected to cause chronic effects in aquatic organisms.

Water quality monitoring Station 2040580, Sugar Creek below Cinnabar Creek, Station 2040581, Sugar Creek above Cinnabar Creek, and Station 2040582, Cinnabar Creek above the confluence with Sugar Creek, have been monitored since 1993. During that interim, no significant concentrations of any metals or trends have been detected. Data for mercury concentrations at these sites are near detection limits, except on Cinnabar Creek on June 2, 1993. This would appear to contradict macroinvertebrate tissue analyses for samples collected at Station 2040309. Water chemistry detection limits, however, are in the range of five (5) to ten (10) parts per billion (ppb), whereas mercury concentrations which are susceptible to bioaccumulations may be in the ten to forty nanogram per liter range (10-40 ng/l = 0.010-0.040 ppb) (Wiener, 1995). Therefore, it is likely that the analyses of macroinvertebrate tissue from Station 2040309 is correct and does not contradict the water chemistry data at the stations located near the confluence of Cinnabar Creek and Sugar Creek. Hardness and pH at these stations averages 38.5 mg/l (as $CaCO_3$) and 8.0 s.u., respectively.

Station 2040309 was established on Sugar Creek above West End Creek (Figure 20) as a reference site in the spring of 1983. Metals concentrations at Station 2040309 (Sugar Creek above West End Creek) have, in general, trended just slightly above detection limits. Exceptions to this trend occurred during the high water years of 1983 and 1984 at which time spikes occurred in analyses for total arsenic, total antimony, and total zinc. These spikes, which have not been observed since, may have resulted from erosion of mine dumps at the Cinnabar Mine which is upstream from the station (Clark and Lappin 1984). Subsequent to the events

