ACCELERATED DISTRIBUTION DEMONSTRATION SYSTEM

REGULATORY INFORMATION DISTRIBUTION SYSTEM (RIDS)

ACCESSION NBR:8912070233 DOC.DATE: ~~88/12/31~~ NOTARIZED: NO DOCKET #
FACIL:50-397 WPPSS Nuclear Project, Unit 2, Washington Public Powe 05000397
AUTH.NAME AUTHOR AFFILIATION
BELL,J.C. Washington Public Power Supply System
RECIP.NAME RECIPIENT AFFILIATION

See Rpt.

SUBJECT: "Operational Ecological Monitoring Program For Nuclear Plant 2." W/891128 ltr.

DISTRIBUTION CODE: IE25D COPIES RECEIVED:LTR 1 ENCL 1 SIZE: 175
TITLE: Environmental Monitoring Rept (per Tech Specs)

NOTES:

	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL	RECIPIENT ID CODE/NAME	COPIES LTTR	COPIES ENCL
	PD5 LA	1	1	PD5 PD	1	0
	SAMWORTH,R	1	1			
INTERNAL:	ACRS	1	1	AEOD/DSP/TPAB	1	1
	IRM TECH ADV	1	0	NRR ROTHMAN,R	1	1
	NRR/DREP/PRPB11	2	2	NUDOCS-ABSTRACT	1	1 use orig
	~~REG FILE 01~~	1	1	RGN5 DRSS/RPB	1	0
	~~RGN5 FILE 02~~	1	1			
EXTERNAL:	EG&G SIMPSON,F	2	2	LPDR	1	1
	NRC PDR	1	1			

R I D S / A D D S

LIMITED DISTRIBUTION OF ENCLOSURES DUE TO SIZE

R I D S / A D D S

TOTAL NUMBER OF COPIES REQUIRED: LTTR 19 ENCL ~~18~~ 12

Env-1

WASHINGTON PUBLIC POWER SUPPLY SYSTEM

P.O. Box 968 • 3000 George Washington Way • Richland, Washington 99352

November 28, 1989

Mr. William L. Fitch
Executive Secretary
Energy Facility Site Evaluation Council
Mail Stop PY-11
Olympia, WA 98504

SUBJECT: TRANSMITTAL OF OPERATIONAL ECOLOGICAL MONITORING PROGRAM NUCLEAR PLANT 2 ANNUAL REPORT

Dear Mr. Fitch:

Enclosed are four (4) copies of the subject report.

J. C. Bell, Manager
Health and Sciences

keh

Enclosure: As stated.

cc: Document Control Desk, NRC (w/enclosure)
R. B. Samworth, NRC (w/enclosure)
D. Becker, Battelle

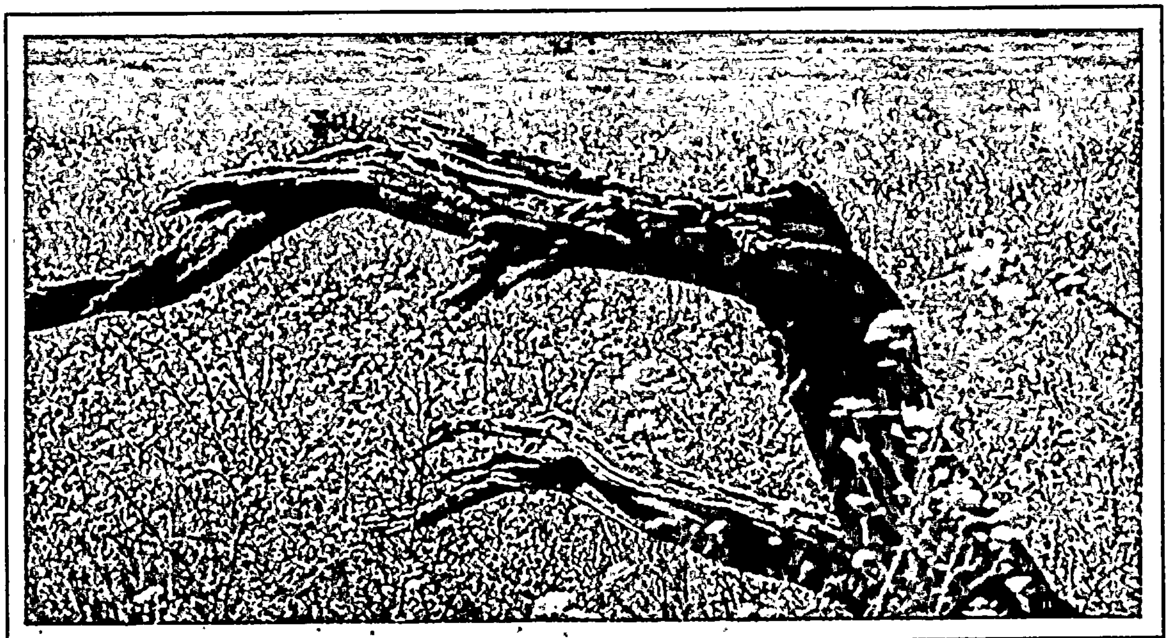
IE25
1/1

8912070233

OPERATIONAL ECOLOGICAL MONITORING PROGRAM FOR NUCLEAR PLANT 2

1988 Annual Report

Prepared by Environmental Sciences Department



WASHINGTON PUBLIC POWER
SUPPLY SYSTEM

TABLE OF CONTENTS

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

TABLE OF CONTENTS
(Continued)

EXECUTIVE SUMMARY

During 1988 there were no unusual events which resulted in significant environmental impacts from the operation of WNP-2.

There were no unanticipated or emergency discharges of water or wastewater during the reporting period.

Water quality sampling Station 7 was relocated to eliminate sampling inconsistencies produced by the surging effect of the discharge plume. No surging effects were noted during 1988. Sampling at mid and bottom depths was initiated for copper concentrations. The results were consistent with surface measurements and generally indicate that the discharge plume is well mixed and uniform in its vertical dispersion as it exits the mixing zone.

Significant interstation differences could not be detected for any of the parameters measured. All measurements taken were within the water quality standards for Class A waters both above and below the mixing zone.

Total herbaceous cover averaged 32.5% in the study area which represents a 55% reduction over 1987. This is attributed to record dry periods which occurred during critical times of the growing season in January and February. Shrub cover and density data continue to reflect recovery from the 1984 range fire with slight increases in cover and density evident at most stations.

With the exception of Station G03 located just south of the cooling towers, no adverse trends or impacts upon soil or vegetation chemistry are apparent from five years of operational data.

WNP-2 intake inspections were made in July and October. No fish were found impinged on the intake screens and algal growth was moderate. Fouling of the intake screens was comparable to that observed in previous years.

No living <u>Corbicula</u> or relic shells were found during inspections of the main condensor water boxes, nor were they observed during routine inspections of the TMU pumphouse pit.

An aerial photography program was established in June of 1988 as an additional tool in detecting signs of vegetation stress surrounding WNP-2. Two flightlines will be photographed annually and examined for signs of stress.

ACKNOWLEDGEMENTS

This annual report, prepared by Washington Public Power Supply System, describes the aquatic, terrestrial and water quality programs for Nuclear Project No. 2 (WNP-2).

Project Team

Joe Bell	Manager, Occupational Health and Environmental Sciences
Terry E. Northstrom	Supervisor, Environmental Sciences
Sara L. Lindberg	Environmental Scientist I
John E. McDonald	Environmental Scientist I
Richard E. Welch	Environmental Scientist I
Lana S. Schleder	Environmental Scientist II
Kathryn E. Humphreys	Administrative Specialist

List of Tables

List of Tables
(Continued)

List of Figures

List of Figures

(Continued)

List of Figures

(Continued)

List of Figures

(Continued)

List of Figures

(Continued)

Number	Title	Page
5-59	Chloride Concentration (%) in Poa sandbergii by Station for 1980 Through 1988	5-87
5-60	Chloride Concentration (%) in Sisymbrium altissimum by Station for 1980 Through 1988	5-88
5-61	Chloride Concentration (%) in Artemisia tridentata by Station for 1980 Through 1988	5-89
5-62	Chloride Concentration (%) in Purshia tridentata by Station for 1980 Through 1988	5-90
5-63	Chloride Concentration (%) in Bromus tectorum by Station for 1980 Through 1988	5-91
5-64	Chloride Concentration (%) in Phlox longifolia by Station for 1980 Through 1988	5-92
5-65	Total Vegetation Chloride for May 1988	5-93

List of Figures

(Continued)

1.0 INTRODUCTION

1.1 BACKGROUND

Washington Public Power Supply System (Supply System) began site preparation for Nuclear Plant Number 2 (WNP-2) near Richland, Washington in March 1973. WNP-2 loaded fuel in December 1983, reached approximately 75 percent thermal load in November 1984, and began commercial operation in December 1984.

The Site Certification Agreement (SCA) for WNP-2, executed on May 17, 1972, between the State of Washington and the Supply System requires that ecological monitoring be conducted during the preoperational and operational phases of site development and use. The Washington State Energy Facility Site Evaluation Council (EFSEC) approved a change in 1978 to the technical scope of environmental monitoring required by the SCA (EFSEC Resolution No. 132, January 23, 1978). In 1980, the aquatic and water quality portions of the preoperational monitoring program were terminated (EFSEC Resolution No. 166, March 24, 1980). The following year the preoperational and operational terrestrial monitoring program scope for WNP-2 was modified (EFSEC Resolution No. 193, May 26, 1981). Prior to operation, the council reviewed the preoperational aquatic monitoring data and approved the operational monitoring program (EFSEC Resolution No. 214, November 8, 1982).

The Supply System in 1974 retained Battelle Pacific Northwest Laboratories (BNW) to conduct the preoperational aquatic monitoring for WNP-2. The results of aquatic studies performed from September 1974 through August 1978 are presented in various reports (Battelle 1976, 1977, 1978, 1979a and 1979b). From August 1978 through March 1980 the aquatic studies were performed by Beak Consultants, Inc. (Beak 1980). In 1982 the Supply System analyzed the 1974-1980 aquatic data and presented the results and a recommended operational monitoring program to EFSEC (Mudge et. al., 1982). The operational program was accepted with minor modifications and initiated in March 1983. Because of

operational conditions, the plant did not consistently discharge liquid effluents until the fall of 1984. Figures 1-1 and 1-2 present summaries of electrical generation and monthly discharges for 1988.

Terrestrial monitoring was initiated in 1974 and was conducted by BNW until 1979 (Rickard and Gano, 1976, 1977, 1979a, 1979b). Beak Consultants, Inc. performed the vegetation monitoring program from 1980-1982 (Beak 1981, 1982a, 1982b). Since 1983, Supply System scientists have been responsible for the vegetation aspects of the program (Northstrom et. al. 1984; Supply System 1985, 1986, 1987). During 1981 the animal studies program was taken over by Supply System scientists and results were reported annually (Schleder 1982, 1983, 1984; Supply System 1985, 1986, 1987, 1988). The first comprehensive operational environmental report was prepared by Supply System scientists in 1984 (Supply System 1985).

During their regular meeting of September 14, 1987 the Energy Facility Site Evaluation Council approved Resolution No. 239 which adopted a long-term environmental Monitoring Program for WNP-2. This decision was based upon the council's examination of the document titled Review of the Environmental Monitoring Program for WNP-2 with Recommendations for Design of Continuing Studies (Davis and Northstrom, 1987). A summary of the monitoring program conducted through September 1987, and the long term program adopted in EFSEC Resolution No. 239 is presented in Table 1-1.

This report presents the results of the Ecological Monitoring Program (EMP) for the period January 1988 through December 1988.

1.2 THE SITE

The WNP-2 plant site is located 19 km (12 miles) north of Richland, Washington in Benton County (Figure 1-3). The Supply System has leased 441 hectares (1089 acres) from the U.S. Department of Energy's Hanford Site for WNP-2.

WNP-2 lies within the boundaries of the Columbia Basin, an extensive area south of the Columbia River between the Cascade Range and Blue Mountains in Oregon and approximately two thirds of the area lying east of the Cascades in Washington. The plant communities within the region are described as shrub-steppe communities consisting of various layers of perennial grasses overlayed by a discontinuous layer of shrubs. In general, moisture relations do not support arborescent species except along streambanks. Aproximately 5 km (3.25 miles) to the east, the site is bounded by the Columbia River. In August of 1984 a range fire destroyed much of the shrub cover which occupied the site and temporarily modified the shrub-steppe associations which were formerly present.

The aquatic and water quality sampling stations are located near the west bank of the Columbia River at mile 352. Sampling was limited to the main channel Benton County side which, near the site, averages 370 meters (1200 feet) wide at a river elevation of 105 meters (345 feet) above sea level and ranges to 7.3 meters (24 feet) deep. Sampling stations have been established in the river both upstream and downstream from the plant intake and discharge structures. The river-level in this area fluctuates considerably diurnally and from day-to-day in response to release patterns at the Priest Rapids Dam (River Mile 397). These fluctuations cause large areas of river bottom to be alternately exposed and covered. The river bottom within the study area varies from exposed Ringold conglomerate to boulders, cobble, gravel, and sand. River velocities at the surface average approximately 2 meters (5 to 6 feet) per second in this area of the river, and water temperature varies from approximately 0 to 22°C.

The flow of the Columbia River at WNP-2 is controlled by releases from Priest Rapids Dam. The minimum flow, measured at the USGS stream-quality station located at river mile 388.1 near the Vernita bridge, was 28,300 cfs, while average and maximum flows in 1988 were 99,839 cfs and 230,000 cfs, respectively (Figure 1-4).

The terrestrial sampling locations are all within an 8 km (5 mile) radius from WNP-2. The topography is flat to gently rolling, gradually increasing from an elevation of 114 meters (375 feet) at the riparian sampling locations to approximately 152 meters (500 feet) at more distant shrubgrass sample stations.

1.3 BIBLIOGRAPHY

Battelle Pacific Northwest Laboratories. 1976. Aquatic ecological studies conducted near WNP-1, 2, and 4, September 1974 through September 1975. Supply System Columbia River ecology studies Vol. 2. Richland, WA.

Battelle Pacific Northwest Laboratories. 1977. Aquatic ecological studies near WNP-1, 2, and 4, October 1975 through February 1976. Supply System Columbia River Ecology Studies Vol. 3. Richland, WA.

Battelle Pacific Northwest Laboratories. 1978. Aquatic ecological studies near WNP-1, 2, and 4, March through December 1976. Supply System Columbia River ecology studies Vol. 4. Richland, WA.

Battelle Pacific Northwest Laboratories. 1979a. Aquatic ecological studies near WNP-1, 2, and 4, March through December 1977. Supply System Columbia River ecology studies Vol. 5. Richland, WA.

Battelle Pacific Northwest Laboratories. 1979b. Aquatic ecological studies near WNP-1, 2, and 4, January through August 1978. Supply System Columbia River ecology studies Vol. 6. Richland, WA.

Beak Consultants, Inc. 1980. Aquatic ecological studies near WNP-1, 2, and 4, August 1978 through March 1980. Supply System Columbia River ecology studies Vol. 7. Portland, OR.

Beak Consultants, Inc. 1981. Terrestrial monitoring studies near WNP-1, 2, and 4, May through December 1980. Portland, OR.

Beak Consultants, Inc. 1982a. Terrestrial monitoring studies near WNP-1, 2, and 4, May through December 1981. Portland, OR.

Beak Consultants, Inc. 1982b. Preoperational terrestrial monitoring studies near WNP-1, 2, and 4, May through August 1982. Portland, OR.

Davis, W. III and T.E. Northstrom. 1987. Review of the environmental monitoring program for WNP-1 with recommendations for design of continuing studies. Washington Public Power Supply System, Richland, WA.

Mudge, J.E., T.B. Stables, W. Davis III. 1982. Technical review of the aquatic monitoring program of WNP-2. Washington Public Power Supply System, Richland WA.

Northstrom, T.E, J.L. Hickam and T.B. Stables. 1984. Terrestrial monitoring studies for 1983. Washington Public Power Supply System, Richland, WA.

Rickard, W.H. and K.A. Gano. 1976. Terrestial ecology studies in the vicinity of Washington Public Power Supply System Nuclear Power Projects 1 and 4. Progress report for the period July 1974 to June 1975. Battelle Pacific Northwest Laboratories, Richland, WA.

Rickard, W.H. and K.A. Gano. 1977. Terrestial ecology studies in the vicinity of Washington Public Power Supply System Nuclear Power Projects 1 and 4. Progress report for 1976. Battelle Pacific Northwest Laboratories, Richland, WA.

Rickard, W.H. and K.A. Gano. 1979a. Terrestial ecology studies in the vicinity of Washington Public Power Supply System Nuclear Power Projects 1 and 4. Progress report for 1977. Battelle Pacific Northwest Laboratories, Richland, WA.

Rickard, W.H. and K.A. Gano. 1979b. Terrestial ecology studies in the vicinity of Washington Public Power Supply System Nuclear Power Projects 1 and 4. Progress report for 1978. Battelle Pacific Northwest Laboratories, Richland, WA.

Schleder, L.S. 1982. Preoperational animal studies near WNP-1, 2 and 4. Annual report for 1981. Washington Public Power Supply System, Richland, WA.

Schleder, L.S. 1983. Preoperational animal studies near WNP-1, 2 and 4. Annual report for 1982. Washington Public Power Supply System, Richland, WA.

Schleder, L.S. 1984. Preoperational animal studies near WNP-1, 2 and 4. Annual report for 1983. Washington Public Power Supply System, Richland, WA.

Washington Public Power Supply System. 1985. Operational ecological monitoring program for Nuclear Plant 2. Annual report for 1984. Richland, WA.

Washington Public Power Supply System. 1986. Operational ecological monitoring program for Nuclear Plant 2. Annual report for 1985. Richland, WA.

Washington Public Power Supply System. 1987. Operational ecological monitoring program for Nuclear Plant 2. Annual report for 1986. Richland, WA.

Washington Public Power Supply System. 1988. Operational ecological monitoring program for Nuclear Plant 2. Annual Report for 1987. Richland, WA.

Table 1-1. Summary of Historical and Long Term Environmental Monitoring Programs for WNP-2

Specific Programs	Historical Program	Proposed Program
	Asiatic clam - inspections in response to an NRC information bulletin.	These inspections will continue based upon our technical response to Inspection and Enforcement Bulletin 81-03.
Water Quality Program	Samples are collected at 4 stations; an upstream control, nearfield just downstream of discharge, just past the end of the mixing zone, and 1800 feet downstream of the discharge.	Continue with slight modifications to the location of the nearfield and downstream station. Add vertical samples to the station at the edge of the mixing zone and increase sampling for copper, the best tracer of the discharge which we have identified.
Terrestrial Annimal Program	Deer and Rabbits - Six plots were reduced to three as the result of fire.	Terminated 1987
	Birds - Spring and fall surveys are conducted.	Terminated 1987
Terrestrial Soil and Vegetation	Vegetation and soil samples are collected each spring at four glassland and 5 shrubland sites.	Continue with the addition of six new sites. Discontinue fluoride and mercury measurements.
	Aerial Photography - Currently not performed.	Initiate annual program to assess changes in vegetation.
	Terrestrial Bioassays - None conducted.	Conduct bioassays on selected plant species utilizing soil exposed to cooling tower drift. Initially conduct the bioassays annually.
Cooling Tower Drift	Indirect drift information from vegetation and soil chemistry data.	Develop a program to directly monitor the pattern and chemistry of the cooling tower drift.
Aquatic Biology Program	Periphyton - Collected quarterly or twice quarterly from 16 artificial sampler stations in the Columbia River.	Terminated 1987
	Benthic Macrofauna - Collected quarterly from 8 artificial sampler stations in the Columbia River.	Terminated 1987
	Fish - Four static bioassays were required by EFSEC. Additional bioassays have been performed to support changes in chemistry of the circulating water.	Conduct flow through bioassays.
	Drift studies in the discharge plume.	Regulatory commitment has been completed. No further studies are proposed.
	Entrainment studies in the intake water pumphouse.	Regulatory commitment has been completed. No further studies are proposed.
	Impingement studies.	Regulatory commitment has been completed. No further studies are proposed; however, incidental observations will be made when maintenance inspections of the intakes are conducted.

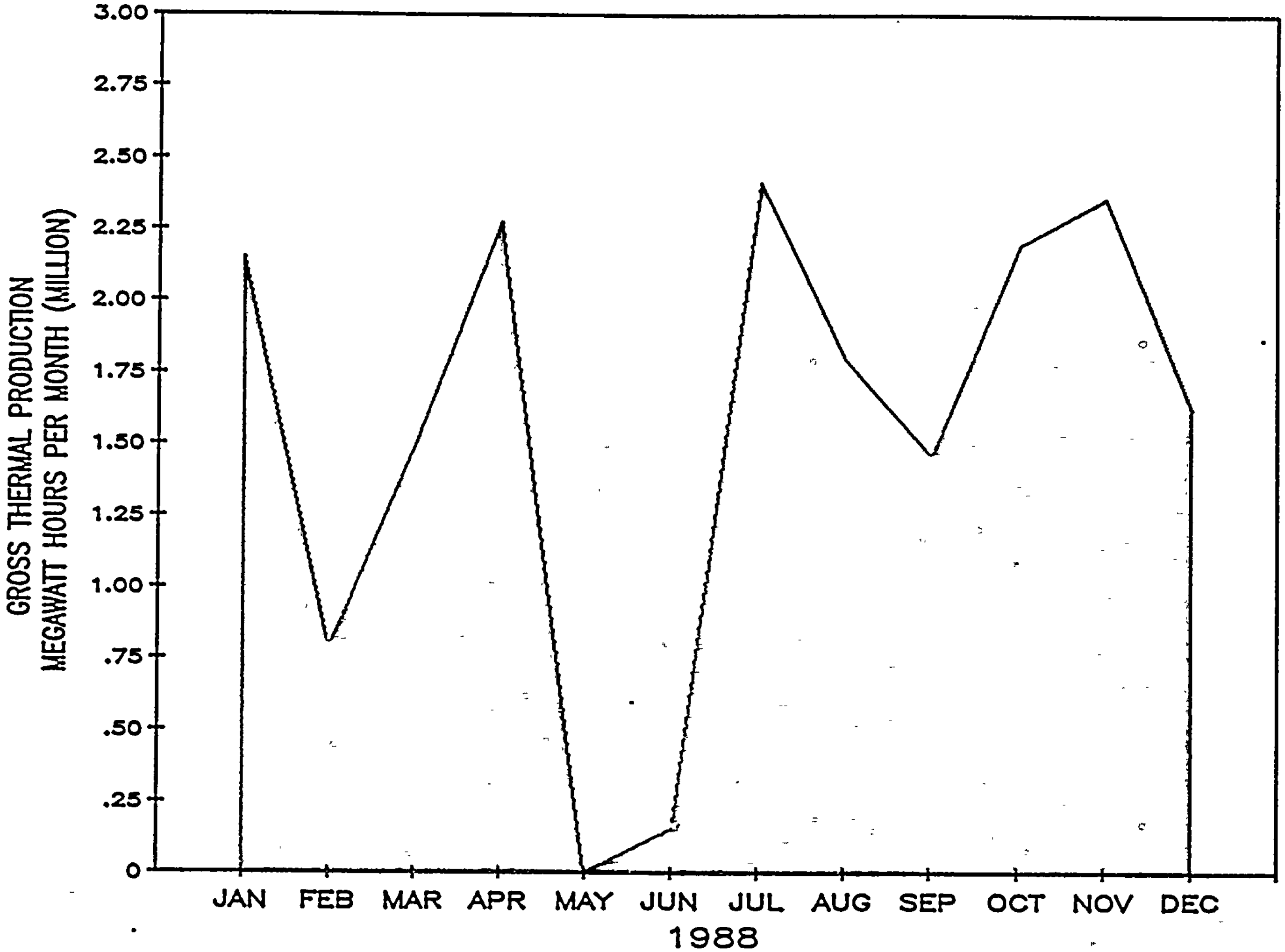


Figure 1-1. WNP-2 Gross Thermal Production for 1988

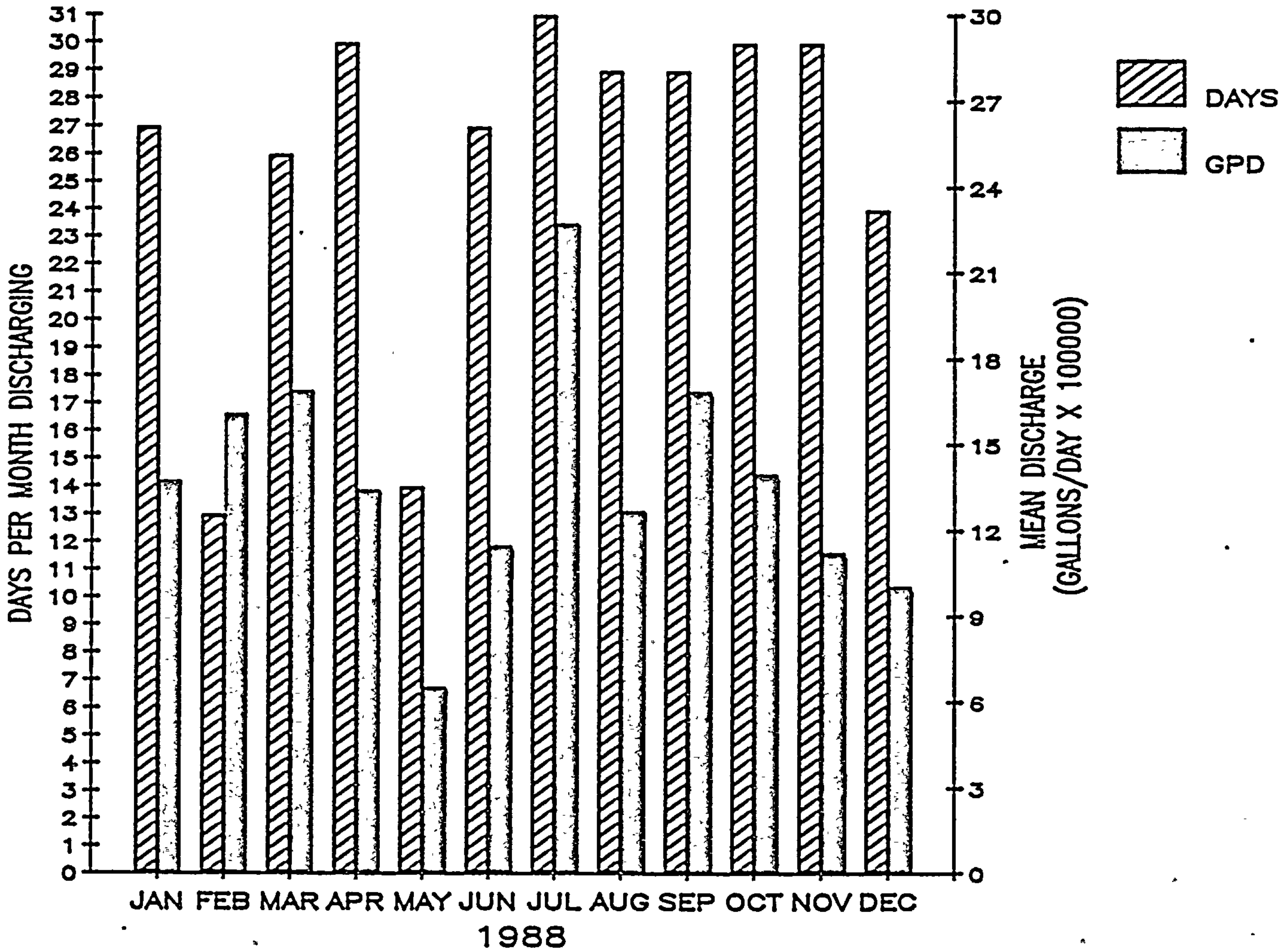


Figure 1-2. WNP-2 Days Per Month Discharging and Mean Monthly Discharge

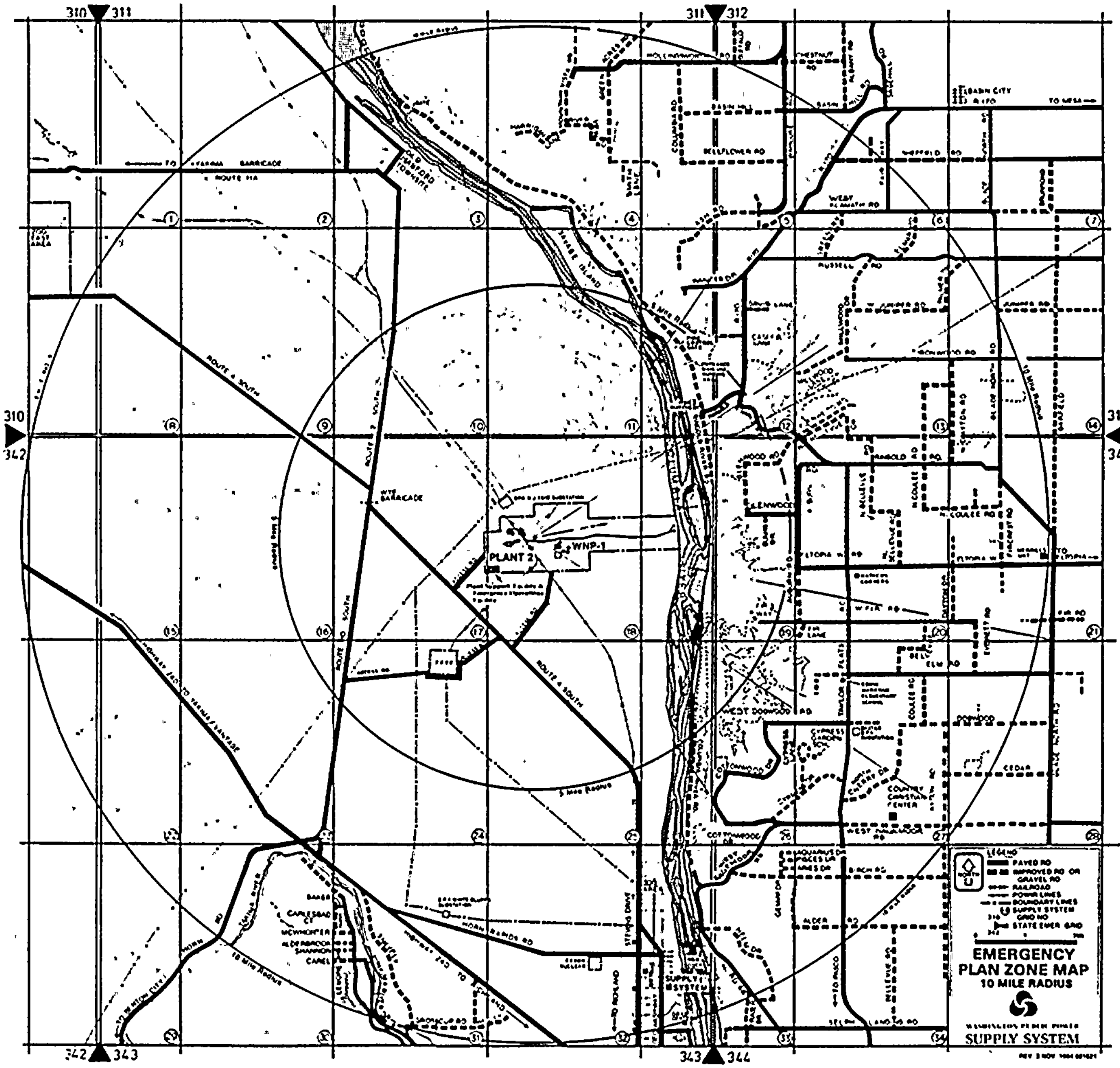


Figure 1-3. WNP-2 Location Map

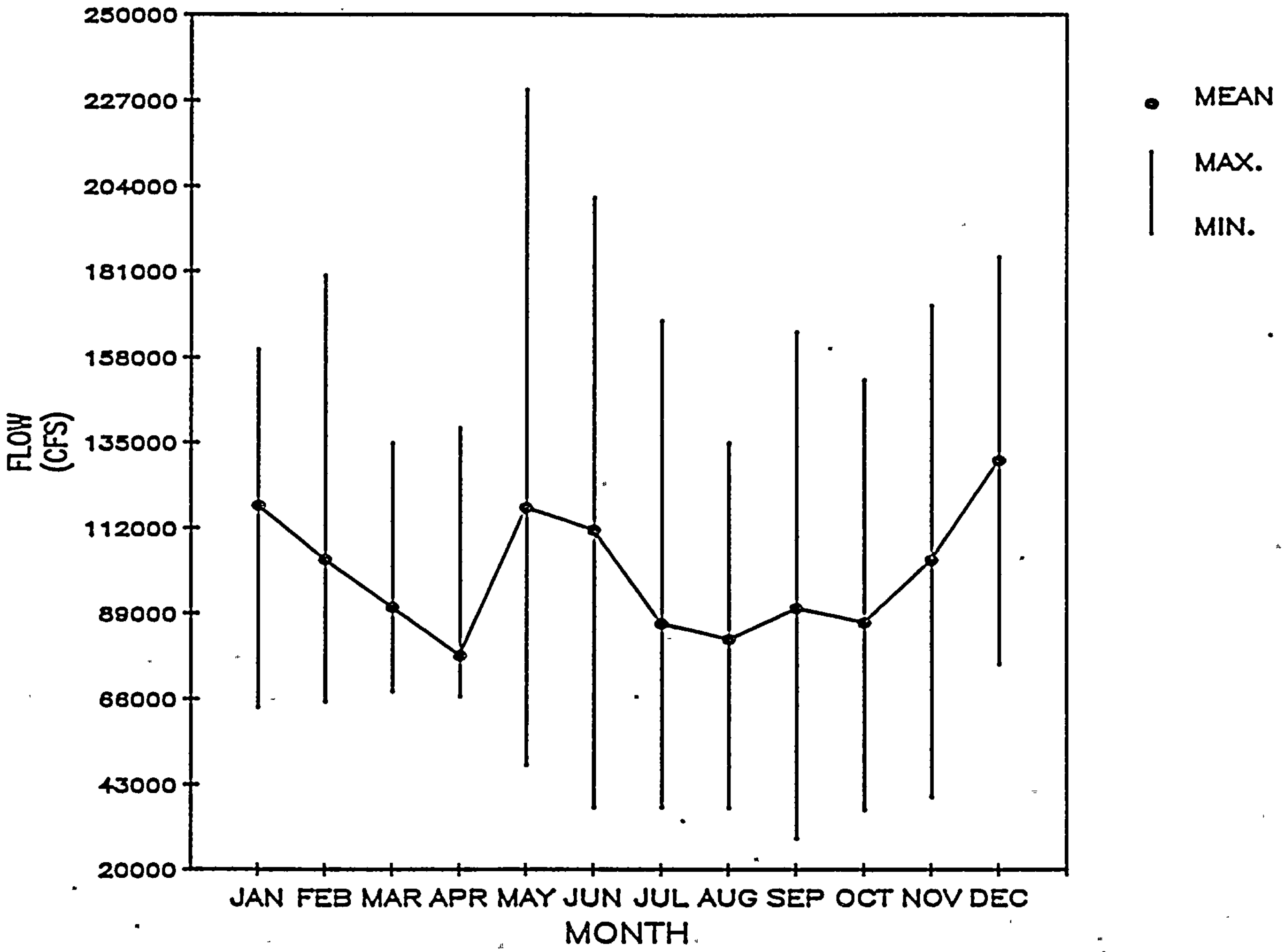


Figure 1-4. Columbia River Mean Monthly Flow for 1988

2.0 NOTABLE ENVIRONMENTAL OBSERVATIONS

2.1 INTRODUCTION

Any occurrence of an unusual or notable event that indicates or could result in a significant environmental impact causally related to plant operation shall be recorded and reported to the NRC within 24 hours followed by a written report. The following are examples: excessive bird impaction events, onsite plant or animal disease outbreaks, mortality or unusual occurrence of any species protected by the Endangered Species Act of 1973, fish kills, increase in nuisance organisms or conditions, and a significant, unanticipated or emergency discharge of waste water or chemical substances.

2.2 METHODS

Weekly ground surveys were conducted from January 1st through December 31st to document the occurrence of unusual species or events within the property boundary of WNP-2 (Figure 2.1). Additional information was supplied by security and environmental personnel.

2.3 RESULTS

There were no unusual or notable events which resulted in significant environmental impacts from the operation of WNP-2. Notable avian observations included, sightings of *Buteo regalis* (Ferruginous hawk), *Falco mexicanus* (Prairie Falcon), and *Cygnus buccinator* (Trumpeter Swan). Also sighted was a Columbia Whitetail deer.

There were no unanticipated or emergency discharges of water or wastewater during the reporting period.

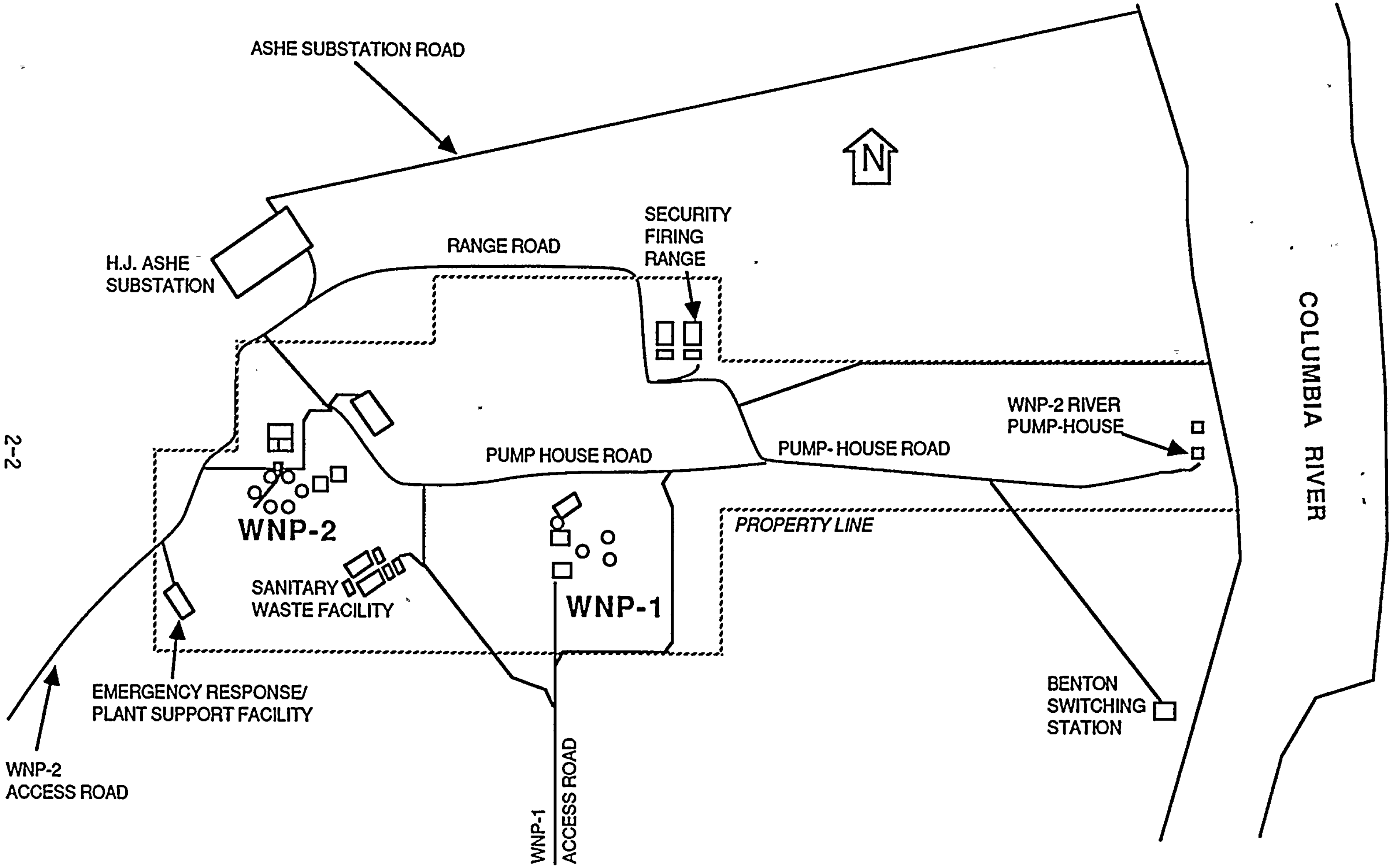


Figure 2-1. **WNP-2 PROPERTY BOUNDARY**

871032.4
FEB 1988

3.0 FISH BIOASSAYS

3.1 INTRODUCTION

In response to the requirements specified in Condition G34 of the WNP-2 National Pollutant Discharge Elimination System (NPDES) Permit and Energy Facility Site Evaluation Council (EFSEC) Resolution No. 214 (January, 1983), several fish bioassays were performed between October 1984 and November 1985. Various concentrations of recirculating cooling water (plant effluent) were tested using a 96 hour static bioassay format. No fish mortalities were observed at any concentration (including 100% effluent) during any of the tests.

As part of the long term environmental monitoring program approved with the adoption of EFSEC Resolution No. 239 (September, 1987), the Supply System committed to conduct improved bioassays utilizing a 96 hour flow-through procedure. In addition, EFSEC Resolution No. 240 (December, 1987) established an approval process for new circulating water additives in which flow-through bioassay testing may be required. Each resolution requires an 80% survival rate in 100% effluent water.

An appropriate flow-through design was developed in September, 1988 and included proposed modifications to the existing facility and installation of a temperature conditioning unit. Upon completion, the bioassay system will provide full temperature control of both tower makeup water (Columbia Rivier) and tower blowdown water (plant effluent). It establishes a test temperature of 12°C and will enable bioassay experiments to be conducted on a year-round basis.

Two types of flow-through bioassays have been identified for use by the Supply System, Plant Effluent Characterization and Chemical Additive Toxicant Characterization. A Plant Effluent Characterization Bioassay will be used to determine if WNP-2's effluent is

acutely toxic to a test species. This test specifically addresses the requirements of EFSEC Resolution No. 239. A chemical additive toxicant characterization bioassay is an acute test intended to allow calculation of an LC50 of proposed new chemical additives in WNP-2 circulating water. This test is designed to respond to the requirements established in EFSEC Resolution No. 240.

Two plant effluent characterization bioassays have been tentatively scheduled for fall, 1989 (chinook salmon) and Spring, 1990 (steelhead trout). Performance of the Fall, 1989 test hinges directly on the ability to acquire system components in a timely manner (some items have extensive lead times for manufacturing and delivery, i.e., temperature control valves) so that final installation and proper unit testing can be completed prior to initiating the bioassay. A Washington Department of Fisheries permit, for use of chinook salmon smolts from the Ringold hatchery, was received on February 6, 1989. This permit applies only to the fall test.

Presently, there are no chemical additive toxicant characterization bioassays scheduled. A description of this type of system will not be included in this report.

3.2 Materials and Methods

The flow-through bioassay generally adheres to the procedures set forth in Standard Methods for the Examination of Water and Waste Water, 1985; ASTM Standard Practice Nos. E-729-88 and E-1192-88; and the Bioassay Procedure Manual for WNP-3/5 established January 1982. Specific methodology is provided in Environmental Programs Instruction, EPI 13.2.11 entitled "WNP-2 Aquatic Bioassays" (Washington Public Power Supply System, 1989).

Fish obtained for testing will be acclimatized in a 2000-liter capacity holding tank for at least 14 days prior to testing. The water temperature of the holding tank will be maintained at 12°C +/-1°

by the temperature conditioning unit. Fish will be fed the food used by the Washington Department of Fisheries or Game (i.e., Oregon Moist Pellets). Food size and feeding rates will be based on fish size. Fish will not be fed for 48 hours prior to handling or during the acute bioassay.

The bioassay system will consist of six test aquaria placed in one water bath table. The system will include three control (100% Columbia River water) and three test (100% plant effluent) aquaria. Aquaria flow rates will be maintained at a minimum of 1 liter/minute/aquarium. The water temperature in the aquaria and water bath table will be controlled by the temperature conditioning unit and will be maintained at 12°C +/-1°.

At the beginning of each test, the system will be operated until at least two volume exchanges have occurred in the aquaria. Fish will be distributed in a stratified random manner to the aquaria with a maximum aquarium loading of 1440 grams or 1 g./liter/24 hours. Fish will be acclimatized in the aquaria at 100% dilution water (Columbia River) for at least 48 hours prior to toxicant introduction. All aquaria will be monitored for mortalities at least twice a day.

The bioassay will be stopped if mortalities exceed 1% during the 48 hour acclimitization period or 10% in the control aquaria during the 96 hour test.

Temperature will be monitored continuously in both control (Columbia River) and toxicant (plant effluent) head boxes.

At least daily, during the bioassay, in-situ water measurements will be performed including temperature, dissolved oxygen, pH and conductivity on the river, control and toxicant head boxes, and each aquarium. Daily, during the bioassay, a random grab water sample will be collected from the river, control and toxicant head boxes, and each aquarium and analyzed for calcium, sodium, potassium, chloride,

fluoride, magnesium, ammonia-N, nitrate-N, sulfate, ortho-phosphate, alkalinity, total copper, dissolved copper, labile copper, total zinc, total phosphorus, and tolyltriazole. In addition, at the beginning and end of each bioassay, grab water samples from the river, control and toxicant head boxes, and each aquarium will be collected and analyzed for total chromium, total iron, total cadmium, total lead, and total nickel. In the same aquaria at the beginning of each bioassay a grab sample will be analyzed for total residual chlorine, total suspended solids and total dissolved solids.

All water samples will be collected, stored and analyzed per Environmental Programs Laboratory Instruction Procedures. (These procedures adhere to the requirements put forth by Standard Methods (1985), EPA (1983), and ASTM.)

Fork lengths and wet weights will be determined on the control fish at the end of the bioassay. All fish surviving the bioassay will be released to the Columbia River within 24 hours.

3.3 Bibliography

- American Public Health Association, 1985. Standard Methods For the Examination of Water and Wastewater. Fifteenth Edition. Washington, DC.

- American Society for Testing and Materials, 1988. Standard Practice for Conducting Acute Toxicity Tests with Fishes, Macroinvertebrates, and Amphibians. Designation E 729-88. Philadelphia, PA.

- American Society for Testing and Materials, 1988. Standard Guide for Conducting Acute Toxicity Tests on Aqueous Effluents with Fishes, Macro-invertebrates, and Amphibians. Designation E1192-88. Philadelphia, PA.

- Environmental Protection Agency. 1983. Methods for Chemical Analysis of Water and Wastes. Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, OH.

- Washington Public Power Supply System, 1982. Bioassay Procedure Manual for WNP-3/5. Richland, Washington.

- Washington Public Power Supply System, 1986. Operational Ecological Monitoring Program for Nuclear Plant 2, 1985 Annual Report. Richland, Washington.

- Washington Public Power Supply System, 1989. WNP-2 Aquatic Bioassays. Environmental Programs Instruction 13.2.11. Richland, WA.

- Washington Public Power Supply System, 1989. Environmental Programs Laboratory Instruction Procedures. Richland, WA.

4.0 WATER QUALITY

4.1 INTRODUCTION

The water quality monitoring program was initiated in April 1983 to document the chemical character of the Columbia River in the vicinity of the WNP-2 discharge. The monitoring data is used to assess if chemical changes in the Columbia River result from WNP-2 cooling tower blowdown. The original program was performed to comply with EFSEC Resolution No. 214.

On September 14, 1987 EFSEC Resolution No. 239 was passed establishing a long-term monitoring program for WNP-2. As a result, the locations of two sampling stations were modified in an attempt to more effectively monitor WNP-2's discharge. In addition, two new stations were added to sample water at mid depth and bottom locations. The new program commenced with the January 1988 sampling period.