Arsenic and Antimony Concentrations

Lower Midnight Creek

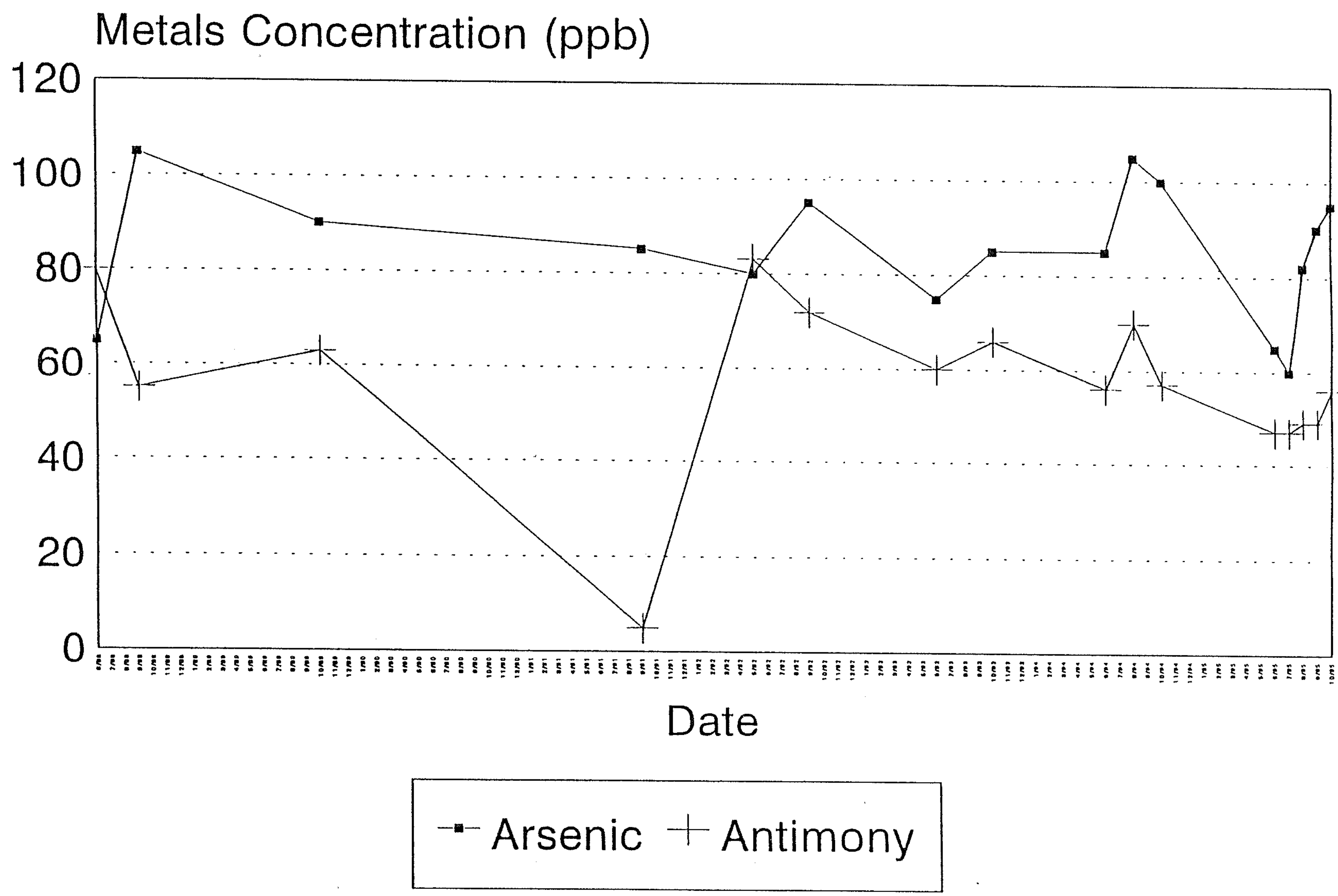


Figure 19

Arsenic and Antimony Concentrations

Sugar Creek Above West End Creek

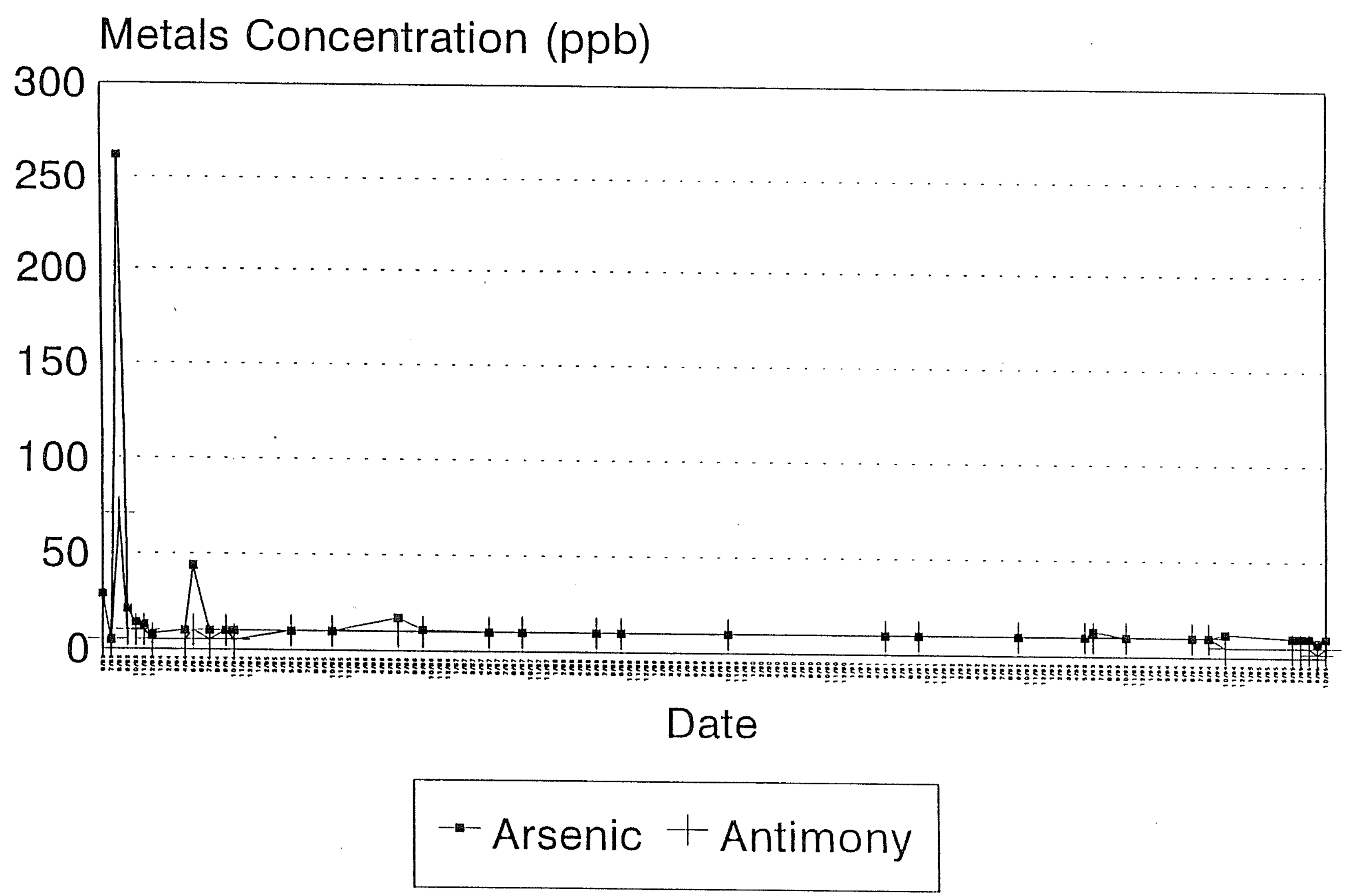


Figure 20

noted, metals concentrations have dropped to detection limits. Hardness and pH average 44.8 mg/l (as $CaCO_3$) and 7.6 s.u., respectively.

Metals concentrations at Station 2040307 (Sugar Creek below West End Creek Figure 21) are slightly higher than and fluctuate more than metals concentrations above West End Creek. These fluctuations in metals concentrations have often peaked at nearly twice the laboratory detection. These fluctuations are dissimilar from those at Station 2040309, and may be indicative of seasonal influences by West End Creek. In general metals concentrations are well below that which may be expected to cause chronic effects in cold water biota. This would indicate that there is are only minor contributions of total metals to Sugar Creek from mining activities in West End Creek.

Station 2040316 was established on Sugar Creek at the bridge to the mines (Figure 22) to evaluate the cumulative effects, if any, of operations at West End and the historic workings in the Homestake Pit and Bradley Dump areas. Although monitoring was rather sporadic at Station 2040316 through the 1980s, data collected during the 1980s and the intensive monitoring during the 1990s indicates that no major changes, for the better or worse, are occurring in metals concentrations. Arsenic concentrations peak at nearly double detection limits, and are consistently higher than those concentrations found at Station 2040307. Data suggests that although there are significant contributions of metals to Sugar Creek between Station 2040307 and Station 2040316, metals concentrations do not approach those which would be expected to cause chronic effects in cold water biota.

Station 2040317 (Figure 23) was established on West End Creek above the confluence with Sugar Creek to monitor contaminant loading due to development and operation of the pits in the West End subwatershed. Metals concentrations in West End Creek were similar to those in Midnight Creek and Garnet Creek in that they were very high relative to the reference sites on the EFSFSR, Meadow Creek, and Sugar Creek. Although concentrations were very high relative to the reference sites they do not approach concentrations which would be expected to adversely impact the aquatic community. Furthermore, although data is sporadic for West End Creek it indicates that metals loadings fluctuate in correspondence to seasonal runoff events. In spite of fluctuations, the mean metals concentrations appear to be rather steady, and it is doubtful that any changes will be noted in the trend until the mine facilities are reclaimed stabilized and revegetated.

Metals concentrations appear to be decreasing since 1987 when extensive BMP implementation began and as both historic and contemporaneous mining operations have been reclaimed. There are several stream segments which exhibit notably high metals concentrations and these segments, particularly Meadow Creek below the Meadow Creek Pond and the EFSFSR below the Glory Hole have impaired aquatic communities. Arsenic and antimony are undoubtedly the metals in highest concentrations are perhaps the most notably detrimental to aquatic communities. The trace metals cadmium, copper, mercury, selenium, and zinc concentrations are more often than not hovering at or below detections limits. This does not, however, mean that they are not present, merely that laboratory analyses are restricted by technology.