4.2 MATERIALS AND METHODS

Columbia River surface water was sampled monthly January 1988 through December 1988. Samples were collected near River Mile 352 from four stations numbered 1, 7, 11, and 8 (Figure 4-1, 4-2). Station 1 is upstream of the WNP-2 intake and discharge and represents a control. Station 7 was moved to the center of the mixing zone approximately 45 meters (150 feet) downstream of the discharge and provides a measure of nearfield discharge effects. Station 11 at 91 meters (300 feet) downstream from the discharge represents the extremity of the mixing zone allowed by WNP-2's National Pollutant Discharge Elimination System (NPDES) permit. Sub-stations 11M and 11B are new stations and sample water from middle and bottom depths, respectively. Station 8 is approximately 568 meters (1870 feet) downstream from the discharge and represents a location where the discharge is well mixed in the Columbia River. This station was moved from its original location to a site more towards the center of the river in an effort to ensure that samples are collected from the discharge plume.

The samples were analyzed for temperature, dissolved oxygen (DO), pH, conductivity, turbidity, total alkalinity, total hardness, filterable residue (total dissolved solids), nonfilterable residue (total suspended solids), ammonia-nitrogen, nitrate-nitrogen, total phosphorus, orthophosphorus, sulfate, oil and grease, total residual chlorine, total copper, total iron, total zinc, total nickel, total lead, total cadmium and total chromium. A summary of water quality parameters, stations and sample frequencies is presented in Table 4-1.

4.2.1 Sample Collection

Columbia River samples were collected by boat approximately 300 feet from the Benton County shore. Temperature, dissolved oxygen, and pH were determined in-situ with portable instruments. Water for total metal analyses was collected in one-liter polypropylene cubitainers and kept on ice until delivered to the Supply System's Environmental Programs Laboratory (EPL). Water for total copper analysis from Stations 11M and 11B were collected in 125 ml nalgene bottles with an All-Teflon pump and Tygon tubing. In the laboratory the metals samples were acidified to 0.5% with concentrated nitric acid. Determinations for filterable residue, non-filterable residue, conductivity, sulfate, total phosphorus, orthophosphorus, ammonia-nitrogen, nitrate-nitrogen, total residual chlorine, turbidity, total alkalinity and total hardness were made on water samples collected in 3.8-liter polypropylene cubitainers and kept on ice until delivered to the Supply System's Radiological Services Laboratory (RSL). Water for oil and grease analysis was skimmed from the surface into solvent rinsed borosilicate glass bottles. After collection, samples were placed on ice and transported to the RSL for analysis.

4.2.2 Field Equipment and Measurements

Surface temperature and dissolved oxygen measurements were made using a Yellow Springs Instruments (YSI) Model 57 meter. Temperature was recorded to within 0.1°C after the probe had been allowed to equilibrate in the river for a minimum of one minute. The field probe was calibrated monthly, against an NBS-traceable thermometer in the laboratory.

The DO meter was air-calibrated prior to each field sample date per manufacturer's instruction. In addition, Winkler DO measurements were made every month and results were compared to the field probe.

Conductivity measurements were made with an IBM Model EC105-1A meter. Prior to each sample date, measurements of conductivity standards were performed.

pH measurements were made with an IBM Model EC105-2A portable pH meter. Prior to each use the instrument was calibrated using pH standards of 4.0, 7.0, and 10.0. If necessary, the probes were adjusted to within 0.1 unit of the standards.

4.2.3 Laboratory Measurements

Total copper, total zinc, total iron, total nickel, total lead, total cadmium and total chromium were determined by Supply System Environmental Programs personnel. The remaining analyses were performed by Supply System's Radiological Services personnel. Sample holding times followed those recommended by the U.S. Environmental Protection Agency (USEPA 1983). Analyses were performed per USEPA (1983) approved methods (Table 4-2).

4.3 RESULTS

4.3.1 Temperature

Columbia River temperatures varied seasonally with a minimum temperature of 3.0°C at all stations on February 10th and a maximum of 18.3°C at Stations 11M and 11B on August 16 (Table 4-3). River temperatures measured in 1988 are presented graphically in Figure 4-3.

4.3.2 Dissolved Oxygen (DO)

The mean and range of DO measurements for each sample station are presented in Table 4-4. Columbia River DO concentrations ranged from 8.0 mg/l at Station 8 in October to 15.1 mg/l at Stations 11 and 8 in January. The mean DO concentrations ranged from 11.2 mg/l at Station 8 to 11.5 mg/l at Station 7. The largest interstation difference in DO occurred between Station 1 (8.8 mg/l) and Station 7 (10.7 mg/l) in October.

DO concentrations were inversely related to river temperature as would be expected from solubility laws. DO levels were never below the 8 mg/l water quality standard for Class A waters (WDOE 1982) indicating good water quality with respect to dissolved oxygen throughout the year. Dissolved oxygen measurements are presented graphically in Figure 4-4.

4.3.3 pH and Alkalinity

Columbia River mean pH values ranged from 7.83 at Station 7 to 7.93 at Station 8 (Table 4-5). pH varied with a measured minimum of 7.27 at Station 7 in December to a maximum of 8.32 at Station 8 in May. The variation in pH between sample stations is small. The largest difference of 0.57 standard units occurred between Station 1 (pH 7.66) and Stations 11M and 8 (pH 8.23) in April.

The pH water quality standard for Class A waters is from 6.5 to 8.5 (WDOE 1982). Measurements for all stations were within this range. pH measurements, presented graphically in Figure 4-5, generally agree with historical data for the Columbia River (Silker 1964).

The alkalinity of a water is a measure of its capacity to neutralize acids and is generally due to the presence of carbonates, bicarbonates, phosphates, silicates, borates, and hydroxides. Columbia River alkalinities ranged from 50.0 to 67.5 mg/l as calcium carbonate (Table 4-6). The greatest interstation differences occurred in January and February between Station 11 (60.0 mg/l) and Station 8 (65.0 mg/l), and between Station 8 (60.0 mg/l) and all other stations (65.0 mg/l), respectively. The alkalinity measurements are presented graphically in Figure 4-6.

4.3.4 Conductivity

Conductivity is a measure of the ionic content of a solution. Columbia River conductivity measurements ranged from 115.7 uS/cm at 25°C at Station 11M in June to 191.8 uS/cm at 25°C at Station 11B in December (Table 4-7). Station mean conductivities ranged from 141.0 uS/cm at 25°C at Station 11M to 148.2 uS/cm at 25°C at Station 7. The largest difference in conductivity (i.e. 19.3 uS/cm) occurred between Station 8 (156.1 uS/cm) and Station 11M (137.8 uS/cm) on February 10, 1988. The conductivity results are very comparable to those reported in earlier studies of the Columbia River (Silker 1964). The measurements are presented graphically in Figure 4-7.

4.3.5 Total Residual Chlorine (TRC)

Total residual chlorine (TRC) measurements for 1988 were less than the measured detection limit of 50 ug/l (Table 4-8).

TRC measurements were made using the Amperometric Titration Method. This method has a detection limit of 50 ug/l.

4.3.6 Metals

Total Copper

Columbia River mean total copper values ranged from 1.0 ug/l at Station 7 to 1.4 ug/l at Station 11M (Table 4-9). Individual copper measurements ranged from 0.5 ug/l to 2.7 ug/l. The largest interstation difference in copper (2.1 ug/l) occurred between Station 1 (2.7 ug/l) and Station 8 (0.6 ug/l) in November. Our copper results show good agreement with earlier studies. In 1962, Silker (1964) analyzed 27 Columbia River samples collected upstream of WNP-2 and reported a mean copper concentration of 4.3 ug/l. Neutron activation analysis of Columbia River water was done in 1968-1969 by Cushing and Rancitelli (1972). They reported a mean copper concentration of 1.4 ug/l. Florence and Batley (1977) state that total copper concentrations in the range of 0.3 - 3.0 ug/l are found in many unpolluted fresh-water rivers throughout the world. The Hanford reach of the Columbia River would generally be in that category.

Total Zinc

Mean total zinc measurements ranged from 7.3 ug/l at Station 8, to 7.6 ug/l at Station 7 (Table 4-10). Individual zinc measurements ranged from 3.3 ug/l at Station 8 to 13.2 ug/l at Station 11. The greatest interstation difference (3.0 ug/l) occurred between Station 7 (9.0 ug/l) and Station 11 (12.0 ug/l) in July, and between Station 11 (5.0 ug/l) and all other stations (8.0 ug/l) in August. The average zinc measurements for the present study are lower than the 18.2 and 14.0 ug/l mean zinc concentrations reported by Silker (1964) and Cushing and Rancitelli (1972).

Total Iron

Columbia River mean iron concentrations ranged from 57.1 ug/l at Station 11 to 61.7 ug/l at Station 8 (Table 4-11). The greatest inter-station difference in concentration of 22 ug/l occurred between Station 7 (82.0 ug/l) and Station 8 (104.0 ug/l) in May.

Total Nickel

Mean total nickel concentrations ranged from 1.1 ug/l to 1.7 ug/l (Table 4-10). Nickel concentrations showed little variation through time or between sample locations.

Total Lead

Mean total lead concentrations ranged from 0.9 ug/l at Station 11 to 1.3 ug/l at Station 8 (Table 4-11). The greatest interstation difference (2.8 ug/l) occurred between Station 7 (1.1 ug/l) and Station 1 (3.9 ug/l) in February.

Total Cadmium

Mean cadmium concentrations were fairly low and ranged from 0.1 ug/l at Stations 11 and 8 to 0.2 ug/l at Stations 1 and 7 (Table 4-12). Several individual measurements were below the minimum detection limit of 0.1 ug/l. No significant interstation differences were evident.

Total Chromium

Chromium concentrations averaged 0.2 ug/l at all stations (Table 4-12). The greatest interstation difference (0.5 ug/l) occurred between Station 11 (0.1 ug/l) and Station 8 (0.6 ug/l) in March.

Total copper, total zinc, total iron, and total lead measurements are presented graphically in Figures 4-8, 4-9, 4-10 and 4-11, respectively.

4.3.7 Hardness

Hardness indicates the quantity of divalent metallic cations present in the system, principally calcium and magnesium ions. Hardness ranged from 53.0 to 74.0 mg/l as calcium carbonate (Table 4-6). Mean hardness values ranged from 62.9 mg/l at Station 8 to 64.2 mg/l at Station 11. The hardness measurements are presented graphically in Figure 4-12.

4.3.8 Oil and Grease

Oil and grease values were below the detection limit of 0.5 mg/l for all stations and periods except Station 11 during December in which 0.90 mg/l was recorded. Oil and grease measurements are summarized in Table 4-13.

4.3.9 Ammonia-Nitrogen and Nitrate-Nitrogen

Ammonia and nitrate are forms of nitrogen commonly found in water systems. Both nitrate and ammonia are assimilated by plants and converted to proteins. Common sources of nitrate and ammonia to the aquatic system are breakdown of organic matter in the soil, industrial discharges, fertilizers and septic tank leachate.

Ammonia concentrations ranged from 0.01 to 0.05 mg-N/l (Table 4-13). Nitrate concentrations ranged from a low of 0.10 mg-N/l at Station 8 in September to a high of 0.80 at all stations in February. Mean station concentrations were similar ranging from 0.30 mg-N/l at Station 11 to 0.33 at Station 1. The nitrate measurements are summarized in Table 4-14. The nitrate measurements are presented graphically in Figure 4-13.

4.3.10 Total Phosphorus and Orthophosphorus

Phosphorus is a required nutrient for plant growth and, while found in certain minerals, is commonly added to streams through fertilizers, treated sewage, and septic tank leachate.

Measured total phosphorus concentrations ranged from 0.01 to 0.05 mg-P/l with mean values of 0.02 to 0.03 mg-P/l (Table 4-14). Orthophosphorus concentrations followed a similar pattern and ranged from 0.01 to 0.03 mg-P/l (Table 4-15). Mean concentrations were 0.02 mg-P/l. Total phosphorus measurements are presented graphically in Figures 4-14.

4.3.11 Sulfate

Mean sulfate concentrations ranged from 11.4 mg/l at Station 8 to 12.5 mg/l at Stations 7 and 11 (Table 4-15). Individual sulfate measurements ranged from 9.0 to 16.0 mg/l. Generally, sulfate concentrations between stations were similar with the largest difference of 4.5 mg/l occurring in November between Stations 7 and 8. Sulfuric acid is added at WNP-2 to control circulating water pH and a by-product is sulfate. Based on the river measurements, WNP-2 discharges are not appreciably altering river sulfate concentrations. Total sulfate measurements are presented graphically in Figure 4-15.

4.3.12 Total Dissolved Solids, Total Suspended Solids and Turbidity

Total dissolved solids or total filterable residue, TDS, is defined as that portion of the total residue that passes through a glass fiber filter and remains after ignition at 180°C for one hour. Total dissolved solids do not necessarily represent only the dissolved constituents but may also include colloidal materials and some small particulates. The mean TDS measured in the Columbia River varied from 83.7 mg/l at Station 8 to 86.5 mg/l at Station 1 (Table 4-16). There were no consistent differences in TDS concentrations between stations or through time.

Total suspended solids (TSS) or total nonfilterable residue is the material retained on a standard glass fiber filter after filtration of a well-mixed sample. TSS concentrations were generally low and varied from 0.6 to 8.2 mg/l (Table 4-16). Mean TSS concentrations ranged from 2.9 mg/l at Station 1 to 3.1 mg/l at all remaining stations.

Turbidity is a measure of the suspended matter that interferes with the passage of light through water. In the Columbia River, measured turbidities were low and ranged from 0.50 nephelometric turbidity units (NTU) to 1.50 NTU (Table 4-8). Total dissolved solids, total suspended solids and turbidity data are presented graphically in Figures 4-16, 4-17, and 4-18.

4.3.13 Quarterly Drinking Well Measurements

The results of the 1988 quarterly drinking well water analyses for pH, alkalinity, nitrate-nitrogen, total phosphorus and orthophosphorus are presented in Table 4-17. pH values ranged from 7.22 to 8.44 which are slightly lower than river pH measurements (Table 4-5). The other parameters are comparable to river measurements and have the following value ranges: alkalinity, 30.0-70.0 mg/l; nitrate-nitrogen, 0.21 - 0.52 mg/l; total-phosphorus, 0.006 - 0.019 (mg/l); and orthophosphorus, 0.002 - 0.013 (mg/l).

4.4 DISCUSSION

On nearly all sampling periods, significant interstation differences could not be detected for any of the measured parameters.

The relocation of Station 7 may have eliminated sampling inconsistancies produced by the surging effect of the discharge plume; as was reported for several sampling periods during 1986. However, results for 1988 compare favorably with results from 1987 in which the previous location for Station 7 was utilized and no surging effects were reported. The reduced blowdown (discharge) volume resulting from WNP-2 operating at higher circulating water cycles of concentration is probably a significant contributor to this phenomenon. (See 1987 Annual Report for a discussion on operating cycles.)

Results for Stations 11M & 11B were consistant with surface measurements and generally indicate that the discharge plume is well mixed and uniform in its vertical dispersion as it exits the mixing zone.

Overall, it appears that, with respect to all the measured parameters sampled under the operating conditions prevailing during 1988, WNP-2 cooling water discharge had little effect upon Columbia River water quality. All measurements taken were within the water quality standards for class A waters both above and below the mixing zone.

4.5 BIBLIOGRAPHY

Cushing, C.E., and L.A. Rancitelli. 1972. Trace element analyses of Columbia River water and phytoplankton. Northwest Science 46(2):115-121.

Florence, T.M. and G.E. Batley. 1977. Determination of the chemical forms of trace metals in natural waters with special reference to copper, lead, cadmium and zinc. Talanta 24:151-158.

Silker, W.B. 1964. Variations in elemental concentrations in the Columbia River. Limnol. Oceanogr. 9:540-545.

Environmental Protection Agency. 1983. Methods for chemical analysis of water and wastes. Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, OH.

Washington Department of Ecology. 1988. Water Quality Standards for Surface Waters of the State of Washington. Water Quality Planning Office of Water Programs. Olympia, WA.

Washington Public Power Supply System. 1987. Operational Ecological Monitoring Program for Nuclear Plant 2. Annual Report for 1986. Richland, WA.

Washington Public Power Supply System. 1988. Operational Ecological Monitoring Program for Nuclear Plant 2. Annual Report for 1987. Richland, WA.

Table 4-1. Summary of Water Quality Parameters, Stations, and Sampling Frequencies, 1988

Parameter	Stations 1	7	11	11M & 11B	8	Wells in Vicinity of Plant Site +
Quantity (flow)	-	-	-	-	-	-
Temperature	M	M	M	M	M	-
Dissolved Oxygen	M	M	M	-	M	-
pH	M	M	M	M	M	Q
Turbidity	M	M	M	-	M	-
Total Alkalinity	M	M	M	-	M	Q
Filterable Residue (Total Dissolved Solid)	M	M	M	-	M	-
Nonfilterable Residue (Suspended Solids)	M	M	M	-	M	-
Conductivity	M	M	M	M	M	-
Iron (Total)	M	M	M	-	M	-
Copper (Total)	M	M	M	M**	M	-
Nickel (Total)	M	M	M	-	M	-
Zinc (Total)	M	M	M	-	M	-
Lead (Total)	M	M	M	-	M	-
Cadmium (Total)	M	M	M	-	M	-
Chromium (Total)	M	M	M	-	M	-
Sulfate	M	M	M	-	M	-
Ammonia Nitrogen	M	M	M	-	M	-
Nitrate Nitrogen	M	M	M	-	M	Q
Ortho Phosphorus	M	M	M	-	M	Q
Total Phosphorus	M	M	M	-	M	Q
Oil and Grease	M	M	M	-	M	-
Chlorine, Total Residual	M	M	M	-	M	-
Hardness	M	M	M	-	M	-

Symbols Key

M = Monthly
Q = Quarterly
+ Samples will be collected if wells are being used for drinking water.
- Analysis not required
** Samples taken in triplicate

Table 4-2. Summary of Water Quality Parameters and EPA Method Number

Parameter	EPA Method Number
Water Temperature (°C)	170.1
Turbidity, (NTU)	180.1
Conductivity (umhos/cm) at 25°C	120.1
Dissolved Oxygen (mg/l) probe	360.1
Dissolved Oxygen (mg/l) Modified Winkler	360.2
pH (Standard Unit)	150.1
Total Alkalinity (mg/l as $CaCO_3$)	310.1
Total Hardness (mg/l as $CaCO_3$)	130.2
Oil and Grease (mg/l)	413.2
Nitrogen, Ammonia, Total (mg/l as N)	350.2
Nitrate Nitrogen, Total (mg/l as N)	352.1
Total Phosphorus (mg/l as P)	365.2
Ortho Phosphorus (mg/l as P)	365.2
Sulfate (mg/l as SO_4)	375.4
Total Copper (ug/l as Cu)	220.1, 220.2
Total Iron (ug/l as Fe)	236.1, 236.2
Total Nickel (ug/l as Ni)	249.1, 249.2
Total Zinc (ug/l as Zn)	289.1, 289.2
Total Lead (ug/l as P6)	239.1, 239.2
Total Cadmium (ug/l as Cd)	213.1, 213.2
Total Chromium (ug/l as Cr)	218.1, 218.2
Total Residual Chlorine (ug/l)	330.1
Filterable Residue: Total Dissolved Solids (mg/l)	160.1
Non-Filterable Residue: Total Suspended Solids (mg/l)	160.2

Table 4-3. Summary of Temperature Measurements for 1988.

Temperature (Degrees C)

Sample Date	1	7	11	11M	11B	8
01/27/88	3.5	3.5	3.5	3.7	3.7	3.5
02/10/88	3.0	3.0	3.0	3.0	3.0	3.0
03/09/88	4.0	4.0	4.0	4.0	4.0	4.0
04/06/88	6.5	6.5	6.5	7.0	6.9	6.7
05/12/88	10.5	10.5	10.5	10.9	11.2	10.5
06/22/88	16.5	16.5	16.5	16.9	17.1	16.5
07/13/88	16.5	16.5	16.5	17.0	17.1	16.5
08/16/88	18.1	18.1	18.1	18.3	18.3	18.1
09/30/88	16.8	16.8	16.8	17.1	16.7	16.8
10/19/88	16.0	16.0	16.0	15.9	15.9	16.0
11/28/88	10.0	10.0	10.0	10.7	10.5	10.0
12/14/88	8.2	8.3	8.2	8.4	8.2	8.2
Mean	10.8	10.8	10.8	11.1	11.1	10.8
SD	5.5	5.5	5.54	5.59	5.59	5.52
Maximum	18.1	18.1	18.1	18.3	18.3	18.1
Minimum	3.0	3.0	3.0	3.0	3.0	3.0

Table 4-4. Summary of Dissolved Oxygen Measurements for 1988.

Sample Date	Dissolved Oxygen (mg/l)					
	1	7	11	11M	11B	8
01/27/88	14.6	14.7	15.1	-	-	15.1
02/10/88	13.2	13.1	12.9	-	-	12.9
03/09/88	13.0	12.9	12.8	-	-	12.8
04/06/88	12.0	12.0	12.0	-	-	12.0
05/12/88	13.4	13.3	13.6	-	-	13.2
06/22/88	10.4	11.6	11.2	-	-	10.7
07/13/88	10.0	9.8	9.8	-	-	9.8
08/16/88	10.9	10.6	10.8	-	-	10.6
09/30/88	9.6	9.4	8.2	-	-	8.8
10/19/88	8.8	10.7	10.5	-	-	8.0
11/28/88	9.6	9.2	9.3	-	-	9.5
12/14/88	10.4	10.4	10.4	-	-	10.5
Mean	11.3	11.5	11.4	-	-	11.2
SD	1.77	1.67	1.88	-	-	1.98
Maximum	14.6	14.7	15.1	-	-	15.1
Minimum	8.8	9.2	8.2	-	-	8.0

Table 4-5. Summary of pH Measurements for 1988.

Sample Date	pH 1	7	11	11M	11B	8
01/27/88	8.01	7.83	7.95	7.94	7.88	8.02
02/10/88	8.21	8.21	8.15	8.15	8.17	8.08
03/09/88	7.60	7.58	7.63	7.62	7.64	7.68
04/06/88	7.66	8.12	8.16	8.23	8.15	8.23
05/12/88	8.12	8.21	8.22	8.29	8.29	8.32
06/22/88	8.17	7.84	7.93	8.08	7.91	8.16
07/13/88	8.17	8.10	8.09	8.15	8.14	8.17
08/16/88	8.09	8.10	8.09	8.01	8.02	8.14
09/30/88	7.62	7.80	7.80	7.76	7.78	7.72
10/19/88	7.51	7.52	7.57	7.53	7.55	7.54
11/28/88	7.53	7.35	7.50	7.38	7.54	7.59
12/14/88	7.49	7.27	7.42	7.62	7.53	7.47
Mean	7.85	7.83	7.88	7.90	7.88	7.93
SD	0.29	0.32	0.27	0.29	0.26	0.29
Maximum	8.21	8.21	8.22	8.29	8.29	8.32
Minimum	7.49	7.27	7.42	7.38	7.53	7.47

Table 4-6. Summary of Alkalinity and Hardness Measurements for 1988.

Total Alkalinity (mg/l)

Sample Date	1	7	11	8
01/27/88	62.5	62.5	60.0	65.0
02/10/88	65.0	65.0	65.0	60.0
03/09/88	62.5	62.5	62.5	62.5
04/06/88	62.5	62.5	62.5	62.5
05/12/88	67.5	65.0	65.0	65.0
06/22/88	50.0	50.0	50.0	50.0
07/13/88	55.0	55.0	52.5	55.0
08/16/88	50.0	50.0	50.0	50.0
09/30/88	50.0	50.0	50.0	50.0
10/19/88	52.5	52.5	52.5	52.5
11/28/88	55.0	55.0	55.0	52.5
12/14/88	60.0	60.0	60.0	60.0
Mean	57.7	57.5	57.1	57.1
SD	6.08	5.77	5.76	5.76
Maximum	67.5	65.0	65.0	65.0
Minimum	50.0	50.0	50.0	50.0

Total Hardness (mg/l)

Sample Date	1	7	11	8
01/27/88	72.0	72.0	74.0	73.0
02/10/88	72.0	71.0	72.0	71.0
03/09/88	68.0	70.0	70.0	70.0
04/06/88	72.0	74.0	74.0	69.0
05/12/88	70.0	70.0	70.0	70.0
06/22/88	53.0	54.0	54.0	54.0
07/13/88	54.0	54.0	55.0	54.0
08/16/88	58.0	58.0	60.0	60.0
09/30/88	58.0	59.0	58.0	58.0
10/19/88	56.0	58.0	59.0	54.0
11/28/88	58.0	60.0	59.0	57.0
12/14/88	65.0	65.0	65.0	65.0
Mean	63.0	63.8	64.2	62.9
SD	7.22	7.06	7.19	7.16
Maximum	72.0	74.0	74.0	73.0
Minimum	53.0	54.0	54.0	54.0

Table 4-7. Summary of Conductivity Measurements for 1988.