Arsenic and Antimony Concentrations

Sugar Creek Below West End Creek

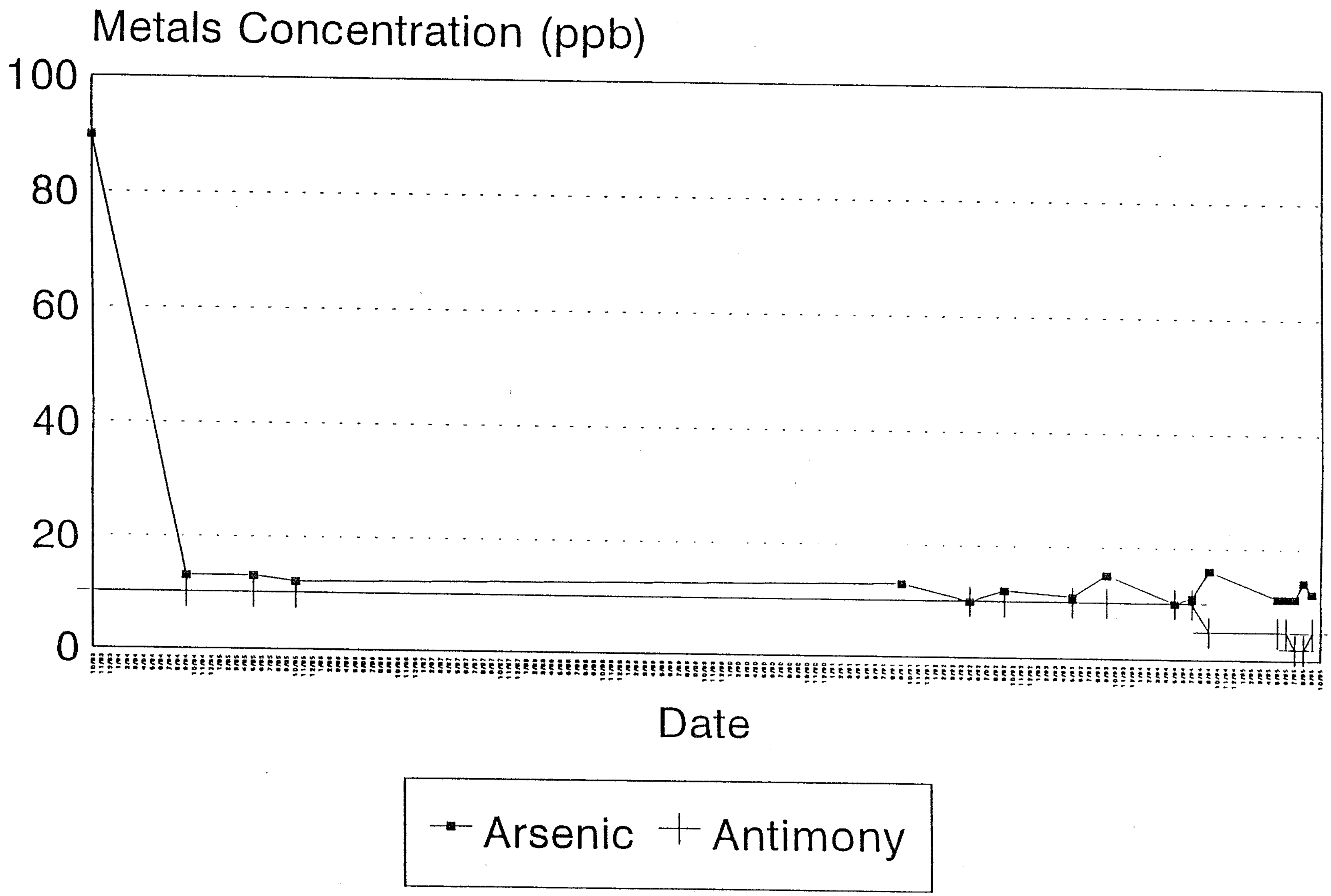


Figure 21

Arsenic and Antimony Concentrations

Sugar Creek At Bridge To Mines

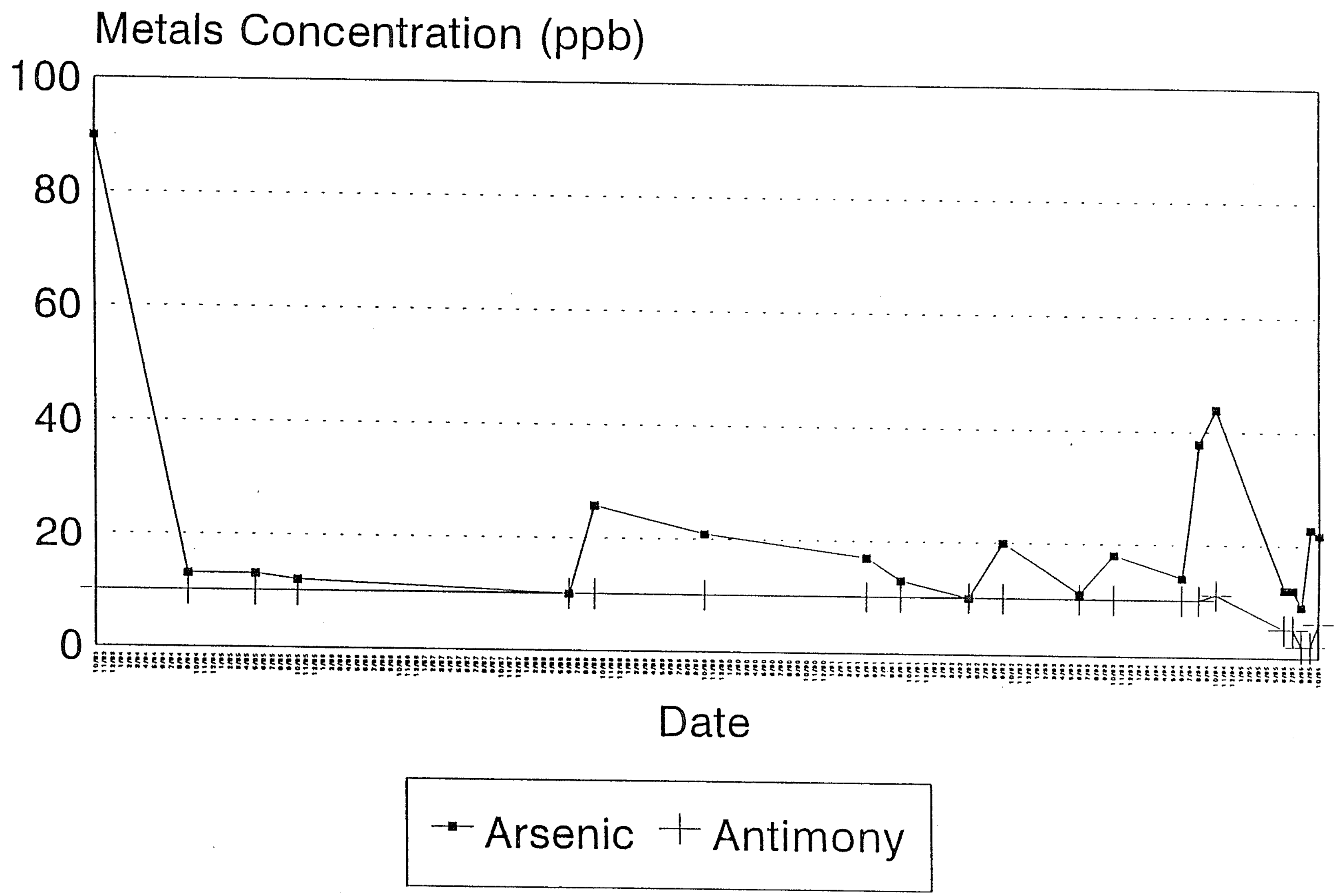


Figure 22

Arsenic and Antimony Concentrations

Lower West End Creek

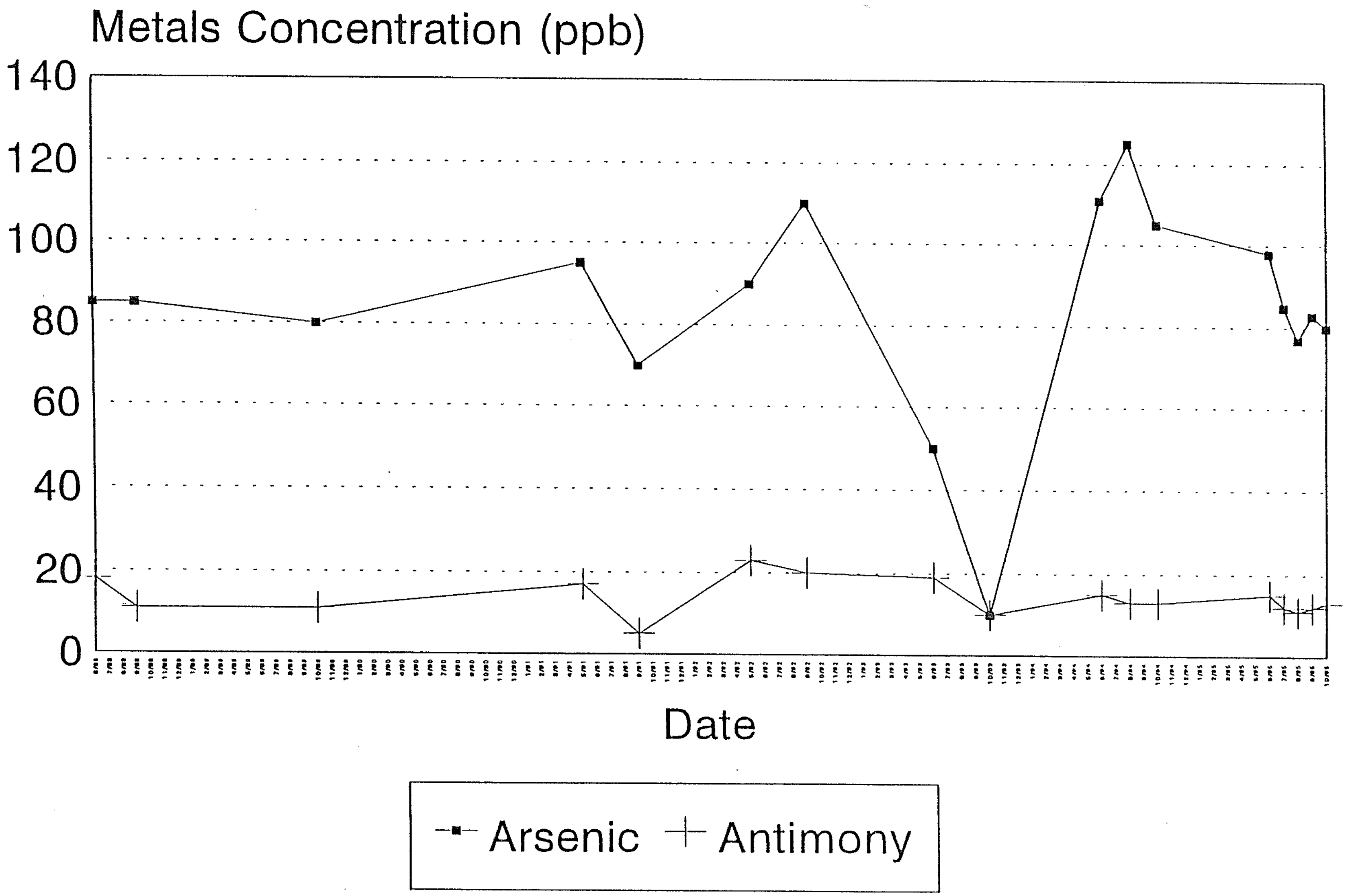


Figure 23

CONCLUSIONS

Data from fine sediment deposition, macroinvertebrate, and chemical analyses of fine sediment, algae, fish tissue, macroinvertebrates tissue, and water are correlative and support several conclusions. These conclusions include:

1) Although several of the metals parameters measured in the water column are consistently at or below detection limits, they are found in significant concentrations in fine sediment, vegetation, fish and macroinvertebrate tissue.