Conductivity at 25 C (uS/cm)

Sample Date	1	7	11	11M*	11B*	8
01/27/88	163.1	158.8	158.6	146.5	148.0	158.0
02/10/88	156.1	157.1	155.5	137.8	138.0	156.1
03/09/88	162.9	163.1	163.5	148.5	148.8	162.8
04/06/88	164.8	171.8	170.9	153.0	156.0	165.4
05/12/88	157.1	162.3	161.1	**	**	159.3
*06/22/88	118.9	116.3	115.8	115.7	121.8	119.5
07/13/88	130.9	130.6	132.8	124.6	127.6	131.1
08/16/88	137.7	138.2	138.3	143.1	143.0	137.2
09/30/88	128.8	129.7	131.0	132.7	133.7	129.6
10/19/88	129.5	129.2	129.9	146.9	146.0	128.3
11/28/88	136.2	141.3	140.5	129.1	137.8	137.4
12/14/88	179.3	179.5	178.8	173.4	191.8	180.0
Mean	147.1	148.2	148.1	141.0	144.8	147.1
SD	18.13	18.99	18.46	14.92	17.60	17.99
Maximum	179.3	179.5	178.8	173.4	191.8	180.0
Minimum	118.9	116.3	115.8	115.7	121.8	119.5

* Calculated from Field Data.

** Field Meter Malfunctioned.

Table 4-8. Summary of Turbidity and Total Residual Chlorine Measurements for 1988.

Turbidity (NTU)

Sample Date	1	7	11	8
01/27/88	0.70	0.50	0.50	0.60
02/10/88	0.90	0.80	0.70	0.70
03/09/88	0.80	0.70	0.80	0.70
04/06/88	0.80	0.70	0.70	0.70
05/12/88	1.40	1.50	1.40	1.50
06/22/88	0.90	1.00	1.00	1.10
07/13/88	1.00	0.70	0.80	0.80
08/16/88	0.80	0.80	1.00	0.80
09/30/88	0.60	0.70	0.70	0.70
10/19/88	0.80	0.70	0.50	0.80
11/28/88	0.90	0.60	0.60	0.60
12/14/88	0.60	0.50	0.60	0.60
Mean	0.85	0.77	0.78	0.80
SD	0.20	0.26	0.25	0.25
Maximum	1.40	1.50	1.40	1.50
Minimum	0.6	0.5	0.5	0.6

Total Residual Chlorine (ug/l)

Sample Date	1	7	11	8
01/27/88	<50.0	<50.0	<50.0	<50.0
02/10/88	<50.0	<50.0	<50.0	<50.0
03/09/88	<50.0	<50.0	<50.0	<50.0
04/06/88	<50.0	<50.0	<50.0	<50.0
05/12/88	<50.0	<50.0	<50.0	<50.0
06/22/88	<50.0	<50.0	<50.0	<50.0
07/13/88	<50.0	<50.0	<50.0	<50.0
08/16/88	<50.0	<50.0	<50.0	<50.0
09/30/88	<50.0	<50.0	<50.0	<50.0
10/19/88	<50.0	<50.0	<50.0	<50.0
11/28/88	<50.0	<50.0	<50.0	<50.0
12/14/88	<50.0	<50.0	<50.0	<50.0
Mean	-	-	-	-
SD	-	-	-	-
Maximum	-	-	-	-
Minimum	<50.0	<50.0	<50.0	<50.0

Table 4-9. Summary of Copper Measurements for 1988.

Copper (ug/l)

Sample Date	1	7	11	11M	11B	8
01/27/88	1.0	1.0	1.0	1.3	1.3	1.0
02/10/88	1.0	1.0	2.0	2.7	2.0	2.0
03/09/88	2.0	2.0	1.7	1.7	1.7	2.0
04/06/88	1.0	1.4	1.7	1.2	1.7	0.7
05/12/88	1.1	1.1	1.3	2.5	1.5	0.9
06/22/88	1.0	1.0	1.0	0.6	1.0	0.8
07/13/88	1.9	0.8	0.8	1.5	1.4	0.9
08/16/88	1.4	1.1	2.2	0.9	1.0	2.0
09/30/88	0.7	0.6	0.7	0.7	0.8	0.5
10/19/88	0.8	0.7	0.6	0.7	0.9	0.8
11/28/88	2.7	1.0	0.7	1.2	1.1	0.6
12/14/88	0.5	0.8	0.8	1.3	0.8	0.7
Mean	1.3	1.0	1.2	1.4	1.3	1.1
SD	0.61	0.35	0.53	0.64	0.38	0.55
Maximum	2.7	2.0	2.2	2.7	2.0	2.0
Minimum	0.5	0.6	0.6	0.6	0.8	0.5

*Results are average of 3 measurements per station.

Table 4-10. Summary of Nickel and Zinc Measurements for 1988.

Nickel (ug/l)					Zinc (ug/l)				
Sample Date	1	7	11	8	Sample Date	1	7	11	8
01/27/88	1.1	<1.0	<1.0	<1.0	01/27/88	10.4	10.7	9.6	10.2
02/10/88	<1.0	<1.0	<1.0	<1.0	02/10/88	12.8	12.2	13.2	12.2
03/09/88	<1.0	<1.0	<1.0	<1.0	03/09/88	-	8.3	8.0	6.9
04/06/88	<1.0	<1.0	<1.0	<1.0	04/06/88	7.3	8.8	9.1	7.8
05/12/88	<1.0	<1.0	<1.0	<1.0	05/12/88	8.7	9.3	8.9	8.8
06/22/88	0.3	0.1	<1.0	0.2	06/22/88	4.5	4.6	5.7	4.8
07/13/88	0.2	0.1	<1.0	0.2	07/13/88	11.0	9.0	12.0	9.0
08/16/88	1.2	1.2	1.7	1.2	08/16/88	8.0	8.0	5.0	8.0
09/30/88	1.7	1.2	1.4	1.6	09/30/88	7.0	6.0	5.0	5.0
10/19/88	1.3	1.7	1.6	1.6	10/19/88	6.0	7.0	6.0	7.0
11/28/88	1.7	1.7	1.9	1.6	11/28/88	3.9	3.5	3.7	3.3
12/14/88	1.6	1.7	1.9	2.0	12/14/88	3.4	3.6	3.6	4.4
Mean*	1.1	1.1	1.7	1.2	Mean	7.5	7.6	7.5	7.3
SD*	0.55	0.67	0.19	0.67	SD	2.89	2.62	3.02	2.49
Maximum	1.7	1.7	1.9	2.0	Maximum	12.8	12.2	13.2	12.2
Minimum	<1.0	<1.0	<1.0	<1.0	Minimum	3.4	3.5	3.6	3.3

* Less than values not included.

Table 4-11. Summary of Iron and Lead Measurements for 1988.

Sample Date	Iron (ug/l) 1	7	11	8	Sample Date	Lead (ug/l) 1	7	11	8
01/27/88	50.0	43.0	39.0	43.0	01/27/88	1.9	2.4	0.7	1.8
02/10/88	44.0	65.0	48.0	48.0	02/10/88	3.9	1.1	1.7	1.8
03/09/88	54.0	55.0	48.0	58.0	03/09/88	1.2	0.6	0.6	0.7
04/06/88	37.0	37.0	40.0	41.0	04/06/88	0.6	0.7	1.5	0.6
05/12/88	103.0	82.0	92.0	104.0	05/12/88	1.3	1.2	0.7	0.7
06/22/88	74.0	70.0	75.0	74.0	06/22/88	0.8	1.5	1.0	1.0
07/13/88	63.0	61.0	62.0	71.0	07/13/88	0.7	0.6	0.8	0.7
08/16/88	78.0	78.0	77.0	76.0	08/16/88	0.6	1.0	0.9	1.0
09/30/88	45.0	51.0	49.0	55.0	09/30/88	0.7	1.0	0.9	0.7
10/19/88	72.0	79.0	73.0	74.0	10/19/88	1.5	1.4	1.2	2.5
11/28/88	34.0	39.7	28.2	41.9	11/28/88	0.8	1.1	0.7	3.1
12/14/88	54.4	52.7	53.5	54.7	12/14/88	0.6	0.1	0.4	0.5
Mean	59.0	59.5	57.1	61.7	Mean	1.2	1.1	0.9	1.3
SD	19.07	14.95	18.05	17.91	SD	0.90	0.55	0.36	0.81
Maximum	103.0	82.0	92.0	104.0	Maximum	3.9	2.4	1.7	3.1
Minimum	34.0	37.0	28.2	41.0	Minimum	0.6	0.1	0.4	0.5

Table 4-12. Summary of Cadmium and Chromium Measurements for 1988.

Cadmium (ug/l)

Sample Date	1	7	11	8
01/27/88	0.2	0.1	0.1	0.2
02/10/88	0.2	0.2	0.1	-
03/09/88	0.1	0.1	0.1	0.1
04/06/88	0.1	0.2	0.1	0.2
05/12/88	<0.1	<0.1	<0.1	<0.1
06/22/88	<0.1	<0.1	<0.1	<0.1
07/13/88	<0.1	<0.1	<0.1	<0.1
08/16/88	<0.1	<0.1	<0.1	<0.1
09/30/88	<0.1	<0.1	<0.1	<0.1
10/19/88	0.1	<0.1	<0.1	0.0
11/28/88	<0.1	0.2	<0.1	0.1
12/14/88	0.3	0.2	0.2	0.1
Mean*	0.2	0.2	0.1	0.1
SD*	0.07	0.05	0.04	0.07
Maximum	0.3	0.2	0.2	0.2
Minimum	<1.0	<1.0	<1.0	0.0

* Less than values not included.

Chromium (ug/l)

Sample Date	1	7	11	8
01/27/88	0.3	0.1	0.1	0.1
02/10/88	0.1	0.2	0.1	0.1
03/09/88	0.3	0.5	0.1	0.6
04/06/88	0.3	<0.1	<0.1	<0.1
05/12/88	0.1	<0.1	<0.1	<0.1
06/22/88	0.1	0.0	0.1	0.1
07/13/88	0.3	0.3	0.3	0.2
08/16/88	0.2	0.2	0.1	0.2
09/30/88	0.2	0.2	0.2	0.1
10/19/88	0.2	0.2	0.1	0.1
11/28/88	0.1	0.1	0.2	0.2
12/14/88	0.3	0.2	0.3	0.3
Mean*	0.2	0.2	0.2	0.2
SD*	0.09	0.13	0.08	0.15
Maximum	0.3	0.5	0.3	0.6
Minimum	0.1	0.0	<0.1	<0.1

* Less than values not included.

Table 4-13. Summary of Oil and Grease, and Ammonia Measurements for 1988.

Oil & Grease (mg/l)

Sample Date	1	7	11	8
01/27/88	<0.50	<0.50	<0.50	<0.50
02/10/88	<0.50	<0.50	<0.50	<0.50
03/09/88	<0.50	<0.50	<0.50	<0.50
04/06/88	<0.50	<0.50	<0.50	<0.50
05/12/88	-	<0.50	<0.50	<0.50
06/22/88	<0.50	<0.50	<0.50	<0.50
07/13/88	<0.50	<0.50	<0.50	<0.50
08/16/88	<0.50	<0.50	<0.50	<0.50
09/30/88	<0.50	<0.50	<0.50	<0.50
10/19/88	<0.50	<0.50	<0.50	<0.50
11/28/88	<0.50	<0.50	<0.50	<0.50
12/14/88	<0.50	<0.50	0.09	<0.50
Mean*	-	-	0.09	-
SD*	-	-	0.00	-
Maximum	-	-	0.09	-
Minimum	<0.50	<0.50	<0.50	<0.50

*Less than values not included.

Ammonia (mg/l)

Sample Date	1	7	11	8
01/27/88	0.02	0.03	0.03	0.03
02/10/88	0.01	0.01	0.01	0.01
03/09/88	0.02	0.03	0.03	0.02
04/06/88	0.03	0.04	0.03	0.03
05/12/88	<0.01	<0.01	<0.01	<0.01
06/22/88	<0.01	0.02	0.01	0.01
07/13/88	0.03	0.03	0.02	0.02
08/16/88	0.03	0.04	0.04	0.04
09/30/88	0.03	0.03	0.03	0.03
10/19/88	<0.01	<0.01	<0.01	<0.01
11/28/88	0.01	0.01	0.01	0.01
12/14/88	0.05	0.05	0.05	0.04
Mean*	0.03	0.03	0.03	0.02
SD*	0.01	0.01	0.01	0.01
Maximum	0.05	0.05	0.05	0.04
Minimum	<0.01	<0.01	<0.01	<0.01

*Less than values not included.

Table 4-14. Summary of Nitrate and Total Phosphorus Measurements for 1988.

Nitrate (mg/l)					Total Phophorus (mg/l)				
Sample Date	1	7	11	8	Sample Date	1	7	11	8
01/27/88	0.42	0.41	0.42	0.36	01/27/88	0.03	0.03	0.04	0.03
02/10/88	0.80	0.80	0.80	0.80	02/10/88	0.03	0.03	0.04	0.03
03/09/88	0.30	0.30	0.30	0.30	03/09/88	0.02	0.02	0.02	0.02
04/06/88	0.25	0.17	0.20	0.17	04/06/88	0.01	0.02	0.02	0.01
05/12/88	0.26	0.25	0.25	0.29	05/12/88	0.01	0.01	0.01	0.01
06/22/88	0.31	0.31	0.25	0.29	06/22/88	0.01	0.01	0.01	0.01
07/13/88	0.20	0.20	0.20	0.20	07/13/88	0.01	0.01	0.02	0.01
08/16/88	0.50	0.40	0.30	0.50	08/16/88	0.02	0.02	0.02	0.02
09/30/88	0.20	0.20	0.20	0.10	09/30/88	0.02	0.02	0.02	0.02
10/19/88	0.20	0.20	0.20	0.20	10/19/88	0.03	0.03	0.03	0.03
11/28/88	0.30	0.30	0.30	0.32	11/28/88	0.03	0.04	0.04	0.05
12/14/88	0.27	0.25	0.22	0.22	12/14/88	0.03	0.03	0.03	0.03
Mean	0.33	0.32	0.30	0.31	Mean	0.02	0.02	0.03	0.02
SD	0.16	0.16	0.16	0.18	SD	0.01	0.01	0.01	0.01
Maximum	0.80	0.80	0.80	0.80	Maximum	0.03	0.04	0.04	0.05
Minimum	0.20	0.20	0.20	0.10	Minimum	0.01	0.01	0.01	0.01

Table 4-15. Summary for Orthophosphate and Sulfate Measurements for 1988.

Sample Date	Orthophosphate (mg/l) 1	7	11	8
01/27/88	0.02	0.02	0.02	0.02
02/10/88	0.02	0.02	0.03	0.02
03/09/88	0.01	0.01	0.02	0.01
04/06/88	0.01	0.01	0.01	0.01
05/12/88	0.01	0.01	0.01	0.01
06/22/88	<0.01	<0.01	<0.01	<0.01
07/13/88	0.01	0.01	0.01	0.01
08/16/88	0.01	0.01	0.01	0.01
09/30/88	0.02	0.02	0.02	0.03
10/19/88	0.02	0.02	0.02	0.02
11/28/88	0.02	0.03	0.03	0.02
12/14/88	0.03	0.03	0.03	0.03
Mean*	0.02	0.02	0.02	0.02
SD*	0.01	0.01	0.08	0.01
Maximum	0.03	0.03	0.03	0.03
Minimum	<0.01	<0.01	<0.01	<0.01

Sample Date	Sulfate (mg/l) 1	7	11	8
01/27/88	14.5	15.0	15.5	15.0
02/10/88	13.0	14.5	16.0	13.5
03/09/88	13.0	13.0	13.5	13.0
04/06/88	12.0	14.0	13.5	10.2
05/12/88	14.0	14.0	13.5	13.0
06/22/88	10.5	9.5	9.5	9.3
07/13/88	10.5	10.0	10.0	9.5
08/16/88	9.0	11.0	11.5	9.0
09/30/88	11.0	11.0	10.0	10.5
10/19/88	10.5	11.0	11.0	10.5
11/28/88	10.5	14.5	13.0	10.0
12/14/88	11.5	12.5	12.5	13.0
Mean	11.7	12.5	12.5	11.4
SD	1.59	1.85	2.03	1.91
Maximum	14.5	15.0	16.0	15.0
Minimum	9.0	9.5	9.5	9.0

*Less than values not included

Table 4-16. Summary of Total Dissolved and Total Suspended Solids Measurements for 1988.

	Total Dissolved Solids (mg/l)					Total Suspended Solids (mg/l)			
Sample Date	1	7	11	8	Sample Date	1	7	11	8
01/27/88	109.0	100.0	103.0	97.0	01/27/88	0.6	1.1	0.7	1.1
02/10/88	97.0	96.0	99.0	94.0	02/10/88	1.1	0.8	1.2	1.4
03/09/88	96.0	99.0	97.0	94.0	03/09/88	2.1	2.2	1.8	1.9
04/06/88	84.0	86.0	89.0	85.0	04/06/88	0.7	2.6	1.8	2.6
05/12/88	96.0	100.0	98.0	94.0	05/12/88	8.2	8.0	7.9	7.9
06/22/88	75.0	75.0	75.0	70.0	06/22/88	5.4	5.2	5.3	5.1
07/13/88	74.0	76.0	78.0	79.0	07/13/88	3.6	3.8	3.9	3.9
08/16/88	89.0	88.0	89.0	86.0	08/16/88	4.7	4.8	4.9	4.5
09/30/88	89.0	82.0	81.0	80.0	09/30/88	2.2	2.3	2.3	2.2
10/19/88	74.0	78.0	79.0	79.0	10/19/88	3.0	3.5	3.9	3.9
11/28/88	80.0	78.0	71.0	72.0	11/28/88	1.4	1.3	1.6	1.3
12/14/88	75.0	73.0	76.0	74.0	12/14/88	1.7	1.8	1.7	1.5
Mean	86.5	85.9	86.3	83.7	Mean	2.9	3.1	3.1	3.1
SD	10.94	10.00	10.50	9.03	SD	2.17	2.00	2.04	1.95
Maximum	109.0	100.0	103.0	97.0	Maximum	8.2	8.0	7.9	7.9
Minimum	74.0	73.0	71.0	70.0	Minimum	0.6	0.8	0.7	1.1

Table 4-17 Quarterly Drinking Well Monitoring

Measurements January - December 1988

Date	pH	Alkalinity*	Nitrogen*	PO4*	PO4*
03/09/88	8.44	50.0	0.50	0.016	0.005
06/22/88	7.68	30.0	0.21	0.010	0.010
09/30/99	7.35	45.0	0.50	0.019	0.013
12/14/88	7.22	70.0	0.52	0.006	0.002

*mg/l

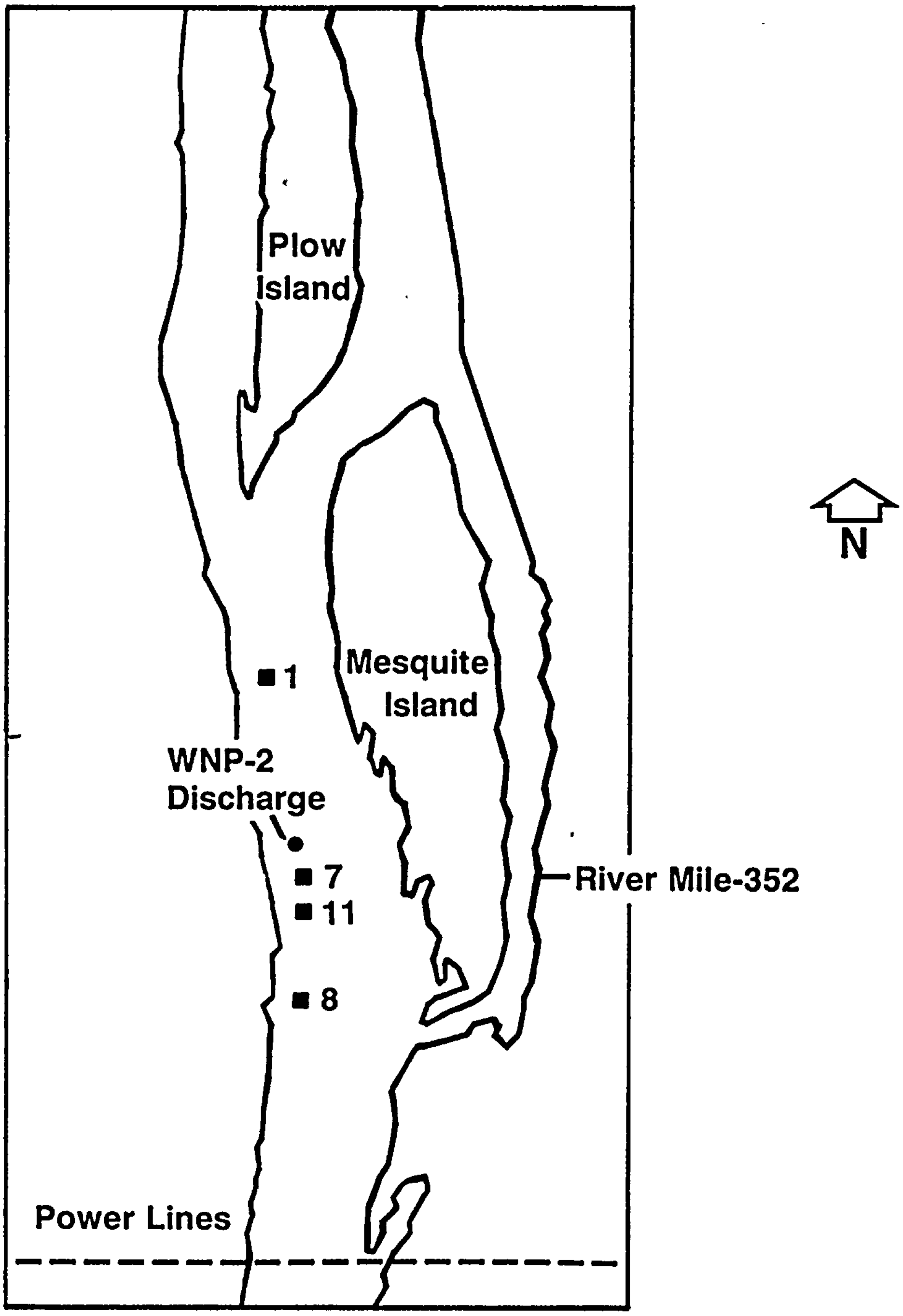


Figure 4-1. Location of Sampling Stations in the Columbia River

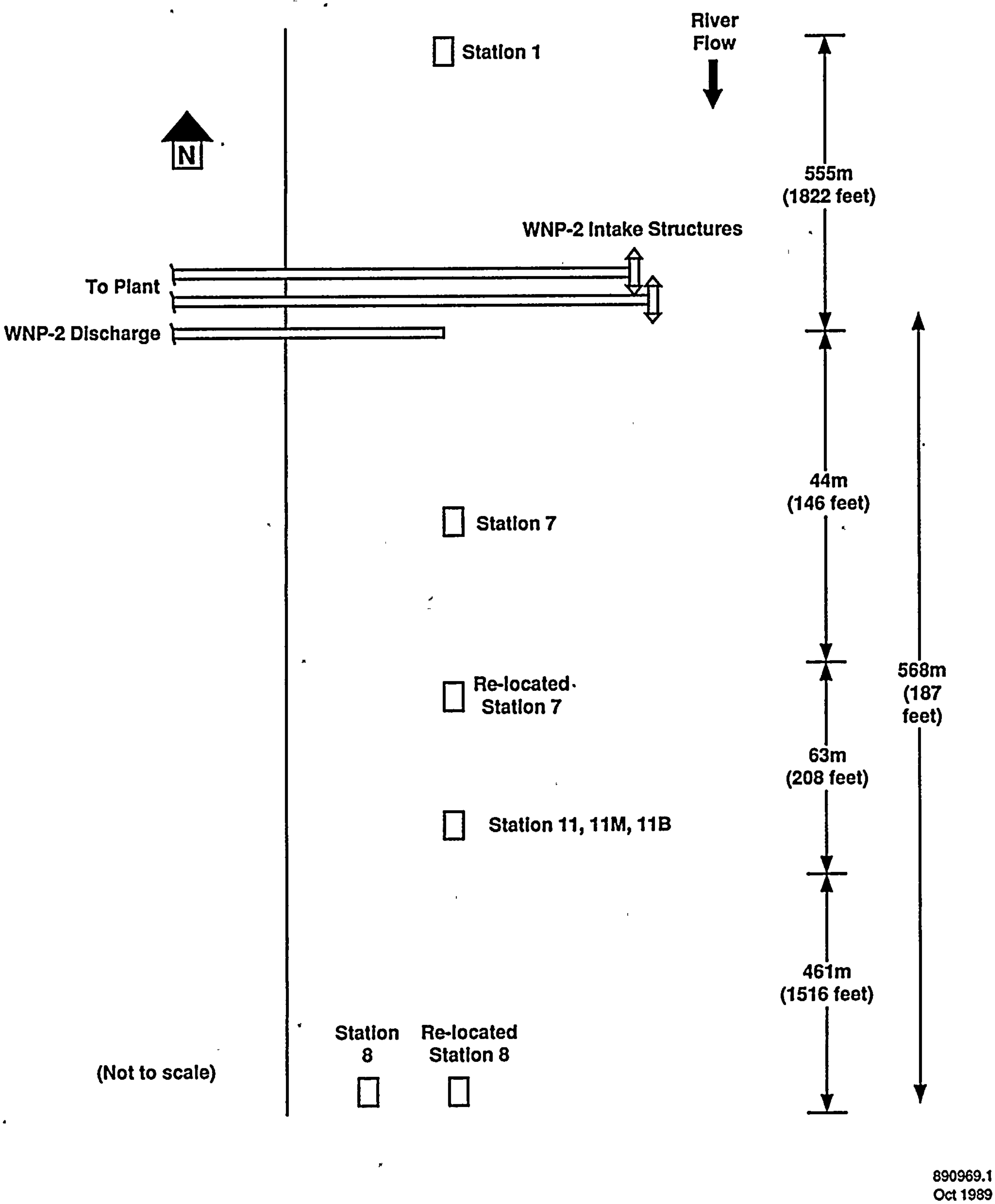


FIGURE 4-2. SAMPLING STATION LOCATIONS FOR WATER CHEMISTRY

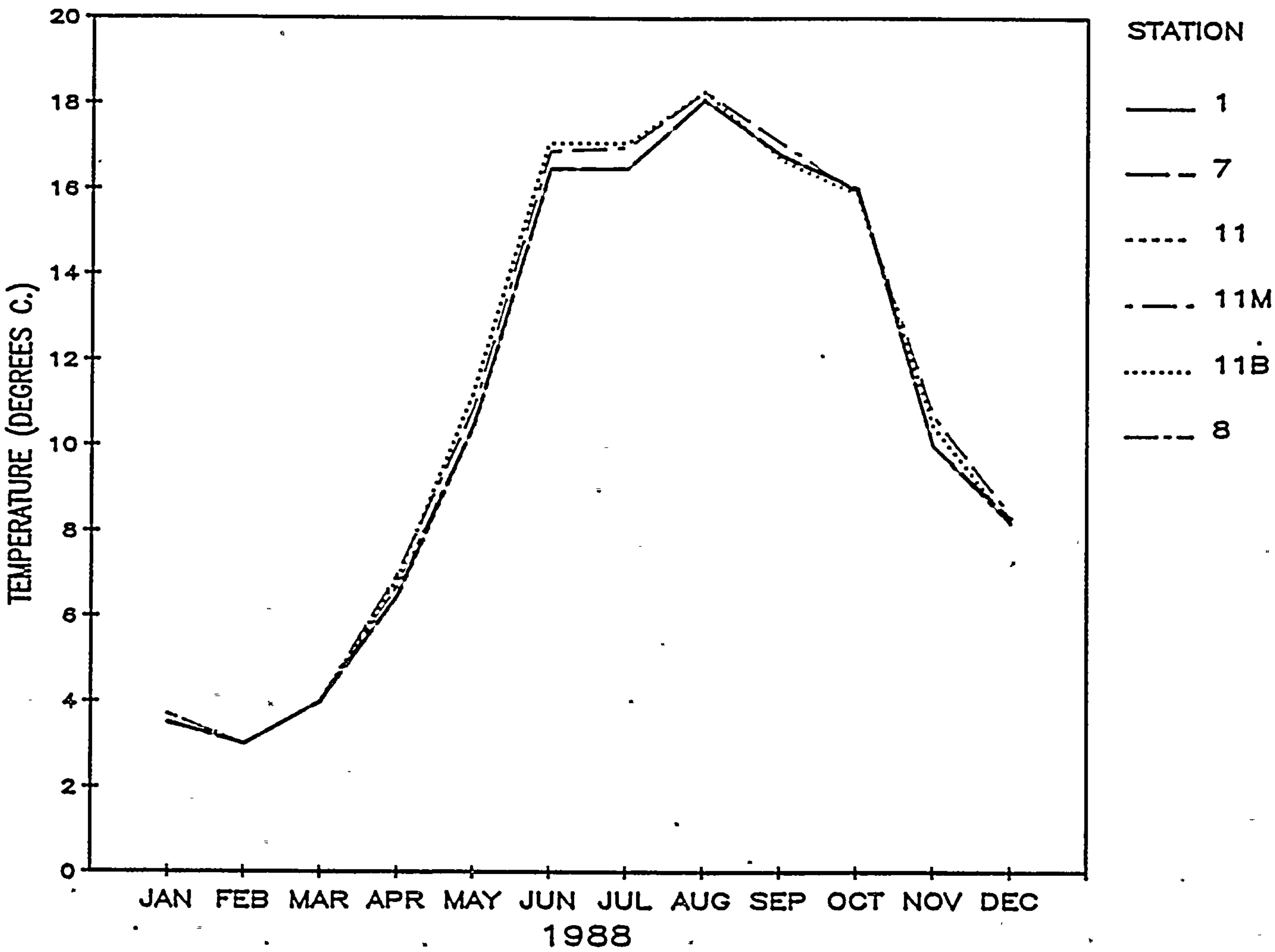


Figure 4-3. Columbia River Temperature Measurements at Six Stations During 1988

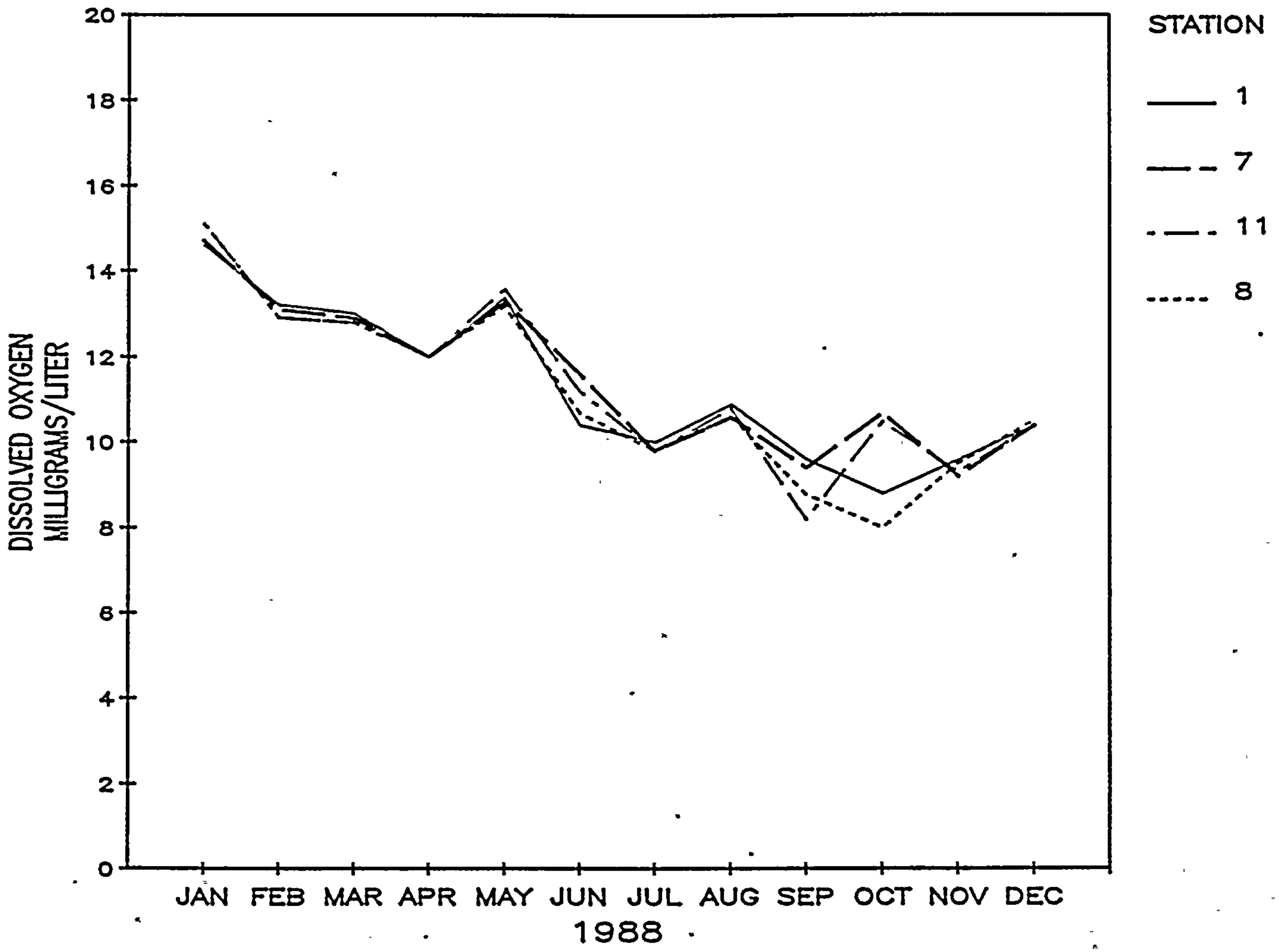


Figure 4-4. Columbia River Dissolved Oxygen Measurements at Four Stations During 1988

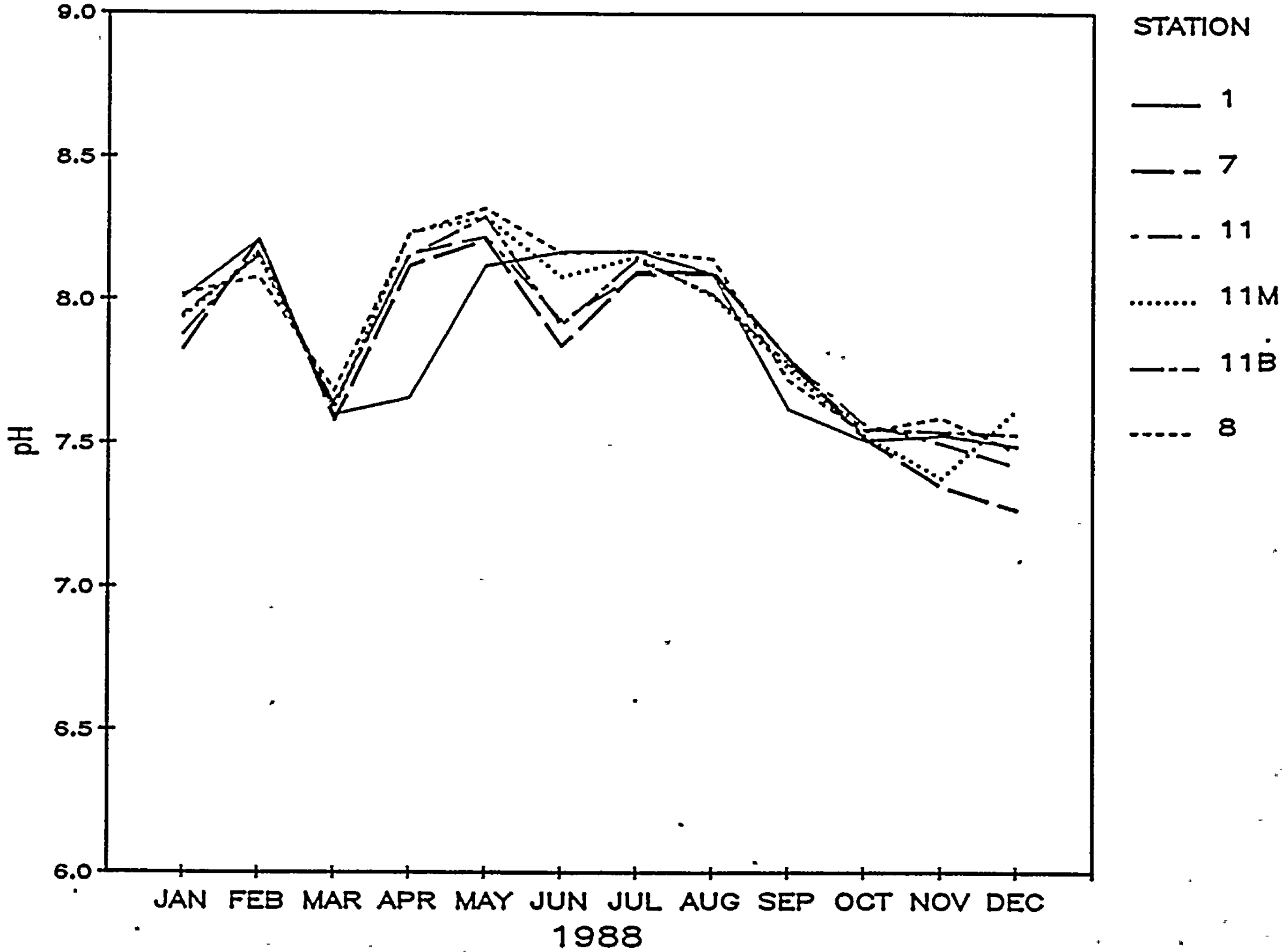


Figure 4-5. Columbia River pH Measurements at Six Stations During 1988

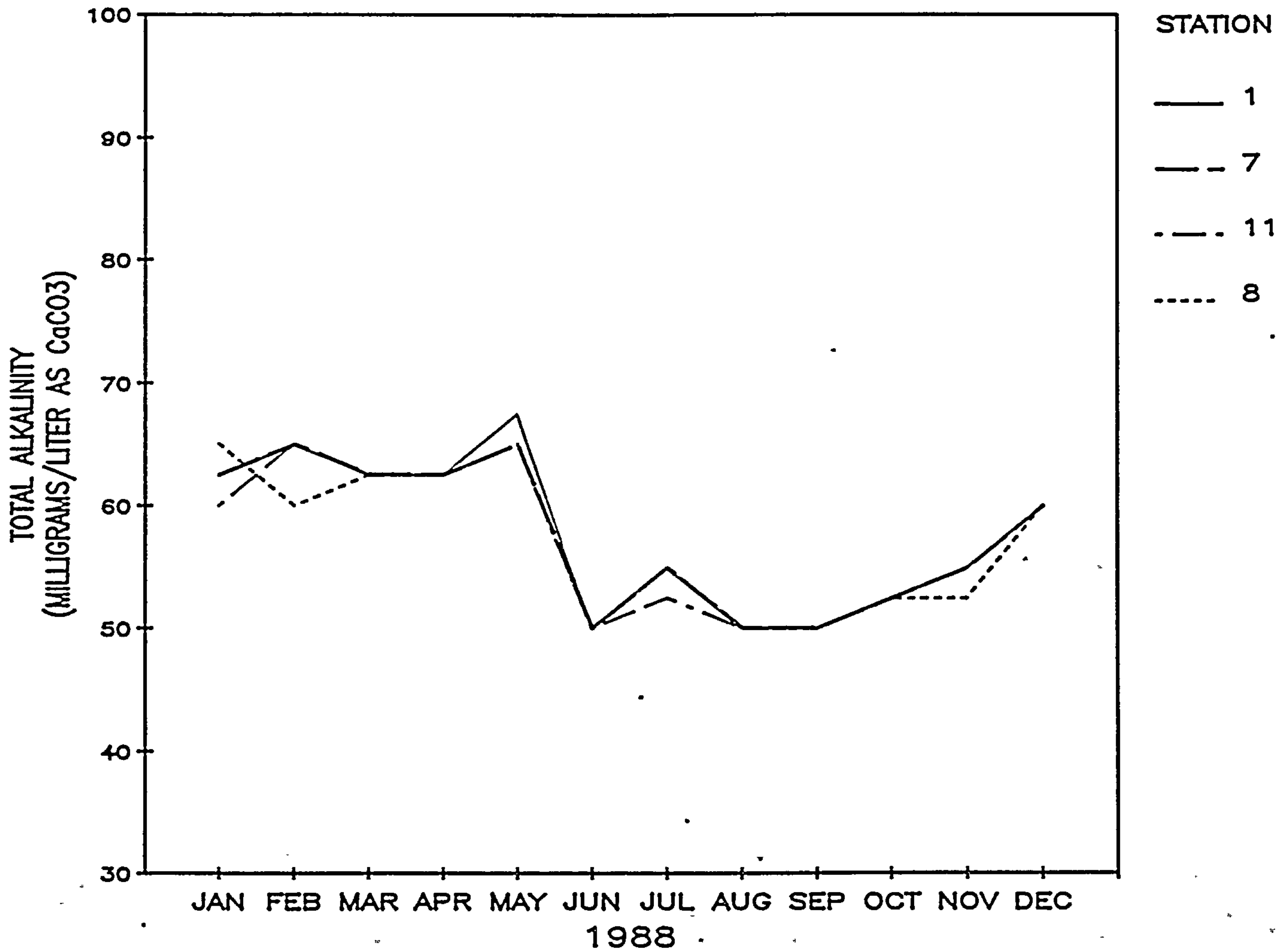


Figure 4-6. Columbia River Total Alkalinity Measurements at Four Stations During 1988