2) Increased use and modifications of best management practices have significantly reduced production and delivery of heavy metal laden sediments;

3) Ongoing reclamation of recent and historical mine facilities has increased metals attenuation by plants and soils, and also reduced production and delivery of arsenic laden sediment;

4) Concentrations of arsenic and cyanide, which are sufficient to cause chronic or acute effects in cold water biota, persist in Meadow Creek in proximity to the Meadow Creek Pond and Old Meadow Creek Channel;

5) Concentrations of arsenic and possibly other heavy metals have caused chronic effects resulting in impaired aquatic communities in the EFSFSR particularly below the Glory Hole.

6) Periodic discharges from active mine facilities and ongoing discharges from historic tailings have caused acute and/or chronic reactions in macroinvertebrates which have resulted in impaired communities in Meadow Creek, and the EFSFSR. These communities are, however, rebounding, and may reach their natural biotic integrity if water quality and habitat continue to improve; and

7) Continued improvements in best management practices, which tend to be low maintenance or self-sustaining will result in long term load reductions regardless of the continuation of mineral development and production;

RECOMMENDATIONS

If total cadmium, total copper, total lead, total mercury, total selenium and total zinc continue to hover at or below detection limits during the 1996 monitoring season, they should be dropped from analyses of water chemistry for surface water samples. These parameters should be retained for all ground water chemistry and tissue analyses.

A correlation has been attempted between Weak Acid Dissociable (WAD) Cyanide and Total Cyanide in surface and groundwater samples. If a correlation can be developed, total analyses will be dropped from ambient water quality monitoring in favor of WAD analyses. This recommendation should not be construed as an override to any federal or state permit requirements, particularly those defined by the "Rules Governing: Ore Processing by Cyanidation" as administered by DEQ.

Data for cobble embeddedness, free matrix, macroinvertebrate, and chemical surveys of fine sediment, algae, fish tissue, macroinvertebrate tissue and water must continue to be collected. In order to properly maintain trend monitoring, stations must be sampled at least monthly for water chemistry and flow. At a minimum, the ten (10) macroinvertebrate stations need to be maintained in order to correlate impairment of macroinvertebrates with pollution sources. In order to obtain additional information during fine sediment surveys, sediment must be collected at least once for chemical analysis. These changes in monitoring will improve the quality and usefulness of the information.

Increased use and modifications of best management practices and ongoing reclamation of recent and historical mine facilities has increased metals attenuation by plants and soils, and reduced production and delivery of arsenic laden sediment to surface waters.

Removal and remedial actions within the Meadow Creek area must be maintained in order to assure that sediment stabilization, the stream substrate and riparian habitat can evolve and transform at more natural rates.

Plans will be completed and implemented to stabilize the historic damages caused by and which persist as a result of a failure of the hydroelectric dam in Blowout Creek (East Fork of Meadow Creek).

Plans will be finalized and implemented for final closure and reclamation of Hecla's ore processing facility. Final closure should incorporate water management.

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APPENDICES

EFSF	Salmon	River	above	Meadow	Creek					
DATE FROM TO	FUNCTION	VALUE	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
78/06/06	Jun−78	Jun−78	10	4			460			
78/07/18	Jul−78	Jul−78	8	4			50			
78/08/15	Aug−78	Aug−78	20	5			30			
78/09/04	Sep−78	Sep−78	10	5			20			
78/10/10	Oct−78	Oct−78	10	5			30			
79/06/01	Jun−79	Jun−79	6	2			50			
79/07/27	Jul−79	Jul−79	10	2			60			
79/09/10	Sep−79	Sep−79	11	2			40			
79/10/24	Oct−79	Oct−79	10	2			50			
80/07/30	Jul−80	Jul−80	7	2			60			
80/10/15	Oct−80	Oct−80	13	2			20			
81/05/21	May−81	May−81	5	5			30			
81/07/08	Jul−81	Jul−81	5	5			60			
81/09/17	Sep−81	Sep−81	5	5			40			
81/10/19	Oct−81	Oct−81	10	5			50			
81/10/20	Oct−81	Oct−81	8	5			150			
82/06/16	Jun−82	Jun−82	7	5			250			
82/07/21	Jul−82	Jul−82	7	5			150			
82/07/23	Jul−82	Jul−82	6	5			50			
82/09/23	Sep−82	Sep−82	60	41			160			
83/06/10	Jun−83	Jun−83	6	5			90			
83/07/21	Jul−83	Jul−83	26	10			70			
83/07/28	Jul−83	Jul−83	15	7			70			
83/09/09	Sep−83	Sep−83	5	5			70			
83/09/30	Sep−83	Sep−83	5	5			70			
83/10/13	Oct−83	Oct−83	9	5			60			
83/11/04	Nov−83	Nov−83	13	5			60			
83/11/29	Nov−83	Nov−83	18	5			50			
84/05/23	May−84	May−84	10	5			180			
84/05/31	May−84	May−84	10	10			660			
84/07/28	Jul−84	Jul−84	10	5			90			
84/09/27	Sep−84	Sep−84	10	5			105			
84/10/24	Oct−84	Oct−84	10	5			120			
85/05/21	May−85	May−85	10	5			200			
85/10/22	Oct−85	Oct−85	10	5			280			
86/06/05	Jun−86	Jun−86	10	10			360			
86/09/17	Sep−86	Sep−86	10	10			225			
87/05/06	May−87	May−87	10	10			90			
87/09/23	Sep−87	Sep−87	10	10			60			
87/09/23	Sep−87	Sep−87	10	10			60			
88/06/09	Jun−88	Jun−88	10	10		10	30			2
89/10/25	Oct−89	Oct−89	10	10		10	100	0.5		3
91/05/22	May−91	May−91	10	10		10	280	0.5		10
91/09/24	Sep−91	Sep−91	10		1	10	130	0.5		2
92/02/06	Feb−92	Feb−92	12			12	10	0.5		5
92/03/25	Mar−92	Mar−92	18	10		10	210	0.5		3
92/05/13	May−92	May−92	10	10			120			
92/09/23	Sep−92	Sep−92	10	10			80			2
93/06/02	Jun−93	Jun−93	10	10			65			5
93/10/25	Oct−93	Oct−93	11	10			50			5
94/06/06	Jun−94	Jun−94	10	10			90	0.5		5
94/08/10	Aug−94	Aug−94	10	10	1		30	0.5		5
94/10/18	Oct−94	Oct−94	15	10		10	60	0.5		5
95/06/15	Jun−95	Jun−95	10	5	1	20	360	0.5	5	85
95/07/13	Jul−95	Jul−95	10	5	1	20	110	0.5	5	5
95/08/27	Aug−95	Aug−95	13	2	0.5	10	30	0.2	5	1
95/09/15	Sep−95	Sep−95	13	5	1	20	50	0.5	5	14
95/10/16	Oct−95	Oct−95	13	5	1	20	50	0.5	5	14