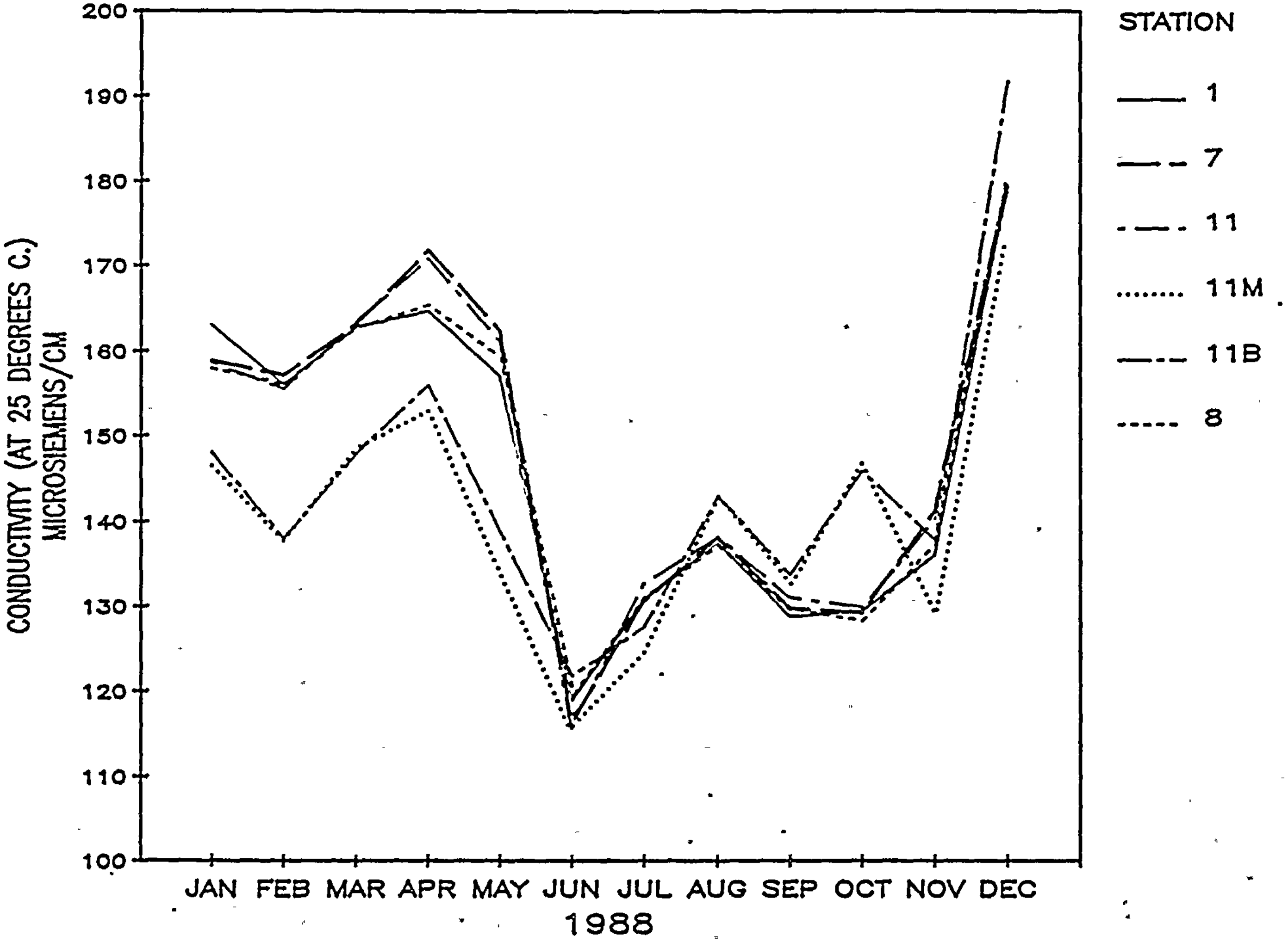


Figure 4-7. Columbia River Conductivity Measurements at Six Stations During 1988

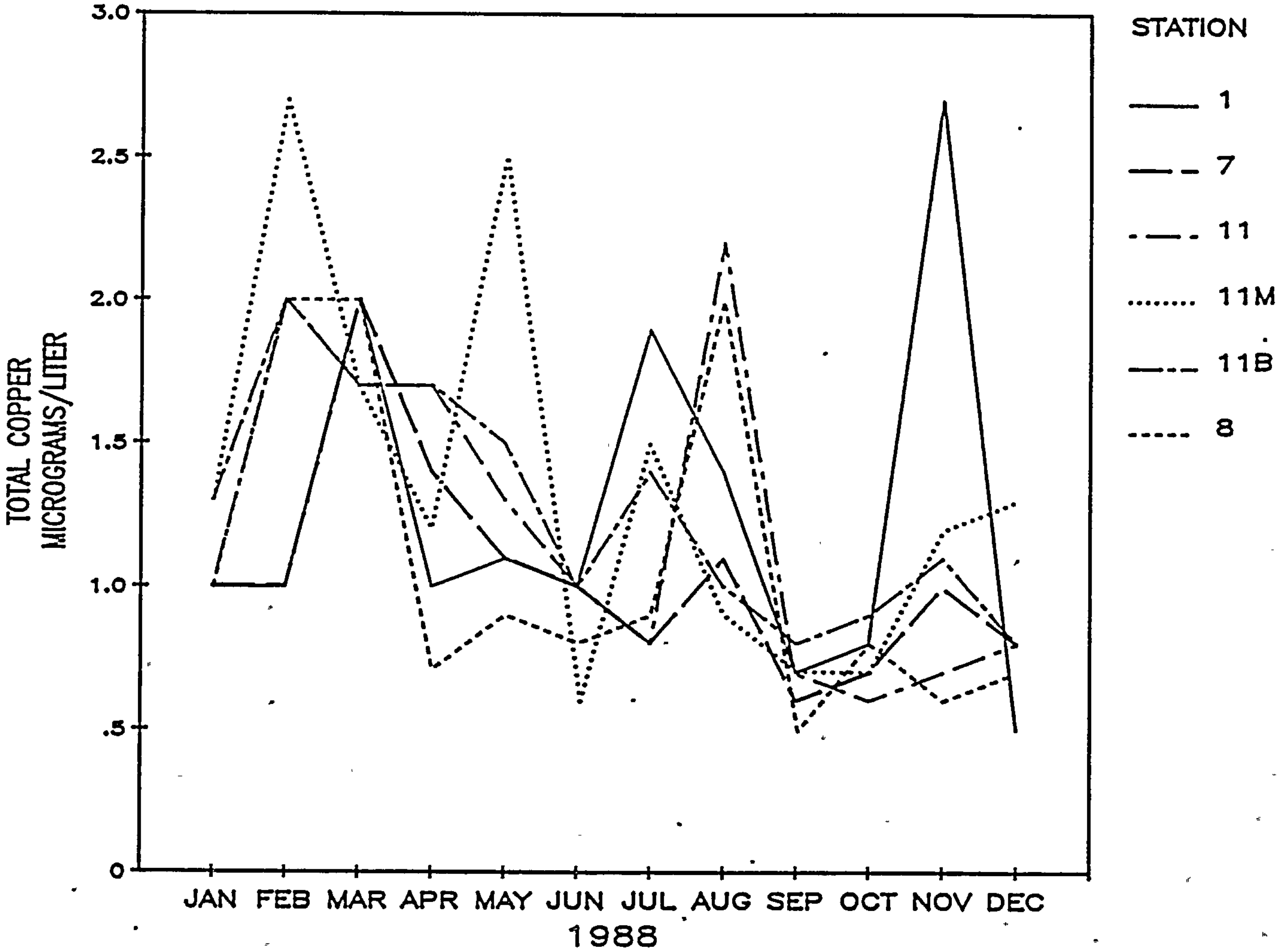


Figure 4-8. Columbia River Total Copper Measurements at Six Stations During 1988

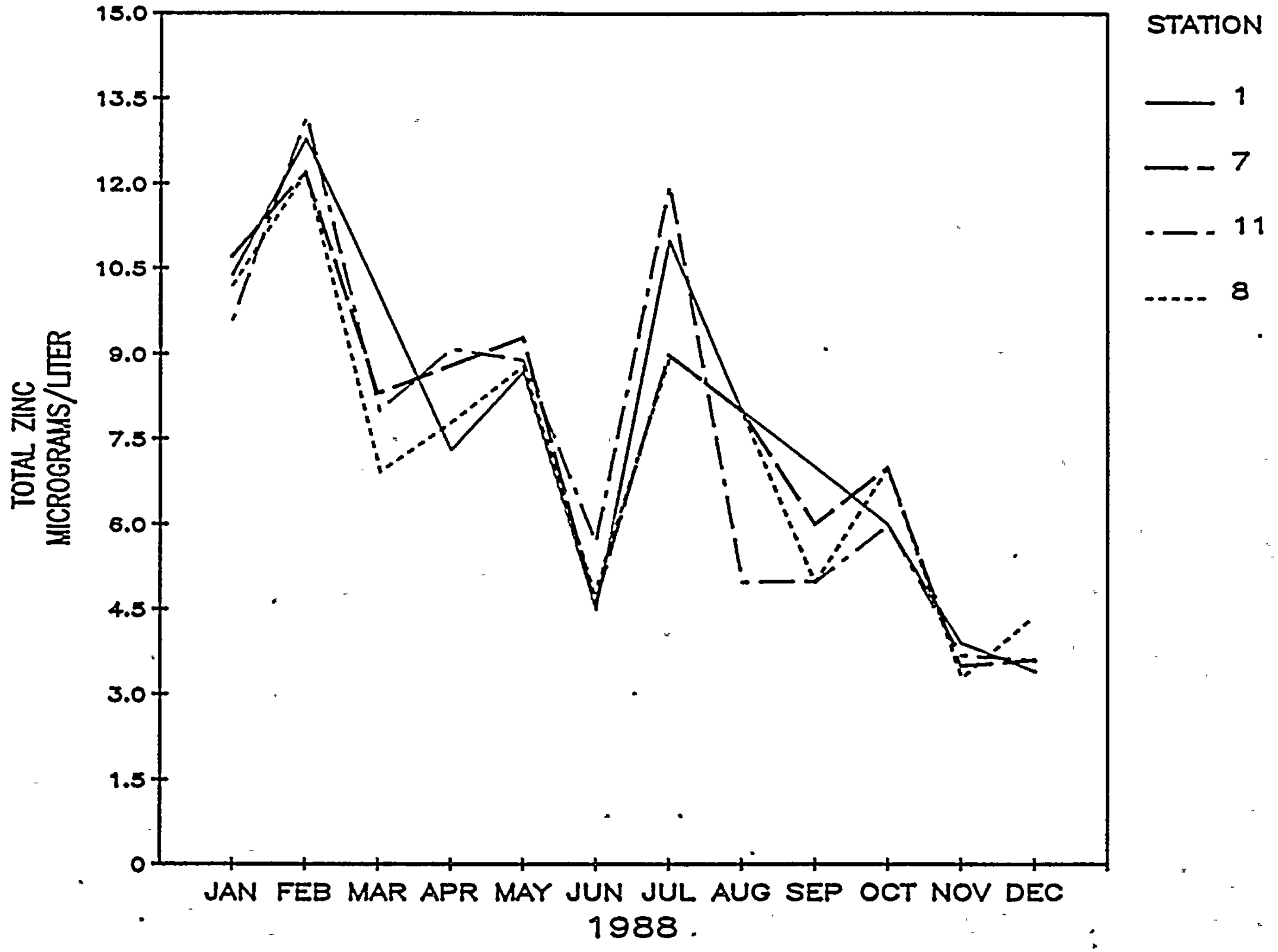


Figure 4-9. Columbia River Total Zinc Measurements at Four Stations During 1988

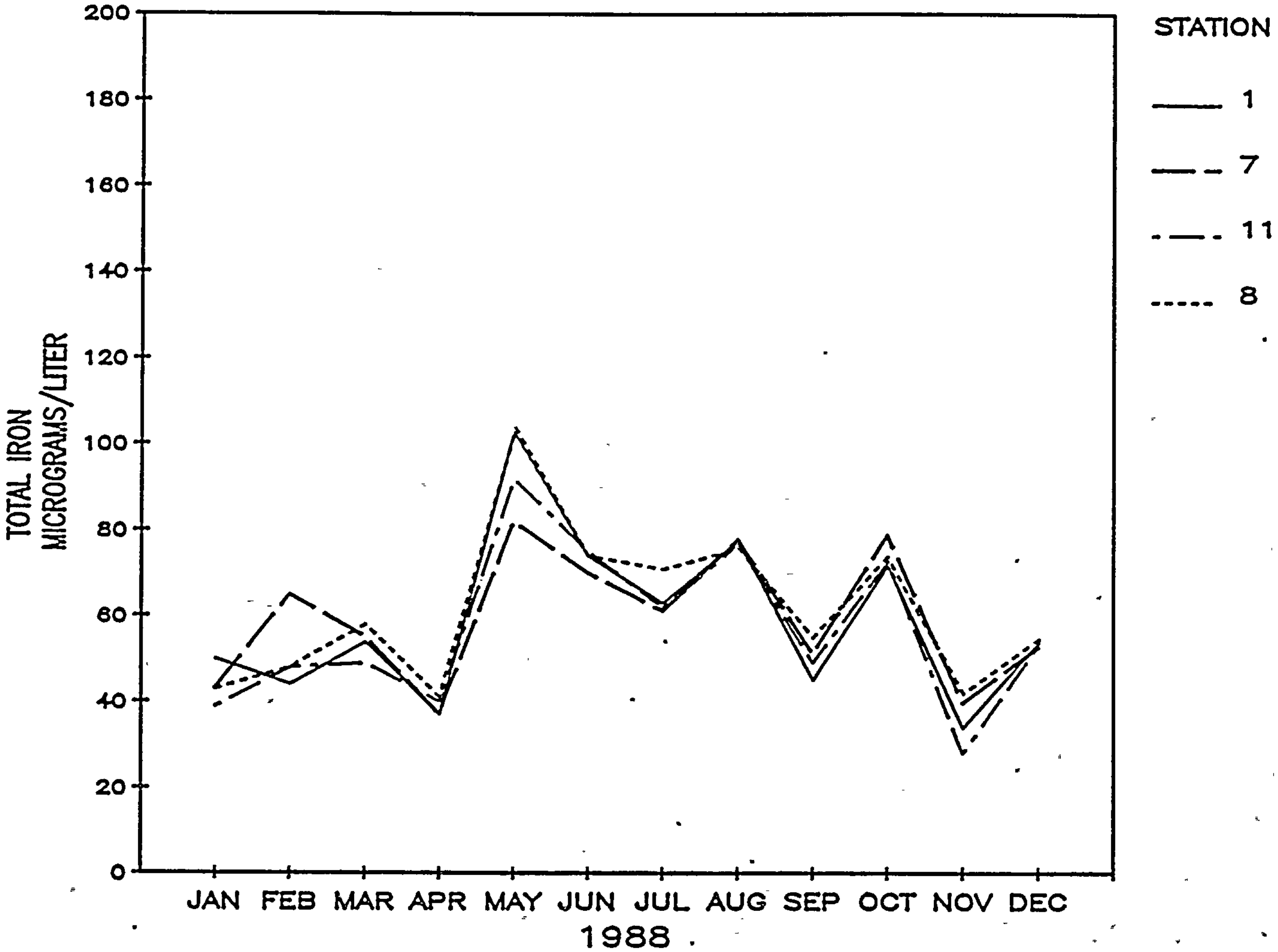


Figure 4-10. Columbia River Total Iron Measurements at Four Stations During 1988

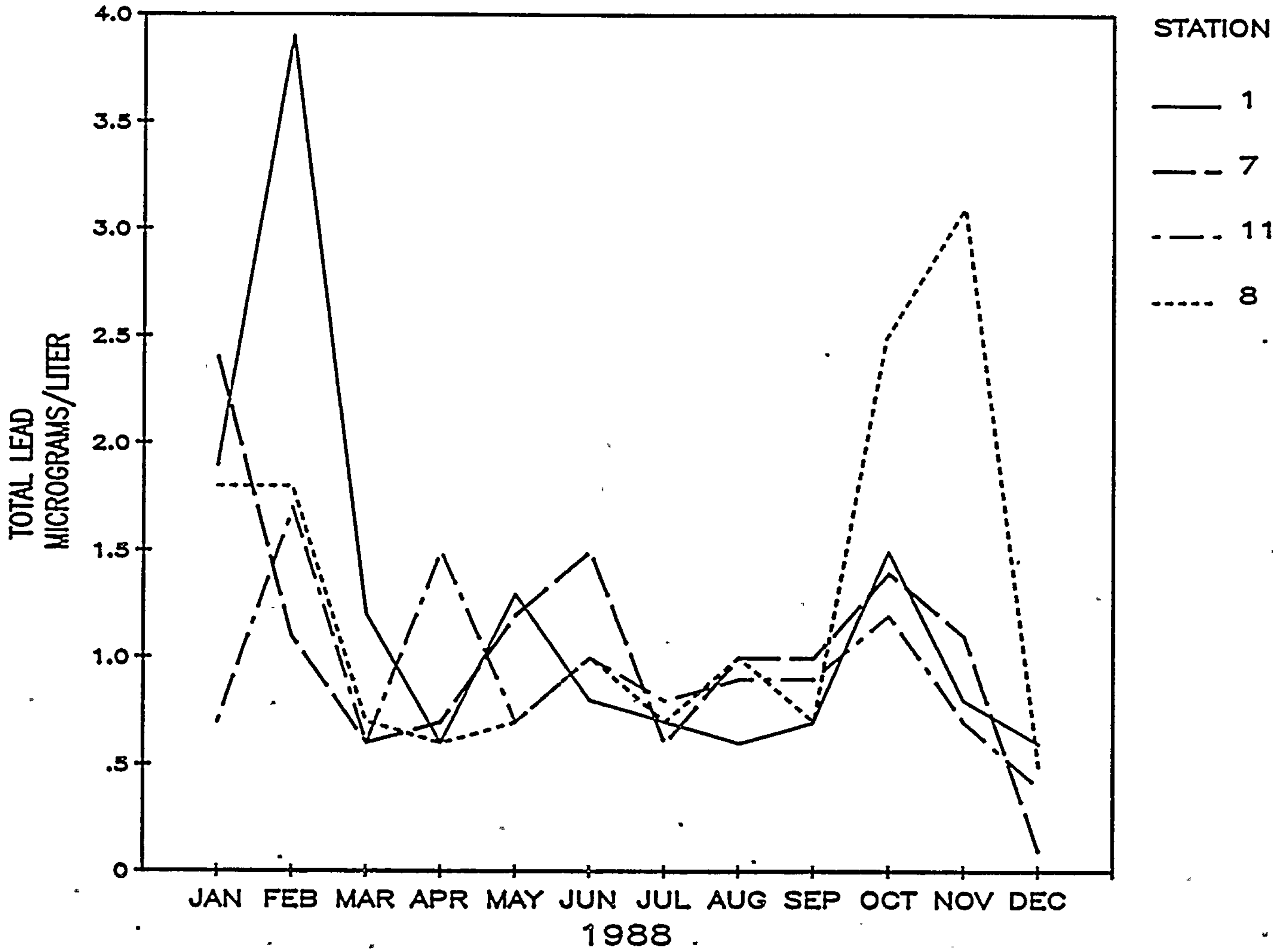


Figure 4-11. Columbia River Total Lead Measurements at Four Stations During 1988

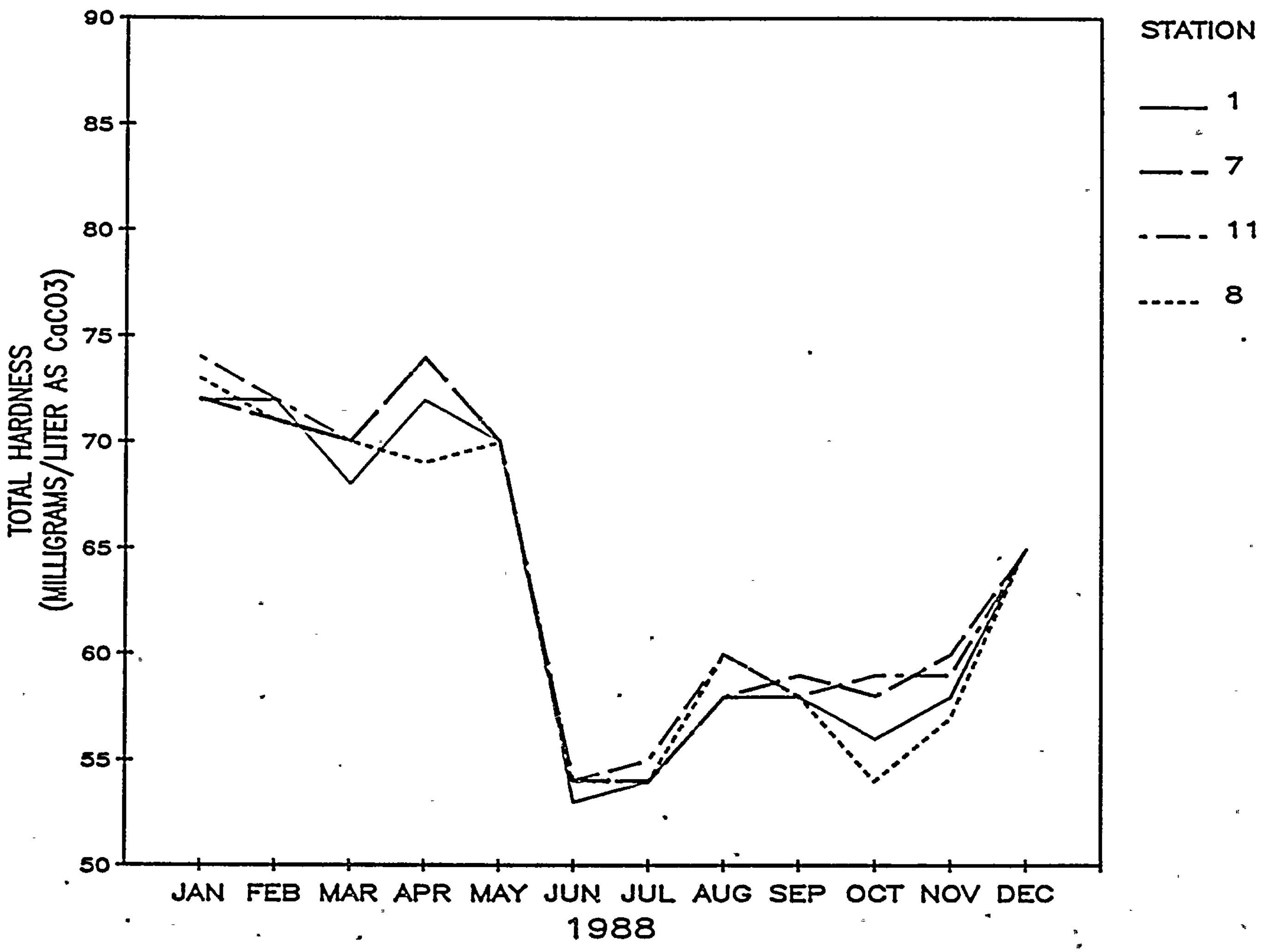


Figure 4-12. Columbia River Total Hardness Measurements at Four Stations During 1988

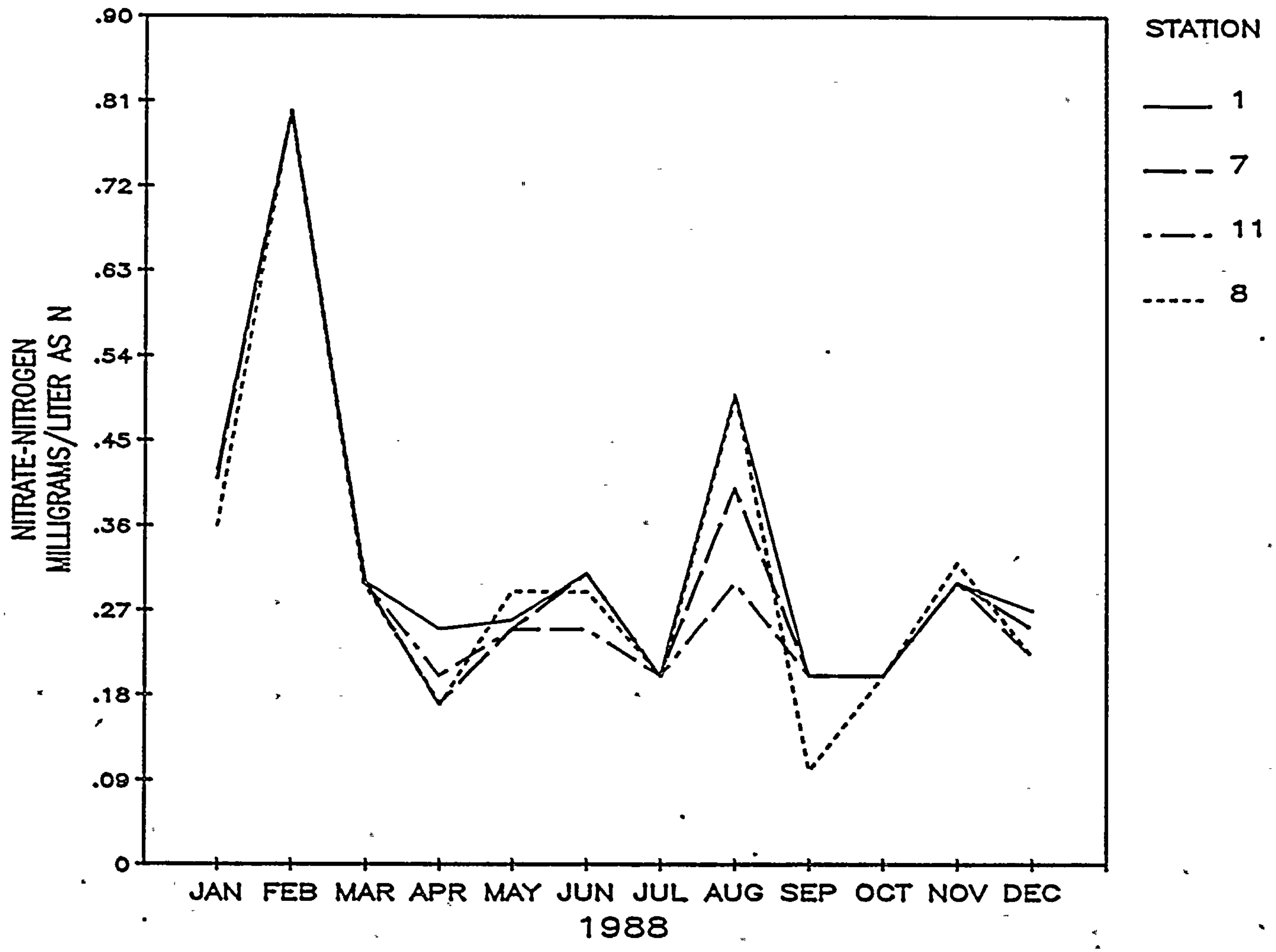


Figure 4-13. Columbia River Nitrate - Nitrogen Measurements at Four Stations During 1988

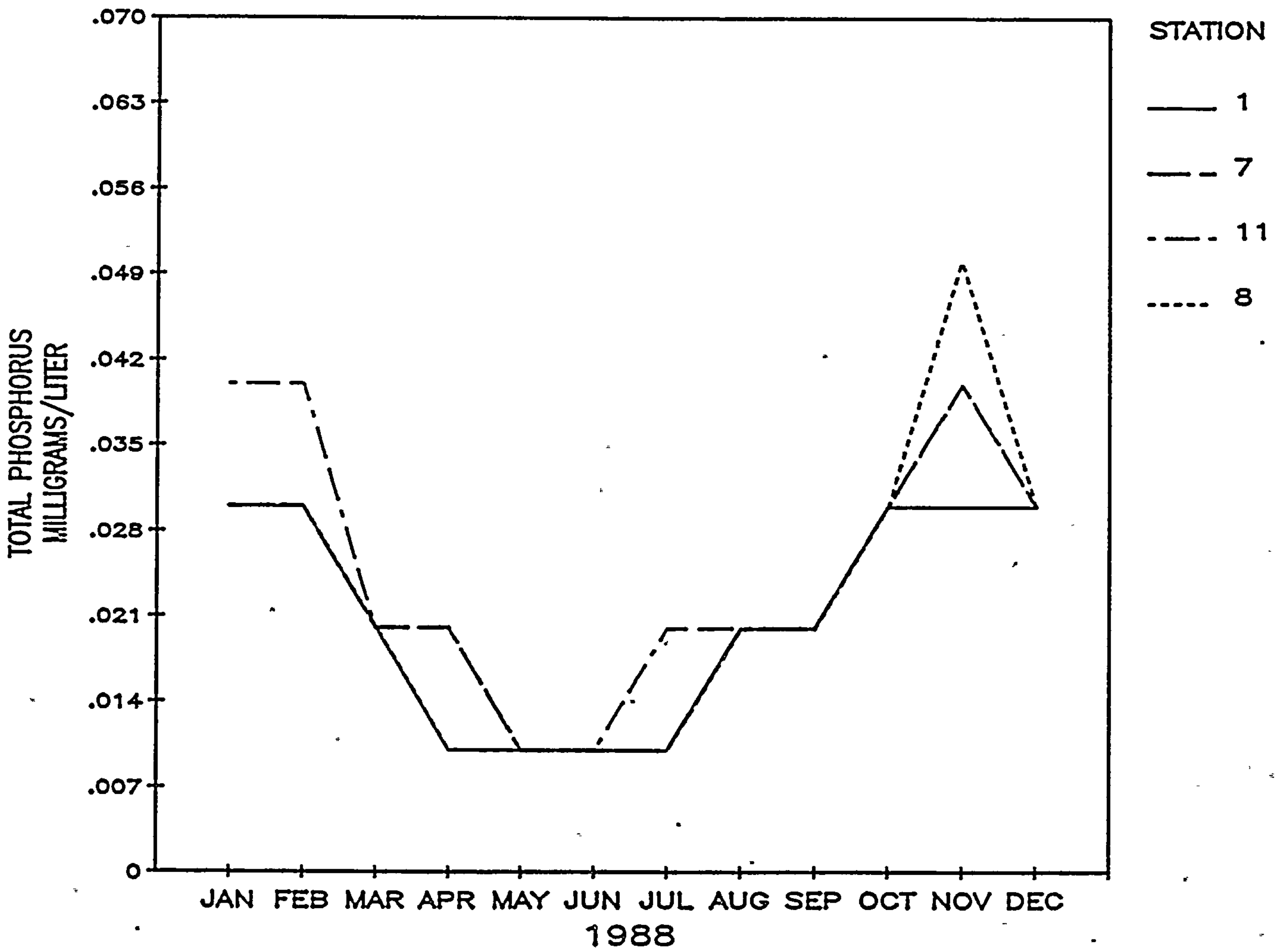


Figure 4-14. Columbia River Total Phosphorus Measurements at Four Stations During 1988

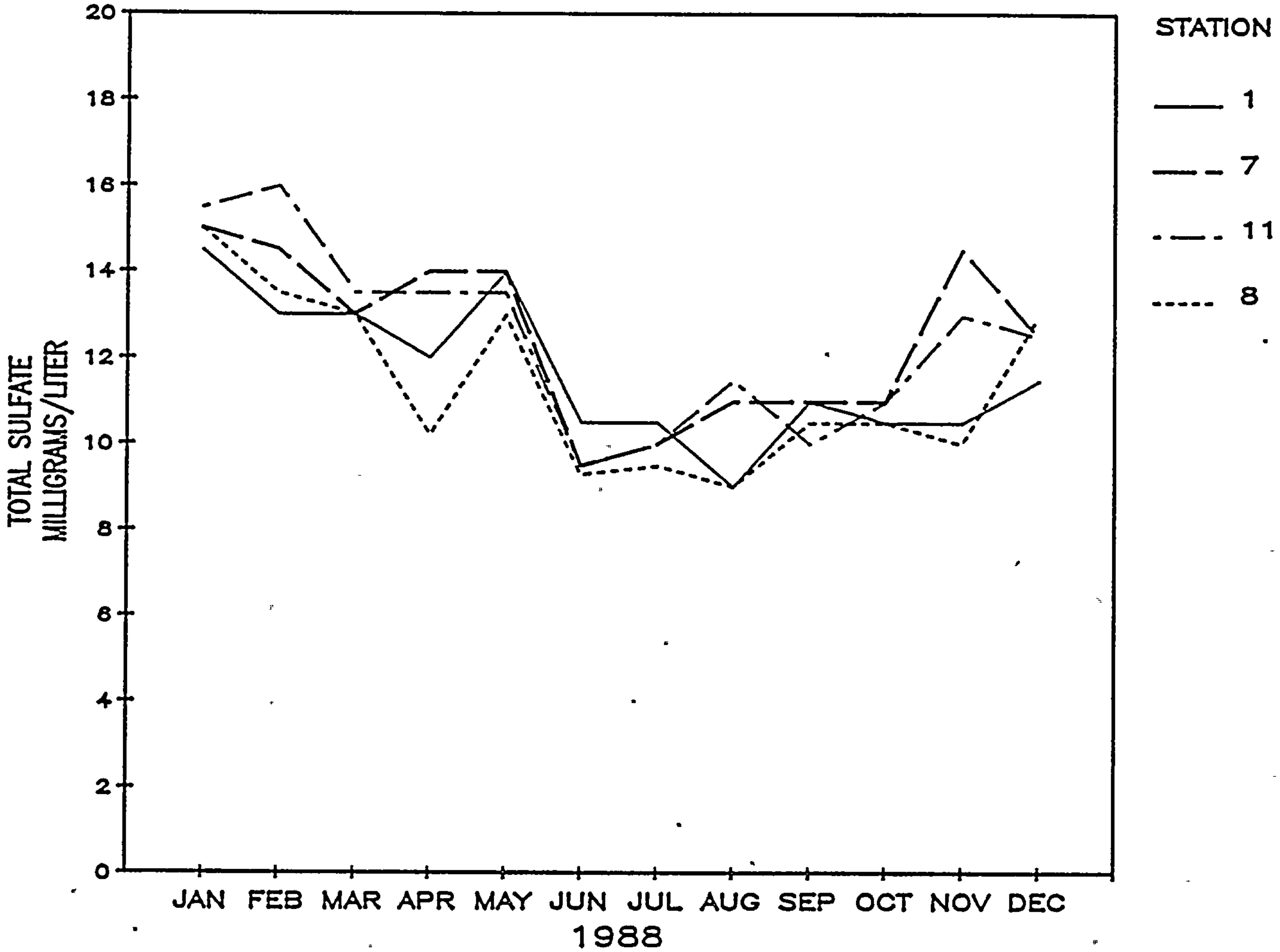


Figure 4-15. Columbia River Total Sulfate Measurements at Four Stations During 1988

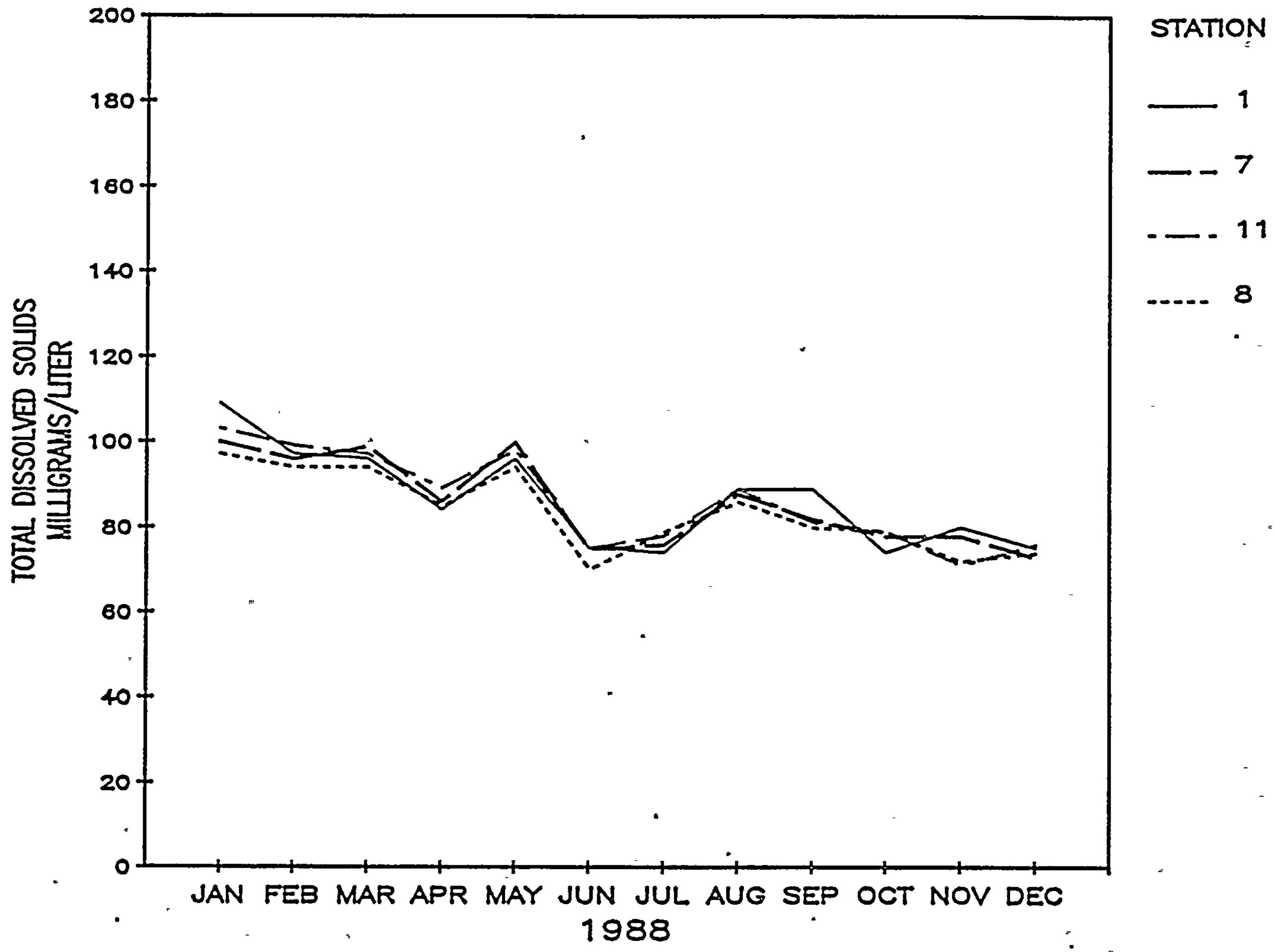


Figure 4-16. Columbia River Total Dissolved Solids Measurements at Four Stations During 1988

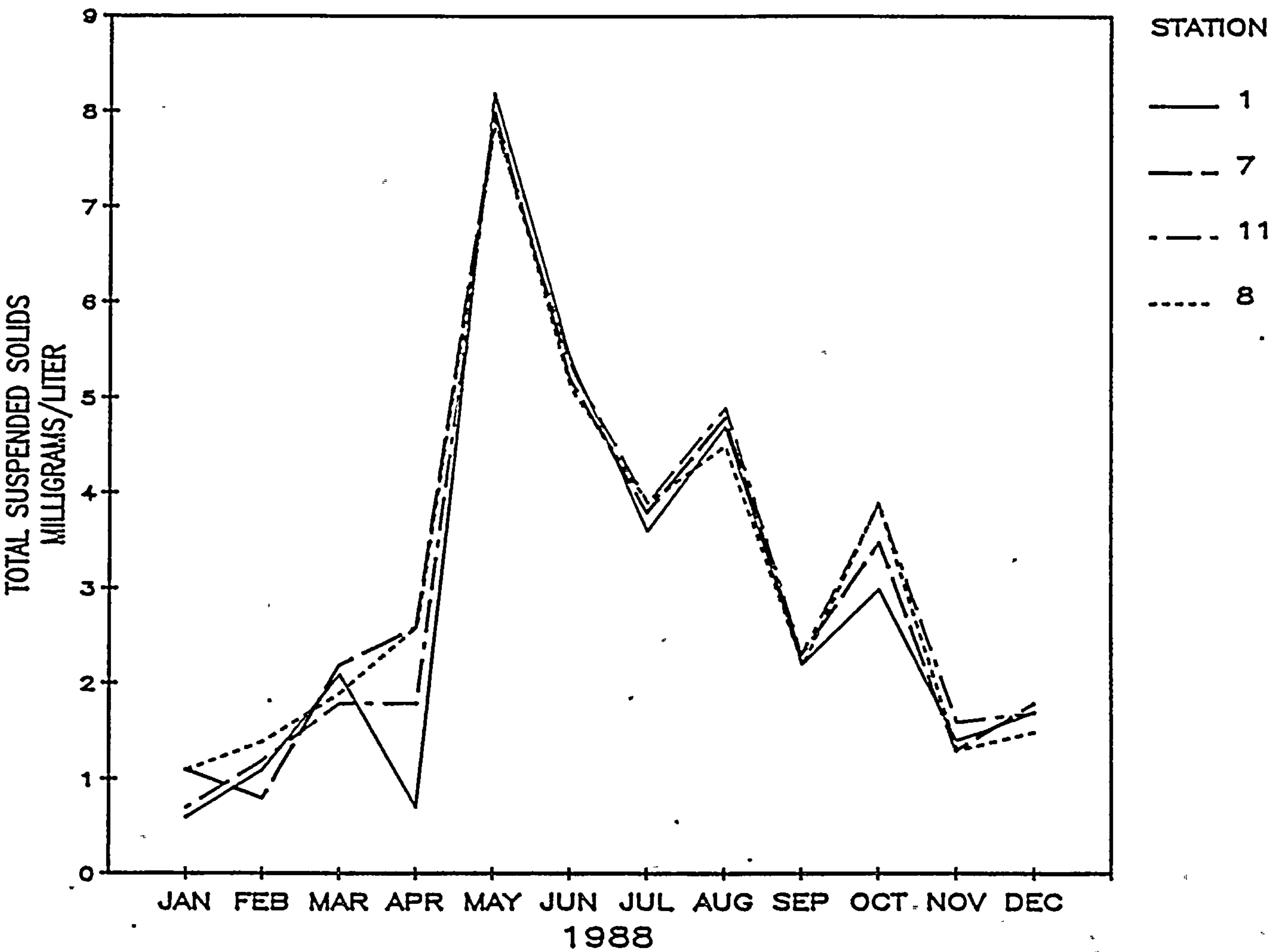


Figure 4-17. Columbia River Total Suspended Solids Measurements at Four Stations During 1988

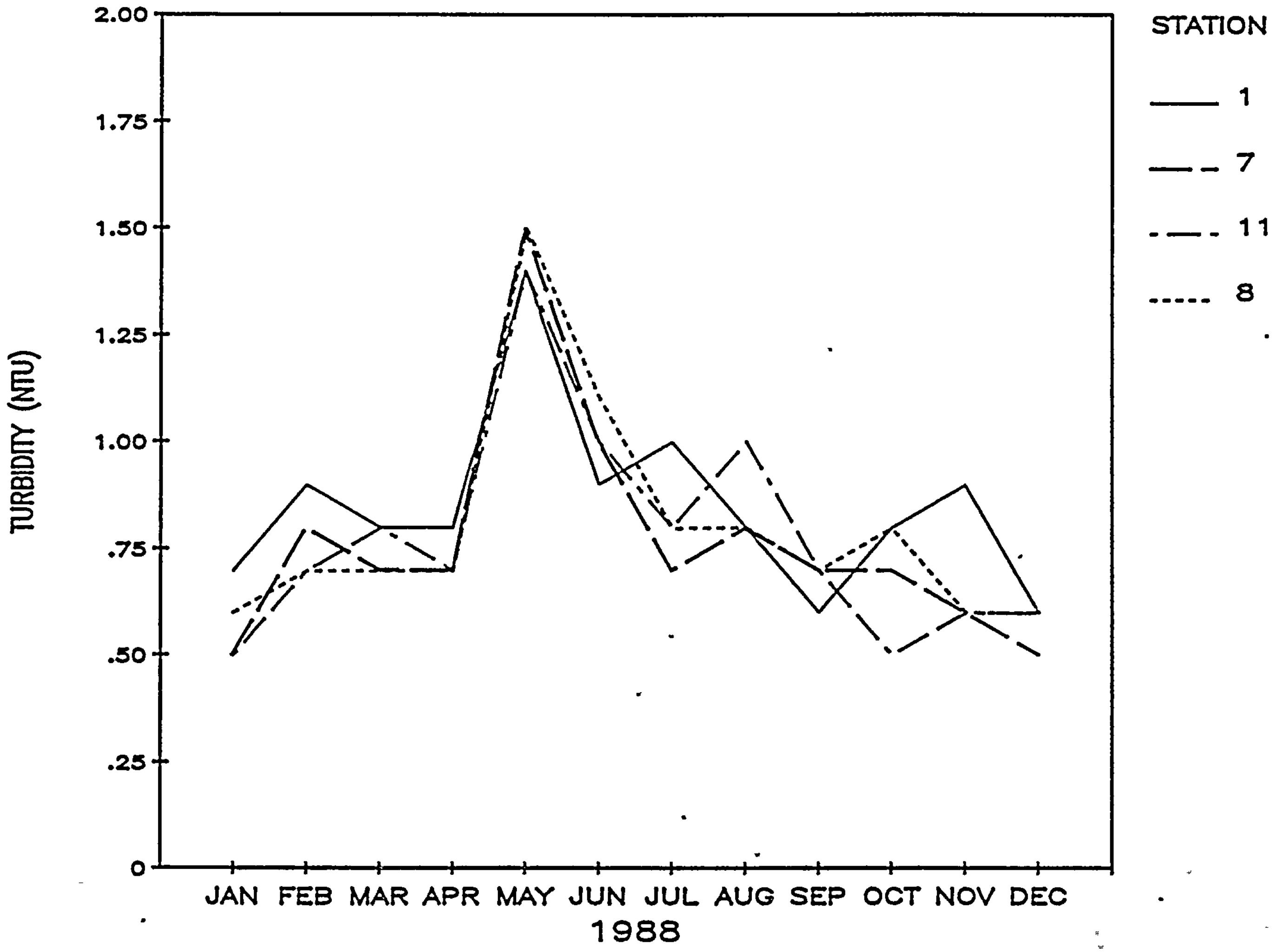


Figure 4-18 Columbia River Turbidity Measurements at Four Stations During 1988

5.0 COOLING TOWER DRIFT STUDIES

5.1 INTRODUCTION

The cooling tower drift studies were designed to identify any impact of cooling tower operation upon the surrounding plant communities, as well as any edaphic impacts. The program includes the measurement of herbaceous and shrub canopy cover, shrub density, herbaceous phytomass, vegetation chemistry and soil chemistry. Soil chemical parameters measured include pH, carbonate, bicarbonate, sulfate, chloride, sodium, potassium, calcium, magnesium, copper, zinc, lead, chromium, nickel, cadmium, and conductivity. Vegetation chemistry includes extractable sulfate, chloride and total copper. This study provides post-operational data for comparisons with preoperational data and meets the requirements of Washington State Energy Facility Site Evaluation Council (EFSEC) Resolutions 193 and 194 dated May 26, 1981.

Sampling was conducted in May at each of nine permanent stations, four grassland Stations G01-G04, and five shrub Stations S01-S05. Figure 5-1 shows the location of each station. The orientation of the various components including transects and productivity plots within each community are depicted in Figure 5-2.

5.2 MATERIALS AND METHODS

5.2.1 Herbaceous Canopy Cover

Fifty microplots (20 cm x 50 cm) were placed at 1-m intervals on alternate sides of the herbaceous transect (Figure 5-2). Canopy cover was estimated for each species occurring within a microplot using Daubenmire's (1968) cover classes. Data were recorded on standard data sheet.

Quality assurance was accomplished by twice sampling three randomly selected microplots on each herbaceous transect. The entire transect was resampled if cover estimates for any major species (>50 percent frequency) differed by more than one cover class.

All vegetation studies including cover, density, productivity, and chemistry were sampled, as in previous years, at the peak of the cheatgrass growth cycle known as the purple stage (Klemmedson and Smith 1964).

5.2.2 Herbaceous Phytomass

Phytomass sampling was conducted concurrently with cover sampling. Phytomass sampling plots were randomly located within an area adjacent to the permanent transects or plots (Figure 5-2). At each station, all live herbaceous vegetation rooted in five randomly located microplots (20 x 50 cm) was clipped to ground level and placed in paper bags. Each bag was stapled shut and labeled with station code, plot number, date and personnel.

Sample bags were transported to the laboratory, opened, and placed in a drying oven at 50°C for 24 hours. Following drying, the bags were removed singly from the oven and their contents immediately weighed to the nearest 0.1 g. Laboratory quality assurance consisted of independently reworking 10 percent of the phytomass samples to assess data validity and reliability.

5.2.3 Shrub Canopy Cover

Five 50-m lines were used to measure shrub canopy cover in each of the five shrub plots (Figure 5-2). Whenever a shrub was crossed by a tape stretched between the end posts, its species and the distance (cm) at which it intercepted the line were recorded. For each shrub plot, intercept distances of each species along all five lines were summed

to give a total intercept distance. From this, a shrub canopy cover value (percent) was obtained by dividing total intercept distance by total line length.

Quality assurance procedures consisted of twice sampling one major species along a randomly selected shrub transect. Resampling was conducted if intercept lengths differed by more than 10 percent.

5.2.4 Shrub Density

Individual live shrubs were counted and recorded by species within each of the four strips delineated by shrub intercept transects (Figure 5-2). Numbers per strip were summed to obtain shrub density by species for the entire 1000 m^2 plot. Sampling was concurrent with cover sampling.

Quality assurance consisted of resampling one randomly selected species within one strip. Resampling was conducted if the count difference exceeded one individual.

5.2.5 Soil Chemistry

At each of the nine grassland and shrub stations, five soil samples were collected from the top 15 cm of soil with a clean stainless steel trowel. The samples were placed in 250 ml sterile plastic cups with lids, labeled and refrigerated at 4°C. Sixteen parameters were analyzed in each sample including pH, bicarbonate, carbonate, conductivity, sulfate, chloride, copper, zinc, nickel, cadmium, lead, chromium, calcium, magnesium, sodium and potassium. Samples were analyzed for pH, bicarbonate, carbonate, sulfate, chloride and conductivity according to Methods of Soil Analysis (1965). Samples for zinc, calcium, magnesium, sodium, and potassium were analyzed by flame atomic absorption spectroscopy according to Methods For Chemical Analysis of Water and Wastes (USEPA 1983). The remaining elements were analyzed by graphite furnace atomic absorption spectroscopy (USEPA 1983). Aliquots

of soil for trace metal analyses were digested according to Procedures for Handling and Chemical Analysis of Sediment and Water Samples (Plumb 1981). Preservation times and conditions, when utilized, were according to USEPA (1983).

Laboratory quality control comprised 10% - 20% of the sample analysis load. Routine quality assurance analysis included internal laboratory standards, reagent blanks, and prepared EPA or NBS controls.

5.2.6 Vegetation Chemistry

Samples of *Bromus tectorum*, *Poa sandbergii*, *Artemisia tridentata* and *Purshia tridentata* were collected at each station. Two species were substituted at some of the stations due to absence of one or more of those listed above. Substitute species were *Phlox longifolia* and *Sisymbrium altissimum*. Samples were collected at the same time as soil samples and as close to the soil sampling station as possible, sufficient quantities of leafy material of each species were collected to yield at least five grams of dry weight. The clipped material was sealed in a plastic bag, labeled and refrigerated at 4°C until analyzed.

In the laboratory, the clipped plant tissue was oven dried to a constant weight, ground in a Wiley mill and digested according to Plumb (1981). Sulfate was analyzed by nephalometry and chloride by mercuric chloride titration according to USEPA (1983). Copper was analyzed by graphite furnace atomic spectroscopy according to USEPA (1983).

5.3 RESULTS AND DISCUSSION

During the 1988 season, 59 plant taxa were observed in the study area. These are presented in Table 5-1. Table 5-2 lists by year the species of vascular plants observed during field activities from 1975-1988.

5.3.1 Herbaceous Cover

Herbaceous cover data for 1988 are summarized in Tables 5-3 and 5-4. Figures 5-3, 5-4, 5-5, and 5-6 provide a comparison with the data of previous years.

Total herbaceous cover averaged 32.52% in 1988 which represents a 54.8% reduction over 1987 (59.37%). As in previous years, the dominant annual grass was Bromus tectorum with 11.50% followed by Festuca octoflora with 0.22%. Perennial grasses averaged 11.63% in comparison to 25.25% in 1987. Poa sandbergii (8.31%) was the dominant perennial grass at most stations followed by Stipa comata (2.45%).

Total annual forb cover averaged 4.96%, down from the 9.85% measured in 1987. Microsteris gracilis was the dominant component with 1.58% followed by Plantago pategonica (0.85%) and Draba verna with 0.46%.

Perennial forb cover increased 27.6% over 1987 (4.21% vs. 3.30%). The dominant species were Oenothera pallida (0.99%), Phlox longifolia (0.94%) and Aster canescens (0.90%).

Species frequency values (%) for each station were similar to previous years and are summarized in Table 5-5. The greatest diversity of species was observed at Station S04 (18) while the smallest was observed at Station G03 (8).

Although growing season precipitation increased by 11.7% in 1988 over 1987 (10.21 vs 9.14 cm), total herbaceous cover decreased markedly in 1988 (32.52% vs 59.57% in 1987). Mean temperature during the growing season was 5.4 degrees C. vs. 5.5 degrees C. in 1987 (Figure 5-7).

5.3.2 Herbaceous Phytomass

Mean production of herbaceous phytomass in 1988 was 35.17 gm/m2. At grassland stations, phytomass production averaged 31.37 g/m2 while at

shrub stations it was 38.20 g/m2. Production varied widely among stations from a low of 14.08 g/m2 at Station G02 to a high of 73.42 g/m2 at Station S02. Mean herbaceous phytomass production at grassland stations and at shrub stations for 1988 is shown graphically in Figures 5-8 and 5-9 and is summarized in Table 5-6. Table 5-7 presents mean phytomass values for each station in each year since 1975. Mean herbaceous phytomass and percent herbaceous cover for each station from 1980 through 1988 are presented graphically in Figures 5-10 through 5-18.