EFSF	Salmon	River	above	Box	Culvert					
DATE FROM TO			ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
79/06/04	Jun-79	Jun-79	52	68			120			
79/07/30	Jul-79	Jul-79	65	54			110			
79/10/10	Oct-79	Oct-79	50	43			100			
80/06/20	Jun-80	Jun-80	15	38			70			
80/10/22	Oct-80	Oct-80	46	44			120			
81/06/23	Jun-81	Jun-81	32	32			100			
81/08/04	Aug-81	Aug-81	65	65			100			
81/10/20	Oct-81	Oct-81	45	45			200			
82/06/16	Jun-82	Jun-82	44	44			1080			
82/07/21	Jul-82	Jul-82	32	29			130			
82/07/23	Jul-82	Jul-82	22	35			100			
82/09/23	Sep-82	Sep-82	60	43			110			
82/10/28	Oct-82	Oct-82	72	47			168			
83/09/09	Sep-83	Sep-83	440	179			700			
83/10/13	Oct-83	Oct-83	95	48			850			
83/11/29	Nov-83	Nov-83	125	91			100			
84/05/23	May-84	May-84	180	208			1050			
84/07/18	Jul-84	Jul-84	40	20			150			
84/09/27	Sep-84	Sep-84	50	34			150			
84/10/24	Oct-84	Oct-84	60	40			230			
85/04/14	Apr-85	Apr-85	240	520						
85/05/21	May-85	May-85	19	33			340			
85/10/22	Oct-85	Oct-85	52				120			
86/06/05	Jun-86	Jun-86	26	39			540			
86/09/17	Sep-86	Sep-86	62	38			120			
87/05/06	May-87	May-87	25	42			160			
87/09/23	Sep-87	Sep-87	42	22			130			
88/06/09	Jun-88	Jun-88	21	23			90			
88/09/21	Sep-88	Sep-88	50	24			120			
89/10/25	Oct-89	Oct-89	42	38			200			
91/03/22	Mar-91	Mar-91	48	124			670			
91/04/09	Apr-91	Apr-91	82							
91/09/24	Sep-91	Sep-91	34		1	10	130	0.5		95
92/02/06	Feb-92	Feb-92	28				110			
92/02/07	Feb-92	Feb-92	28			10	110	0.5		8
92/03/24	Mar-92	Mar-92	45	91			190			
92/05/13	May-92	May-92	25	33			170			
92/09/23	Sep-92	Sep-92	29	30			100			23
93/05/25	May-93	May-93	26	46		10				72
93/06/02	Jun-93	Jun-93	24	36		10	310			72
93/10/25	Oct-93	Oct-93	29	30		190	150			5
93/11/12	Nov-93	Nov-93	40	30	1	10		0.5		5
94/06/06	Jun-94	Jun-94	25	25			140	0.5		5
94/08/10	Aug-94	Aug-94	34	32	1		120	0.5		10
94/10/20	Oct-94	Oct-94	36	30	1		170	0.5		10
95/06/14	Jun-95	Jun-95	22	20	1	20	230	0.5	5	5
95/07/13	Jul-95	Jul-95	48	62	1	20	850	0.5	5	12
95/08/28	Aug-95	Aug-95	27	12	0.5	10	110	0.2	5	2
95/09/18	Sep-95	Sep-95	36	21	0.5	10	110	0.2	5	10
95/10/16	Oct-95	Oct-95	27	18	1	20	140	0.5	5	16

EFSF	Salmon	River	at	USGS	Station					
DATE FROM TO			ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
88/06/09	Jun-88	Jun-88	21	23		10	90			6
89/10/25	Oct-89	Oct-89	42	38		10	200	0.9		2
91/03/22	Mar-91	Mar-91	48	124		10	670	0.5		10
91/04/09	Apr-91	Apr-91	90	232		10	813			15
91/09/24	Sep-91	Sep-91	34	87		10	140	0.5		2
92/02/06	Feb-92	Feb-92	28	70		10	110	0.5		3
92/03/24	Mar-92	Mar-92	45	91			190			3
92/05/13	May-92	May-92	25	33			170			
92/09/23	Sep-92	Sep-92	29	28			100			2
93/05/25	May-93	May-93	26	46			310			5
93/10/25	Oct-93	Oct-93	32	24			120			5
94/06/06	Jun-94	Jun-94	29	27			300	0.5		5
94/08/10	Aug-94	Aug-94	50	30	1		120	0.5		5
94/10/20	Oct-94	Oct-94	36	24		10	110	0.5		5
95/06/14	Jun-95	Jun-95	20	18	1	20	170	0.5	5	5
95/07/13	Jul-95	Jul-95	72	110	1	30	1620	0.5	5	76
95/08/28	Aug-95	Aug-95	24	13	0.5	10	110	0.2	5	1
95/09/18	Sep-95	Sep-95	37	22	0.5	10	120	0.2	5	1
95/10/18	Oct-95	Oct-95	27	16	1	20	160	0.5	5	16

EFSF	Salmon	River	Below	Garnet	Creek					
Date From To			ARSENIC AS, TOT UG/L	ANTIMONY SB, TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	01045 FE, TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
79/06/01	Jun–79	Jun–79	35	60			260			
79/06/04	Jun–79	Jun–79	40	65			100			
79/07/27	Jul–79	Jul–79	120	98			280			
79/07/30	Jul–79	Jul–79	63	66			130			
79/09/10	Sep–79	Sep–79	120	64			320			
79/10/10	Oct–79	Oct–79	46	55			100			
79/10/24	Oct–79	Oct–79	76	96			270			
80/06/20	Jun–80	Jun–80	17	40			120			
80/07/30	Jul–80	Jul–80	102	73			300			
80/10/15	Oct–80	Oct–80	90	50			210			
80/10/22	Oct–80	Oct–80	48	50			140			
81/05/21	May–81	May–81	128	1090			30			
81/06/23	Jun–81	Jun–81	29	64			110			
81/07/08	Jul–81	Jul–81	5	120			290			
81/08/04	Aug–81	Aug–81	65	84			120			
81/07/23	Jul–81	Jul–81	28	55			120			
82/09/23	Sep–82	Sep–82	62	49			90			
83/07/21	Jul–83	Jul–83	60	11			100			
83/09/09	Sep–83	Sep–83	150	79			50			
83/10/08	Oct–83	Oct–83	74	49			270			
83/10/13	Oct–83	Oct–83	160	93			3740			
83/11/29	Nov–83	Nov–83	65	51			180			
84/05/23	May–84	May–84	180	206			830			
84/05/31	May–84	May–84	42	66			1450			
84/07/18	Jul–84	Jul–84	40	20			120			
84/09/27	Sep–84	Sep–84	50	37			150			
84/10/24	Oct–84	Oct–84	60	40			150			
85/05/21	May–85	May–85	25	34			370			
85/10/22	Oct–85	Oct–85	44	60			120			
86/06/05	Jun–86	Jun–86	21	30			750			
86/09/17	Sep–86	Sep–86	76	90			130			
91/05/22	May–91	May–91	62	75		10	730	0.5		10
91/09/27	Sep–91	Sep–91	31	55		1	10	0.5		10
92/09/23	Sep–92	Sep–92	30	34			100			
92/05/13	May–92	May–92	23	38			150			
92/09/23	Sep–92	Sep–92	30	34			100			2
93/10/25	Oct–93	Oct–93	40	35			270			16
94/06/06	Jun–94	Jun–94	24	17			0.5			5
94/08/10	Aug–94	Aug–94	48	26	1		220	0.5		5
94/10/18	Oct–94	Oct–94	34	30		10	130	0.5		5
95/06/14	Jun–95	Jun–95	22	24	1	20	280	0.5	5	5
95/07/13	Jul–95	Jul–95	30	24	1	20	230	0.5	5	5
95/08/27	Aug–95	Aug–95	30	23	0.5	10	130	0.2		1
95/09/15	Sep–95	Sep–95	36	24	0.5	10	110	0.2	5	1
95/10/18	Oct–95	Oct–95	33	21	1	20	140	0.5	5	14

EFSF	Salmon	River	Below	Midnight	Creek					
DATE FROM TO	Function	Value	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
92/05/13	May−92	May−92	36	52			290			
92/09/23	Sep−92	Sep−92	48	51			70			2
93/06/02	Jun−93	Jun−93	23	27		10				5
93/10/25	Oct−93	Oct−93	38	42			210			5
94/06/06	Jun−94	Jun−94	25	22			190			5
94/08/10	Aug−94	Aug−94	36	44	1		90	0.5		597
95/06/14	Jun−95	Jun−95	30	27	1	30	330	0.5	5	34
95/08/28	Aug−95	Aug−95	41	34	0.5	10	140	0.2	5	7
95/09/14	Sep−95	Sep−95	44	30	0.5	10	80	0.2	5	1
95/10/16	Oct−95	Oct−95	37	29	1	20	140	0.5	5	17

EFSF	Salmon	River	Below	Sugar	Creek					
DATE FROM TO	FUNCTION	VALUE	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
79/06/04	Jun-79	Jun-79	32	24			50			
79/07/30	Jul-79	Jul-79	105	69			110			
79/10/10	Oct-79	Oct-79	130	56			130			
80/06/20	Jun-80	Jun-80	20	25			60			
80/10/22	Oct-80	Oct-80	90	51			120			
81/06/23	Jun-81	Jun-81	29	34			90			
81/08/04	Aug-81	Aug-81	77	77			110			
81/10/20	Oct-81	Oct-81	95	70			160			
82/07/21	Jul-82	Jul-82	38	25			120			
82/09/23	Sep-82	Sep-82	75	54			140			
83/07/28	Jul-83	Jul-83	65	15			1040			
83/09/30	Sep-83	Sep-83	430	36			5010			
83/10/13	Oct-83	Oct-83	100	40			940			
83/11/04	Nov-83	Nov-83	300	24			19500			
84/05/23	May-84	May-84	100	30			510			
84/05/31	May-84	May-84	95	10			7300			
84/07/18	Jul-84	Jul-84	60	30			160			
84/09/07	Sep-84	Sep-84	75	52			270			
84/10/24	Oct-84	Oct-84	70	40			210			
85/05/21	May-85	May-85	28	23			180			
85/10/22	Oct-85	Oct-85	75				130			
86/06/05	Jun-86	Jun-86	34	21			1030			
86/09/17	Sep-86	Sep-86	105	54			130			
87/05/06	May-87	May-87	30	33			170			
87/05/06	May-87	May-87	27	35			170			
87/09/23	Sep-87	Sep-87	110	36			180			
87/09/23	Sep-87	Sep-87	110	35			190			
88/06/09	Jun-88	Jun-88	28	31			110	0.5		
89/09/21	Sep-89	Sep-89	105	43			150			
89/10/25	Oct-89	Oct-89	90	58			360	0.5		
89/10/25	Oct-89	Oct-89	80	65			360	0.7		
91/05/22	May-91	May-91	38	58		10	570	1.1		10
91/09/24	Sep-91	Sep-91	80		1	10	200	0.5		18
92/05/14	May-92	May-92	19	19			170			
92/09/23	Sep-92	Sep-92	70	43			160			2
93/06/02	Jun-93	Jun-93	23	18		10	155			10
93/10/25	Oct-93	Oct-93	40	36			150			26
94/06/06	Jun-94	Jun-94	30	14			30	0.5		16
94/08/10	Aug-94	Aug-94	44	70	1		140	0.5		5
94/10/18	Oct-94	Oct-94	85	36		10	140	0.5		5
95/06/14	Jun-95	Jun-95	15	1	1	20	590	0.5	5	5
95/07/13	Jul-95	Jul-95	31	19	1	20	190	0.5	5	5
95/08/28	Aug-95	Aug-95	57	39	0.5	10	120	0.2	5	1
95/09/14	Sep-95	Sep-95	80	34	0.5	10	240	0.2	5	2
95/10/16	Oct-95	Oct-95	70	37	1	20	520	0.5	5	20

EFSF	Meadow	Creek	Above	Diversion	2040320					
DATE FROM TO	Function	Value	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	IRON FE,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
78/06/06	Jun-78	Jun-78	5	10	120					
78/07/18	Jul-78	Jul-78	4	7	50					
78/08/15	Aug-78	Aug-78	10	5	110					
78/09/04	Sep-78	Sep-78	10	5	40					
78/10/10	Oct-78	Oct-78	10	5	120					
79/06/01	Jun-79	Jun-79	5	2	50					
79/07/27	Jul-79	Jul-79	5	2	100					
79/09/10	Sep-79	Sep-79	5	2	60					
80/06/20	Jun-80	Jun-80	10	10	10					
80/07/23	Jul-80	Jul-80	14	6	30					
80/07/30	Jul-80	Jul-80	5	2	50					
80/10/15	Oct-80	Oct-80	5	2	20					
80/10/22	Oct-80	Oct-80	10	10	70					
81/05/21	May-81	May-81	5	5	30					
81/06/23	Jun-81	Jun-81	10	10	20					
81/07/08	Jul-81	Jul-81	5	5	50					
81/08/04	Aug-81	Aug-81	10	10	10					
81/10/19	Oct-81	Oct-81	5	5	50					
81/10/20	Oct-81	Oct-81	10	10	10					
82/06/16	Jun-82	Jun-82	5	5	210					
82/07/21	Jul-82	Jul-82	10	10	20					
82/07/23	Jul-82	Jul-82	14	5	50					
82/09/23	Sep-82	Sep-82	10	10	10					
82/09/23	Sep-82	Sep-82	5	5	10					
82/10/28	Oct-82	Oct-82	5	5	69					
83/06/10	Jun-83	Jun-83	5	5	150					
83/07/21	Jul-83	Jul-83	9	9	80					
83/07/28	Jul-83	Jul-83	10	10	90					
83/09/09	Sep-83	Sep-83	5	5	90					
83/09/30	Sep-83	Sep-83	10	10	10					
83/10/08	Oct-83	Oct-83	6	5	80					
83/10/13	Oct-83	Oct-83	10	10	140					
83/11/04	Nov-83	Nov-83	10	12	350					
83/11/29	Nov-83	Nov-83	5	5	40					
84/05/23	May-84	May-84	10	7	140					
84/05/31	May-84	May-84	10	10	410					
84/07/18	Jul-84	Jul-84	10	5	110					
84/09/27	Sep-84	Sep-84	10	10	30					
84/10/24	Oct-84	Oct-84	10	5	140					
85/04/14	Apr-85	Apr-85	10	10	105					
85/05/21	May-85	May-85	10	70	70					
88/06/09	Jun-88	Jun-88	10	10	10		10			2
88/09/21	Sep-88	Sep-88	10	10	20		10			2
89/10/25	Oct-89	Oct-89	10	10	120		10			5
91/05/22	May-91	May-91	10	10	150		10			10
91/09/24	Sep-91	Sep-91	10	10	110		10	0.5		8
91/10/23	Oct-91	Oct-91	10	10	120					
92/02/06	Feb-92	Feb-92	1	10	10		10	0.5		12
92/05/13	May-92	May-92	10	10	60					
92/09/23	Sep-92	Sep-92	10	10	50					2
93/06/02	Jun-93	Jun-93	10	10	50		10			10
93/10/25	Oct-93	Oct-93	10	10	50					10
94/06/06	Jun-94	Jun-94	10	10	100		20	0.5		10
94/08/11	Aug-94	Aug-94	10	10	60	1		0.5		5
94/10/20	Oct-94	Oct-94	10	5	80		10	0.5		9
95/06/14	Jun-95	Jun-95	10	5	140	1	20	0.5	5	5
95/07/14	Jul-95	Jul-95	10	5	80	1	20	0.5	5	5
95/08/27	Aug-95	Aug-95	5	2	20	0.5	10	0.2	5	24
95/09/15	Sep-95	Sep-95	5	2	20	0.5	10	0.2	5	1
95/10/18	Oct-95	Oct-95	5	2	30	1	20	0.5	5	14

EFSFSR	Study	Meadow	Creek	Below	Keyway					
DATE FROM TO	FUNCTION	VALUE	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
84/05/23	May-84	May-84	110	270			520			
84/05/31	May-84	May-84	150	310			1090			
84/07/18	Jul-84	Jul-84	410	90			440			
84/09/27	Sep-84	Sep-84	10	10			30			
84/10/24	Oct-84	Oct-84	100	100			640			
85/04/14	Apr-85	Apr-85	300	310						
85/05/21	May-85	May-85	10	10			120			
85/10/22	Oct-85	Oct-85	70				320			
86/06/05	Jun-86	Jun-86	114	92			10			
86/09/17	Sep-86	Sep-86	650	64			530			
89/05/10	May-89	May-89	28			10	300	0.5		2
90/04/11	Apr-90	Apr-90	375	150			810			
91/05/22	May-91	May-91	240	212		10	710	2.6		9
91/09/24	Sep-91	Sep-91	375		1	10	1940	0.9		5
91/10/24	Oct-91	Oct-91	1200	320			6700			
92/05/13	May-92	May-92	230	260			420			
92/09/29	Sep-92	Sep-92	240	130			860			18
93/10/25	Oct-93	Oct-93	150	122		10				10
93/11/10	Nov-93	Nov-93	110	110	1	10		0.5		5
94/06/06	Jun-94	Jun-94	213	177			630	0.6		5
94/08/11	Aug-94	Aug-94	325	230	1		1170	0.5		5
94/10/20	Oct-94	Oct-94	230	170		10	890	0.5		12
95/06/14	Jun-95	Jun-95	21	115	1	30	610	0.5	5	50
95/07/14	Jul-95	Jul-95	185	85	1	20	590	0.5	5	10
95/08/27	Aug-95	Aug-95	327	175	0.5	10	1250	0.2	5	1
95/09/15	Sep-95	Sep-95	298	166	0.5	10	950	0.1	5	1
95/10/18	Oct-95	Oct-95	260	105	1	20	1070	0.5	5	14

EFSF	Study	Meadow	Creek	Below	Diversion					
Date	Function	Value	ARSENIC AS,TOT (UG/L)	ANTIMON. (UG/L)	CADMIUM CD,TOT (UG/L)	COPPER CU, TOT (UG/L)	IRON (UG/L)	MERCURY HG, TOT (UG/L)	SELENIUM SE, TOT (UG/L)	ZINC ZN. TOT (UG/L)
81/10/20	Oct-81	Oct-81	50							
82/07/21	Jul-82	Jul-82	26							
82/09/23	Sep-82	Sep-82	45							
82/10/28	Oct-82	Oct-82	12							
83/06/10	Jun-83	Jun-83	188							
83/07/21	Jul-83	Jul-83	5							
83/07/28	Jul-83	Jul-83	30							
83/09/09	Sep-83	Sep-83	364							
83/09/30	Sep-83	Sep-83	90							
83/10/08	Oct-83	Oct-83	46							
83/11/29	Nov-83	Nov-83	106							
84/05/23	May-84	May-84	80							
84/05/31	May-84	May-84	24							
84/07/18	Jul-84	Jul-84	30							
84/09/27	Sep-84	Sep-84	44							
84/10/24	Oct-84	Oct-84	40							
85/05/21	May-85	May-85	15							
85/10/22	Oct-85	Oct-85	46							
86/06/05	Jun-86	Jun-86	28							
86/09/17	Sep-86	Sep-86	66							
90/04/11	Apr-90	Apr-90	400	250			950			
91/04/09	Apr-91	Apr-91	240	150		10	805			16
91/05/22	May-91	May-91	44	50		10	660	0.5		10
91/09/24	Sep-91	Sep-91	54	43		10	240	0.5		2
91/10/23	Oct-91	Oct-91	40	48			250			
92/02/06	Feb-92	Feb-92	46	63		10	460	0.5		16
92/03/25	Mar-92	Mar-92	70	79			390			5
92/05/13	May-92	May-92	34	31			190			
92/09/23	Sep-92	Sep-92	64	41			290			2
93/10/23	Oct-93	Oct-93	42	33		10	210			5
93/11/10	Nov-93	Nov-93	40	30	1	10	200	0.5		5
94/06/06	Jun-94	Jun-94	31	30			190	0.5		5
94/08/11	Aug-94	Aug-94	125	64	1		370	0.5		5
94/10/18	Oct-94	Oct-94	85	60		10	440	0.5		5
95/06/14	Jun-95	Jun-95	33	19	1	30	170	0.5		
95/07/13	Jul-95	Jul-95	25	10	1	50	150	5	5	39
95/08/27	Aug-95	Aug-95	47	23	0.5	10	210	0.2	5	1
95/09/15	Sep-95	Sep-95	46	24	0.5	10	160	0.2	5	1
95/10/16	Oct-95	Oct-95	32	13	1	20	220	0.5	5	9

EFSF	Meadow	Creek	Above	EFSFSR						
DATE FROM TO	Function	Value	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/l
78/04/20	Apr-78	Apr-78	240	390			550			
78/06/06	Jun-78	Jun-78	210	160			2200			
78/07/18	Jul-78	Jul-78	30	40			260			
78/08/15	Aug-78	Aug-78	80	65			320			
78/09/04	Sep-78	Sep-78	120	86			250			
78/10/10	Oct-78	Oct-78	90	68			280			
79/07/30	Jul-79	Jul-79	107	76			330			
79/10/10	Oct-79	Oct-79	96	52			280			
80/06/20	Jun-80	Jun-80	23	66			130			
80/10/22	Oct-80	Oct-80	82	58			270			
81/06/23	Jun-81	Jun-81	43	94			230			
81/08/04	Aug-81	Aug-81	110	65			240			
81/10/20	Oct-81	Oct-81	110	72			360			
82/07/21	Jul-82	Jul-82	55	41			140			
82/09/23	Sep-82	Sep-82	130	60			230			
83/07/28	Jul-83	Jul-83	55	24			220			
83/09/30	Sep-83	Sep-83	160	100			2790			
83/10/13	Oct-83	Oct-83	125	86			580			
83/11/04	Nov-83	Nov-83	90	144			2510			
84/05/31	May-84	May-84	70	92			1710			
87/05/06	May-87	May-87	38	55			280			
87/09/23	Sep-87	Sep-87	90	57			280			
88/06/09	Jun-88	Jun-88	31	34		10	100			2
88/09/21	Sep-88	Sep-88	80	47		10	250	0.5		10
89/10/25	Oct-89	Oct-89	60	60		10	320	1.8		5
91/05/23	May-91	May-91	70	137		10	770	0.5		10
93/05/25	May-93	May-93	210	130		10	300			5
93/10/25	Oct-93	Oct-93	44	46		10	240			5
94/06/06	Jun-94	Jun-94	28	43			150			6
94/08/10	Aug-94	Aug-94	100	65	1		200	0.5		5
94/10/15	Oct-94	Oct-94	63	123		10	210	0.5		123
95/06/14	Jun-95	Jun-95	34	33	1	30	230	0.5	5	35
95/07/18	Jul-95	Jul-95	38	20	1	20	160	0.5	5	11
95/08/27	Aug-95	Aug-95	40	25	0.5	10	190	0.2	5	1
95/09/15	Sep-95	Sep-95	57	38	0.5	10	200	0.2	5	7
95/10/18	Oct-95	Oct-95	42	27	1	20	250	0.5	5	18

Sugar	Creek	Above	West	End	Creek					
DATE FROM TO	FUNCTION	VALUE	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
83/06/10	Jun-83	Jun-83	29	5			340			
83/07/21	Jul-83	Jul-83	5	5			40			
83/07/28	Jul-83	Jul-83	10	10			140			
83/09/09	Sep-83	Sep-83	262	71			270			
83/09/30	Sep-83	Sep-83	21	10			580			
83/10/08	Oct-83	Oct-83	18	5			50			
83/10/13	Oct-83	Oct-83	14	10			160			
83/11/04	Nov-83	Nov-83	13	10			870			
83/11/29	Nov-83	Nov-83	8	5			120			
84/05/23	May-84	May-84	10	5			400			
84/05/31	May-84	May-84	44	10			4890	7.4		
84/07/18	Jul-84	Jul-84	10	5			80			
84/09/27	Sep-84	Sep-84	10	10			20	0.5		
84/10/24	Oct-84	Oct-84	10	5			150			
85/05/21	May-85	May-85	10	10			250	0.8		
85/10/22	Oct-85	Oct-85	10	10			30			
86/06/05	Jun-86	Jun-86	17	10			1660			
86/09/17	Sep-86	Sep-86	11	10			10			
87/05/06	May-87	May-87	10	10			100			
87/09/23	Sep-87	Sep-87	10	10			20			
88/06/09	Jun-88	Jun-88	10	10			90	0.5		
88/09/21	Sep-88	Sep-88	10	10			10			
89/10/25	Oct-89	Oct-89	10	10			80	0.5		
91/05/22	May-91	May-91	10	10		10	490	1.1		10
91/09/24	Sep-91	Sep-91	10	10	1	10	50	0.5		21
92/05/13	May-92	May-92	10	10			80			
92/09/23	Sep-92	Sep-92	10	10			20			27
93/05/13	May-93	May-93	10	10		10	50			10
93/06/02	Jun-93	Jun-93	13	10		10	10			10
93/10/25	Oct-93	Oct-93	10	10			50			6
94/06/06	Jun-94	Jun-94	10	10			100	0.5		5
94/08/10	Aug-94	Aug-94	10	10	1		20	0.5		5
94/10/18	Oct-94	Oct-94	12	5		10	30	0.5		5
95/06/14	Jun-95	Jun-95	10	5	1	20	250	0.5	5	5
95/07/13	Jul-95	Jul-95	10	5	1	20	80	0.5	5	5
95/08/28	Aug-95	Aug-95	10	5	0.5	10	10	0.2	5	1
95/09/14	Sep-95	Sep-95	8	2	0.5	10	10	0.2	5	1
95/10/16	Oct-95	Oct-95	10	5	1	20	30	0.5	5	17

Sugar	Creek	Below	West	End	Creek					
DATE FROM TO	Function	Value	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
83/10/13	Oct–83	Oct–83	90	10			3950			
84/09/27	Sep–84	Sep–84	13	10			20	0.5		
85/05/21	May–85	May–85	13	10			310	1.2		
85/10/22	Oct–85	Oct–85	12	10			30	0.5		
91/09/21	Sep–91	Sep–91	13			10	40	0.5		3
92/05/13	May–92	May–92	10	10			50			
92/09/29	Sep–92	Sep–92	12	10			20			2
93/06/02	Jun–93	Jun–93	11	10		10				7
93/10/25	Oct–93	Oct–93	15	10			130			13
94/06/06	Jun–94	Jun–94	10	10			150	0.5		5
94/08/10	Aug–94	Aug–94	11	10			20	0.5		8
94/10/18	Oct–94	Oct–94	16	5		10	10	0.5		5
95/06/15	Jun–95	Jun–95	11	5	1	20	850	0.6	5	5
95/07/14	Jul–95	Jul–95	11	5	1	20	140	0.5	5	5
95/08/28	Aug–95	Aug–95	11	2	0.5	10	20	0.2	5	1
95/09/14	Sep–95	Sep–95	14	2	0.5	10	10	0.2	5	1
95/10/18	Oct–95	Oct–95	12	5	1	20	13	0.5	5	5

Sugar	Creek	At	Bridge	To	Mines					
DATE FROM TO	Function	Value	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
83/10/13	Oct-83	Oct-83	90	10			3950			
84/09/27	Sep-84	Sep-84	13	10			20			
85/05/21	May-85	May-85	13	10			310			
85/10/22	Oct-85	Oct-85	12	10			30			
88/06/09	Jun-88	Jun-88	10	10			70	0.5		
88/09/21	Sep-88	Sep-88	26	10			20			
89/10/25	Oct-89	Oct-89	21	10			100	0.5		
91/05/22	May-91	May-91	17	10		10	500	1.2		10
91/09/21	Sep-91	Sep-91	13	10			40			
91/09/24	Sep-91	Sep-91	14	10	1	10	100	0.5		12
92/05/13	May-92	May-92	10	10			50			
92/05/13	May-92	May-92	12	10			110			
92/09/23	Sep-92	Sep-92	20	10			80			17
92/09/29	Sep-92	Sep-92	12	10			20			
93/06/02	Jun-93	Jun-93	11	10		10	20			7
93/06/02	Jun-93	Jun-93	12	10		10	20			7
93/10/25	Oct-93	Oct-93	18	10			100			130
93/10/25	Oct-93	Oct-93	15	10			130			
94/06/06	Jun-94	Jun-94	14	10			50	0.5		5
94/08/10	Aug-94	Aug-94	38	10	1		30	0.5		5
94/10/18	Oct-94	Oct-94	44	11		10	50	0.5		5
95/06/14	Jun-95	Jun-95	12	5	1	20	600	0.8	5	16
95/07/14	Jul-95	Jul-95	12	5	1	20	120	0.5	5	5
95/08/28	Aug-95	Aug-95	9	2	0.5	10	10	0.2	5	1
95/09/14	Sep-95	Sep-95	23	2	0.5	10	30	0.2	5	2
95/10/18	Oct-95	Oct-95	22	6	1	20	70	0.5	5	17

Garnet Creek Below Garnet Creek Pit

DATE FROM TO	Function	Value	ARSENIC AS.TOT UG/L	ANTIMONY SB.TOT UG/L	CADMIUM CD. TOT UG/L	COPPER CU/TOT UG/L	IRON FE.TOT UG/L	MERCURY HG. TOT UG/L	SELENIUM SE. TOT UG/L	ZINC ZN. TOT UG/L
88/06/09	Jun-88	Jun-88	27	10			10			
88/09/21	Sep-88	Sep-88	38	10			20			
89/10/25	Oct-89	Oct-89	44	10			100			
91/05/22	May-91	May-91	100	58		10	160	0.5		10
91/09/24	Sep-91	Sep-91	160		1	10	60	0.5		8
92/05/13	May-92	May-92	100	53			120			
92/09/23	Sep-92	Sep-92	170	90			500			2
93/06/02	Jun-93	Jun-93	85	32	1	10		0.5		7
93/10/25	Oct-93	Oct-93	180	72			110			5
94/06/06	Jun-94	Jun-94	130	44			180	0.5		5
94/08/10	Aug-94	Aug-94	180	100	1		70	0.5		5
95/06/14	Jun-95	Jun-95	80	26	1	30	150	0.5	5	25
95/08/28	Aug-95	Aug-95	136	59	0.5	10	30	0.2	5	1
95/09/14	Sep-95	Sep-95	173	77	0.5	10	50	0.2	5	1
95/10/16	Oct-95	Oct-95	170	72	1	20	150	0.5	5	11

Garnet Creek Above Garnet Creek Pit

DATE FROM TO	Function	Value	ARSENIC AS.TOT UG/L	ANTIMONY SB.TOT UG/L	CADMIUM CD. TOT UG/L	COPPER CU.TOT UG/L	IRON FE.TOT UG/L	MERCURY HG. TOT UG/L	SELENIUM SE. TOT UG/L	ZINC ZN. TOT UG/L
95/08/28	Aug-95	Aug-95	26	2	0.5	10	10	0.2	5	1
95/09/14	Sep-95	Sep-95	36	4	0.5	10	20	0.2	5	1
95/10/16	Oct-95	Oct-95	33	8	0.5	10	30	0.5	5	1

Garnet	Creek	Above	Confluence	With	EFSFSR					
DATE FROM TO	Function	Value	ARSENIC AS,TOT UG/L	ANTIMONY SB,TOT UG/L	CADMIUM CD, TOT UG/L	COPPER CU, TOT UG/L	IRON FE,TOT UG/L	MERCURY HG, TOT UG/L	SELENIUM SE, TOT UG/L	ZINC ZN, TOT UG/L
88/06/09	Jun-88	Jun-88	100	65			60			
88/09/21	Sep-88	Sep-88	170	95			30			
89/10/25	Oct-89	Oct-89	150	83			100			
91/05/22	May-91	May-91	85	64		10	470	0.5		10
91/09/24	Sep-91	Sep-91	180	139	1	20	70	0.5		139
92/05/13	May-92	May-92	90	68			110			
92/09/23	Sep-92	Sep-92	66	41			630			2
93/06/02	Jun-93	Jun-93	70	58		10	550	0.5		33
93/10/25	Oct-93	Oct-93	170	82			630			10
94/06/06	Jun-94	Jun-94	120	38			290	0.5		5
94/08/10	Aug-94	Aug-94	150	100			100	0.5		5
94/10/18	Oct-94	Oct-94	180	90		10	300	0.5		5
95/06/14	Jun-95	Jun-95	78	26	1	20	160	0.5	5	28
95/07/14	Jul-95	Jul-95	105	39	1	20	50	0.5	5	8
95/08/28	Aug-95	Aug-95	134	57	0.5	10	20	0.2	5	1
95/09/14	Sep-95	Sep-95	167	69	0.5	10	10	0.2	5	1
95/10/16	Oct-95	Oct-95	170	70	1	20	150	0.5	5	10