5.3.3 Shrub Cover and Density

There are four shrub species in the study area: *Artemisia tridentata*, *Purshia tridentata*, *Chrysothamnus nauseosus* and *Chrysothamnus viscidiflorus*. *Eriogonum niveum* (a subshrub) and *Opuntia polyacantha* (a cactus) are also present, however, they are not included in the cover data. During a 1984 August range fire, all viable shrubs were completely destroyed at Stations S02 and S04, while the only individuals surviving at Station S01 were isolated clumps of low growing *Eriogonum niveum*.

Shrub density and cover values continue to reflect recovery from the 1984 fire. In 1988, shrub cover at Stations S01 and S02 was 0.1%, while at Station S04, shrub cover was still zero. Shrub cover increased slightly at Station S03 (7.67% to 7.69%) and Station S05 (0.59% to 8.6%). Shrub density declined slightly at Station S03 but increased at Stations S01, S02, S04 and S05. Shrub density data for 1988 is summarized in Table 5-8 while shrub density data at each station from 1980 through 1988 is presented in Figure 5-19. Shrub cover data for 1988 is summarized in Table 5-9 while Figure 5-20 presents mean shrub cover values measured from 1975 through 1988. Shrub cover and density at each station for 1988 are presented graphically in Figure 5-21.

5.3.4 Soil Chemistry

The results of the 1988 soil chemical analyses are presented in Table 5-10 and are shown graphically in Figures 5-22 through 5-51.

Total nickel, cadmium, zinc, potassium, copper, lead and chromium concentrations were within the ranges observed in previous years at all stations. Magnesium concentrations were elevated slightly from previous years at all stations, while calcium concentrations were lower than in previous years except at Station G01. Sodium concentrations were elevated from previous years at one station, G02. Bicarbonate concentrations were elevated at Station S02 with post-operational data being generally higher than preoperational data. Conductivity was generally low at all stations except G03 where it increased markedly as in 1985. The same trend was evident for total sulfate. Chloride concentrations were much lower than in previous years at all stations. No increase in chloride was evident at Station G03 as occurred with conductivity and sulfate. Soil pH at Station G03 decreased slightly for the fifth straight year.

At most stations, no signs of adverse impacts from operation of WNP-2 cooling towers are evident. However, at Station G03 which is approximately 200 meters south of the towers, some signs of disturbance are evident both in vegetation composition and in soil chemistry.

5.3.5 Vegetation Chemistry

The results of the 1988 vegetation chemical analyses are presented in Table 5-11 and shown graphically in Figures 5-52 through 5-72.

Concentrations of extractable sulfate and total copper measured in *Bromus tectorum* and *Poa sandbergii* are within the ranges observed in previous years. Increases in extractable chloride concentrations were evident at Station S03 for *Poa sandbergii* and at Station G02 for *Bromus tectorum*.

5.4 SUMMARY AND CONCLUSIONS

Total herbaceous cover for 1988 averaged 32.5% in the study area. This is down markedly from the 59.4% measured in 1987. Although the 1987-1988 growing season was not an unusually dry one (10.21 cm), the pattern of precipitation during the growing season was evidently responsible for the reduction in cover and phytomass. Precipitation during November 1987 totaled only 1.02 cm, 50% of normal. January 1988 was also a dry month with only 50% of normal precipitation. February 1988 tied with the Februarys of 1920 and 1967 as the driest on record with only a trace of precipitation having been received. Total precipitation between January 1 and February 28 was only 31% of normal. In contrast, December 1987 precipitation (4.14 cm) totaled 172% of normal with about normal temperatures. Total precipitation for March was 0.99 cm, 98% of normal. Mean production of herbaceous phytomass in 1988 was 35.17 gm/m2 compared to 98.92 gm/m2 in 1987.

Shrub cover and density data continue to reflect recovery from the 1984 range fire with slight increases in cover and density evident at most stations.

With the exception of Station G03, which is only a few hundred meters south of the cooling towers, no adverse trends or impacts upon soil or vegetation chemistry are apparent from the five years of operational data.

5.5 COOLING TOWER DRIFT MODEL VALIDATION STUDY

5.5.1 Introduction

This study is to be initiated in January 1989 and is designed to measure the levels of and determine the patterns of airborne salt deposition originating from the WNP-2 cooling tower plume. Information acquired from this study will be used to validate a salt emission and deposition model which used plant operating and meteorological data. This program is performed to comply with EFSEC Resolution No. 239.

5.5.2 Methods and Materials

Beginning in January 1989, two collection vessels will be placed at each of 16 sample stations for a total of 32 samplers. One sample station is located directly adjacent to the WNP-2 cooling towers. Seven stations are located at approximately half-mile intervals along a northwest transect originating at the cooling towers. Another seven stations lie at half-mile intervals along a south-southwest transect. The remaining location is a control station located at the old Hanford Townsite approximately eight miles north of WNP-2. An additional pair of cylinders will be kept in the laboratory as a building control. A map of the sample locations is shown in Figure 5-73.

The collection vessel consists of an open-topped linear polyethylene cylinder with vertical sides and a flat bottom. The cylinder is six inches in diameter and eighteen inches high. A support stand positions the cylinder such that its bottom is eighteen inches above ground level. A metal bird ring is positioned above the cylinder to help prevent interference from birds. The cylinder is also covered with a screen to prevent sample contamination from bird droppings and insects. Figure 5-74 illustrates a typical sample collector.

5.5.3 Sample Preparation and Collection

Sample collection will occur monthly (every 30 +/-2 days). In the laboratory, the cylinders will be washed, rinsed and then filled with four liters of deionized water. They will then be transported to the field and placed in the support stands. During the summer months, the samplers are to be periodically checked to insure an adequate liquid level is maintained. In the winter, an antifreeze, isopropyl alcohol, will be added to prevent freezing. After approximately 30 days in the field, the cylinders will be covered, exchanged with clean samplers, and transported back to the laboratory. Any evidence of contamination (insects, bird droppings) will be noted and recorded. A 500 milliliter aliquot will then be taken for analysis and the remaining sample discarded.

5.5.4 Sample Analysis

The sample will be analyzed for pH, conductivity, alkalinity, calcium, magnesium, sodium, copper, chloride, sulfate and orthophosphate. The parameters chosen for analysis were those which are characteristically the major components of the WNP-2 cooling water. As a result, detection of these components in the drift collectors will serve to verify their source as WNP-2 cooling tower drift. Analytical methods for the metals will consist of graphite furnace atomic absorption spectroscopy and inductively-coupled plasma emission spectroscopy. Anions will be determined by ion chromatography. All measurements and analyses will be performed in the Supply System Environmental Laboratory.

5.5.5 Objectives

The main objective of this study is to identify the patterns and rate of drift deposition in the area surrounding the WNP-2 cooling towers. The data obtained from this study will be compared to estimated drift patterns and rates generated from a model which was designed using plant operational data and local meteorological data. The data will be handled using statistical methods to determine the significance, if any, of the results. This comparison of the field data and the calculated model estimates will indicate the validity of the model. Other objectives of this study are to provide additional data and information for studies dealing with correlation of any long-term changes in soil and vegetation chemistry with plant operation, correlation between changes in vegetation species diversity or density and cooling tower drift deposition and determination of the extent of uptake of salt loading near the WNP-2 plant.

5.6 BIBLIOGRAPHY

American Society of Agronomy. 1965. Methods of soil analysis. Agronomy Series, No. 9.

ASTM D1739-70, Standard Method for Collection and Analysis of Dustfall.

Daubenmire, R. 1968. Plant communities. Harper and Row, New York, NY.

Droppo, J. G., Hane, C. E., Woodruff, R. K., Atmospheric Effects of Circular Mechanical Draft Cooling Towers at Washington Public Power Supply System Nuclear Power Plant Number Two, B2311200735, November 1976.

Environmental Protection Agency. 1983. Methods for chemical analysis of water and wastes. Environmental Monitoring and Support Laboratory, Office of Research and Development, Cincinnati, OH.

Klemmedson, J.O. and J.G. Smith, 1964. Cheat Grass (Bromus tectorum L.) Bot. Rev. 30; 226-262.

NUS Corporation, Annual Report for the PVNGS Salt Deposition Monitoring Program January-December 1986; April 1987.

Plumb, R.H. 1981. Procedure for handling and chemical analysis of sediment and water samples, Technical Report EPA/CE-81-1, prepared by Great Lakes Laboratory, State University College at Buffalo, Buffalo, N.Y., for the U.S. Environmental Protection Agency/Corps of Engineers Technical Committee on Criteria for Dredged and Fill Material. Published by the U.S. Army Engineer Waterways Experiment Station, CE, Vicksburg, MS.

Table 5-1. Vascular Plants Observed During 1988 Field Work

	Common Name
APIACEAE	Parsley Family
Cymopterus terebinthinus (Hook.) T.&G. var. *terebinthinus*	Turpentine cymopterus
Lomatium macrocarpum (Nutt.) Coult & Rose	Large-fruit lomatium
ASTERACEAE	Aster Family
Achillea millefolium L.	Yarrow
Antennaria dimorpha (Nutt.) T&G	Low pussy-toes
Artemisia tridentata Nutt.	Big sagebrush
Balsamorhiza careyana Gray	Carey's balsamroot
Chrysothamnus nauseosus (Pall.) Britt	Gray rabbitbrush
Chrysothamnus viscidiflorus (Hook.) Nutt	Green rabbitbrush
Crepis atrabarba Heller	Slender hawksbeard
Franseria acanthicarpa Hook.	Bur ragweed
Layia glandulosa (Hook.) H&A	White daisy tidytips
Tragopogon dubius Scop.	Yellow salsify
Aster canescens (Pursh)	Hoary Aster
BORAGINACEAE	Borage Family
Amsinckia lycopsoides Lehm.	Tarweed fiddleneck
Cryptantha circumscissa (H&A) Johnst.	Matted cryptantha
Cryptantha pterocarya (Torr.) Greene	Winged cryptantha
BRASSICACEAE	Mustard Family
Descurainia pinnata (Walt.) Britt.	Western tansymustard
Draba verna L.	Spring draba
Erysimum asperum (Nutt.) DC.	Prairie rocket
Sisymbrium altissimum L.	Tumblemustard
CACTACEAE	Cactus Family
Opuntia polyacantha Haw.	Starvation cactus
CARYOPHYLLACEAE	Pink Family
Arenaria franklinii Dougl. var. *franklinii*	Franklin's sandwort
Holosteum umbellatum L.	Jagged chickweed
CHENOPODIACEAE	Chenopod Family
Salsola kali L.	Russian thistle

Table 5-1. (Continued)

	Common Name
FABACEAE	Pea Family
Astragalus purshii Dougl.	Wooly-pod milk-vetch
Astragalus sclerocarpus Gray	Stalked-pod milk-vetch
Psoralea lanceolata Pursh	Lance-leaf scurf-pea
HYDROPHYLLACEAE	Waterleaf Family
Phacelia hastata Dougl.	Whiteleaf phacelia
Phacelia linearis (Pursh) Holz.	Threadleaf phacelia
LILIACEAE	Lily Family
Brodiaea douglasii Wats.	Douglas' brodiaea
Calochortus macrocarpus Dougl.	Sego lily
Fritillaria pudica (Pursh) Spreng.	Chocolate lily
LOASACEAE	Blazing-star Family
Mentzelia albicaulis Dougl.	White-stemmed mentzelia
MALVACEAE	Mallow Family
Sphaeralcea munroana (Dougl.) Spach	White-stemmed globe-mallow
ONAGRACEAE	Evening-primrose Family
Oenothera pallida Lindl. var. *pallida*	White-stemmed evening-primrose
OROBANCHACEAE	
Orobanche californica Cham. & Schlecht	Broomrape
PLANTAGINACEAE	Plantain Family
Plantago patagonica Jacq.	Indian-wheat
POACEAE	Grass Family
Agropyron cristatum (L.) Gaertn.	Crested wheatgrass
Agropyron dasystachyum (Hoak.) Scribn.	Thick-spiked wheatgrass
Agropyron spicatum (Pursh) Scribn. & Smith	Bluebunch wheatgrass
Bromus tectorum L.	Cheatgrass
Festuca octoflora Walt.	Six-weeks fescue
Koeleria cristata Pers.	Prairie Junegrass
Oryzopsis hymenoides (R&S) Ricker	Indian ricegrass

Table 5-1. (Continued)

	Common Name
Poa sandbergii Vasey	Sandberg's bluegrass
Sitanion hystrix (Nutt.) Smith	Bottlebrush squirreltail
Stipa comata Trin & Rupr.	Needle-and-thread
POLEMONIACEAE	Phlox Family
Gilia minutiflora Benth.	Gilia
Gilia sinuata Dougl.	Shy gilia
Microsteris gracilis (Hook.) Greene var. humilior (Hook.) Cronq.	Pink microsteris
Phlox longifolia	Long-leaf phlox
POLYGONACEAE	Buckwheat Family
Eriogonum niveum Dougl.	Snow buckwheat
Rumex venosus Pursh	Wild begonia
RANUNCULACEAE	Buttercup Family
Delphinium nuttallianum Pritz. ex Walpers	Larkspur
ROSACEAE	Rose Family
Purshia tridentata (Pursh) DC.	Antelope bitterbursh
SANTALACEAE	Sandalwood Family
Comandra umbellata (L.) Nutt.	Bastard toad-flax
SAXIFRAGACEAE	
Ribes aureum Pursh	Golden current
SCROPHULARIACEAE	Figwort Family
Penstemon acuminatus Dougl.	Sand-dune penstemon
VALERIANACEAE	Valerian Family
Plectritis macrocera T&G	Longhorn plectritis

Table 5-2. Vascular Plants Observed During 1975-1988 Field Work

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Annual Grasses														
Bromus tectorum	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Festuca octoflora	X					X	X	X	X	X	X	X	X	X
Festuca sp.		X		X										
Perennial Grasses														
Agropyron cristatum							X	X	X	X	X	X	X	X
Agropyron dasystachyum				X			X	X	X	X	X	X	X	X
Agropyron spicatum						X	X	X	X	X	X	X	X	X
Koeleria cristata				X		X	X	X	X	X	X	X	X	X
Oryzopsis hymenoides	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Poa sandbergii							X	X	X	X	X	X	X	X
Poa scabrella							X	X	X	X		X	X	
Sitanion hystrix						X		X	X	X	X	X	X	X
Stipa comata		X		X	X	X	X	X	X	X	X	X	X	X
Stipa thurberiana					X									

Table 5-2. (Cont'd)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Annual Forbs														
Franseria acanthicarpa	X		X	X	X			X	X	X	X	X	X	X
Amsinckia lycopsoides	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Amsinckia menziesii							X	X						
Chenopodium leptophyllum			X											
Cryptantha pterocarya		X		X		X	X	X	X	X	X	X	X	X
Cryptantha circumscissa	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Descurainia pinnata	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Draba verna	X	X		X	X	X	X	X	X	X	X	X	X	X
Epilobium paniculatum	X	X	X	X	X									
Erysimum asperum							X	X	X	X	X	X	X	X
Gilia minutiflora					X				X		X	X	X	X
Gilia sinuata						X		X	X	X	X	X	X	X
Holosteum umbellatum	X	X		X	X	X	X	X	X	X	X	X	X	X
Lagophylla ramosissima						X								
Layia glandulosa			X		X			X	X	X	X	X	X	X
Mentzelia albicaulis			X		X			X	X	X	X	X	X	X
Microsteris gracilis	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Orobanche californica													X	X
Phacelia hastata							X	X	X	X	X	X	X	X
Phacelia linearis				X		X	X	X	X	X	X	X	X	X
Phacelia sp.		X												
Plantago patagonica	X	X		X	X	X	X	X	X	X	X	X	X	X
Plectritis macrocera		X							X		X	X	X	X

Table 5-2. (Cont'd)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Polemonium micranthum	X			X										
Salsola kali	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Sisymbrium altissimum	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Tragopogon dubius				X			X	X	X	X	X	X	X	X
Perennial Forbs														
Achillea millefolium	X	X	X			X	X	X	X	X	X	X	X	X
Antennaria dimorpha						X	X	X	X	X	X	X	X	X
Arenaria franklinii var. *franklinii*						X	X	X	X	X	X	X	X	X
Aster canescens (*Machaeranthera canescens*)		X			X				X	X	X	X	X	X
Astragalus lyallii			X											
Astragalus purshii	X	X				X	X	X	X	X	X	X	X	X
Astragalus sclerocarpus						X	X	X	X	X	X	X	X	X
Astragalus sp.				X										
Balsamorhiza careyana	X	X		X	X	X	X	X	X	X	X	X	X	X
Brodiaea douglasii	X	X		X	X	X	X	X	X	X	X	X	X	X
Brodiaea howellii				X										
Calochortus macrocarpus	X				X									
Comandra umbellata	X		X	X	X	X	X	X	X	X	X	X	X	X
Crepis atrabarba		X	X	X	X	X	X	X	X	X	X	X	X	X
Cryptantha leucophaea						X	X	X	X		X	X		

Table 5-2. (Cont'd)

	1975	1976	1977	1978	1979	1980	1981	1982	1983	1984	1985	1986	1987	1988
Cymopterus terebinthinus	X			X		X	X	X	X	X	X	X	X	X
Delphinium sp.				X					X	X	X	X	X	X
Erigeron divergens							X							
Fritillaria pudica									X	X	X	X	X	X
Lomatium macrocarpum	X		X		X	X	X	X	X	X	X	X	X	X
Lomatium sp.				X										
Oenothera pallida	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Penstemon acuminatus							X	X	X	X	X	X	X	X
Penstemon sp.						X								
Phlox longifolia	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Psoralea lanceolata	X	X	X	X	X		X	X	X	X	X	X	X	X
Rumex venosus				X		X	X	X	X	X	X	X	X	X
Sphaeralcea munroana								X	X		X	X	X	X
Shrubs, subshrubs, cacti														
Artemisia tridentata	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chrysothamnus nauseosus	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Chrysothamnus viscidiflorus	X	X	X	X		X	X	X	X	X	X	X	X	X
Eriogonum niveum	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Leptodactylon pungens									X	X				
Opuntia polyacantha	X			X		X	X	X	X	X	X	X	X	X
Purshia tridentata	X	X	X	X	X	X	X	X	X	X	X	X	X	X
Ribes aureum											X	X	X	X

Table 5.3 Herbaceous Cover for Nine Stations in 1988

	G01	G02	G03	G04	S01	S02	S03	S04	S05	
Annual Grasses										
Bromus tectorum	22.95	10.10	16.75	4.80	13.80	5.05		11.80	10.15	10.60
Festuca octoflora								2.00		0.22
Total Annual Grass Cover	22.95	10.10	16.75	4.80	13.80	5.05	0.00	13.80	10.15	10.82
Perennial Grasses										
Agropyron spicatum						4.95			1.30	0.69
Oryzopis hymenoides						0.30		1.25		0.17
Poa sandbergii	17.85	21.70	0.05	10.15	1.75	3.15	11.95	8.15	0.05	8.31
Stipa comata				20.05					2.00	2.45
Total Perennial Grass Cover	17.85	21.70	0.05	30.20	1.75	8.40	11.95	9.40	3.35	11.63
Annual Forbs										
Amsinckia lycopsoides	0.05	0.10	0.30	0.10	0.10	0.35			0.20	0.13
Cryptantha circumscissa					0.80	0.05		0.35	0.60	0.20
Cryptantha pterocarya					0.60					0.07
Descurainia pinnata					0.40			0.15		0.06
Draba verna	0.75	1.80	0.45		0.30	0.30	0.30	0.05	0.20	0.46
Franseria acanthacarpa			0.95	0.60	1.00	0.05		0.25	0.60	0.38
Gilia sinuata									0.10	0.01
Holosteum umbellatum	0.55	0.05			0.05	1.15	0.05		0.25	0.23
Layia glandulosa	0.05				0.30				0.10	0.05
Mentzelia albicaulis					0.60	2.75	0.05	0.10		0.39
Microsteris gracilis	1.30	3.80	5.45		1.45	0.05	0.20	1.25	0.70	1.58
Phacelia linearis						0.50	0.05	0.05		0.07
Plantago pategonica	2.80	0.20		0.95			2.80		0.90	0.85
Salsola kali	0.20	0.45	0.05	0.10	0.60	0.05		0.15	0.20	0.20
Sisymbrium altissimum	0.55	0.40	0.35		0.15		0.15	0.75	0.15	0.28
Total Annual Forb Cover	6.25	6.80	7.55	1.75	6.35	5.25	3.60	3.10	4.00	4.96
Perennial Forbs										
Achillea millefolium						1.70		0.70		0.27
Aster canescens		0.10		2.75	3.10	0.05	0.05	0.45	1.60	0.90
Astragalus sclerocarpus								0.75		0.08
Balsamorhiza careyana								2.85	0.30	0.35
Crepis atrabarba							0.70			0.08
Cymopterus terebinthinus						5.30				0.59
Oenothera pallida				0.40	8.45				0.05	0.99
Phlox longifolia	0.10	1.90		1.25		3.75	1.35	0.10		0.94
Rumex venosus	0.10									0.01
Total Perennial Forb Cover	0.20	2.00	0.00	4.40	11.55	10.80	2.10	4.85	1.95	4.21
Total Herbaceous Cover	47.25	40.60	24.35	41.15	33.45	29.50	17.65	31.15	19.45	31.62

Table 5-4 Mean Herbaceous Cover - 1975-1988

Class	Year	S01	S02	S03	S04	S05	XS	G01	G02	G03	G04	XG	XSG
AG	1975	49.90	35.30	43.80			43.00	43.90	43.00			43.45	43.18
PG	1975	0.60	2.00	4.50			2.37	3.70	5.50			4.60	3.26
AF	1975	14.60	11.70	11.70			12.67	29.50	13.00			21.25	16.10
PF	1975	4.30	0.90	1.80			2.33	1.50	2.10			1.80	2.12
ALL	1975	69.40	49.90	61.80			60.37	78.60	63.60			71.10	64.66
AG	1976	50.70	40.90	34.30			41.97	71.20	51.60			61.40	49.74
PG	1976	0.40	10.50	10.30			7.07	4.40	3.10			3.75	5.74
AF	1976	5.50	5.30	7.20			6.00	11.90	8.50			10.20	7.68
PF	1976	0.00	0.50	0.20			0.23	0.00	0.20			0.10	0.18
ALL	1976	56.60	57.20	52.00			55.27	87.50	63.40			75.45	63.34
AG	1977	1.35	0.65	1.90			1.30	5.20	1.45			3.33	2.11
PG	1977	0.35	11.30	8.28			6.64	3.25	2.90			3.08	5.22
AF	1977	0.25	0.05	0.90			0.40	2.40	9.35			5.88	2.59
PF	1977	0.55	0.60	1.42			0.86	0.05	6.30			3.18	1.78
ALL	1977	2.50	12.60	12.50			9.20	10.90	20.00			15.45	11.70
AG	1978	51.00	67.00	51.00			56.33	68.00	42.00			55.00	55.80
PG	1978	3.00	18.00	11.00			10.67	8.00	7.00			7.50	9.40
AF	1978	38.00	10.00	33.00			27.00	23.00	25.00			24.00	25.80
PF	1978	8.00	0.00	5.00			4.33	2.00	3.00			2.50	3.60
ALL	1978	100.00	95.00	100.00			98.33	101.00	77.00			89.00	94.60
AG	1979	25.00	29.00	9.00			21.00	31.00	10.00			20.50	20.80
PG	1979	1.00	18.00	11.00			10.00	7.00	5.00			6.00	8.40
AF	1979	2.00	4.00	10.00			5.33	43.00	33.00			38.00	18.40
PF	1979	11.00	0.00	3.00			4.67	0.00	7.00			3.50	4.20
ALL	1979	39.00	51.00	33.00			41.00	81.00	55.00			68.00	51.80
AG	1980	50.40	51.80	24.30	56.20	56.40	47.82	64.30	77.80	73.80	12.30	57.05	51.92
PG	1980	1.00	7.20	23.30	10.90	0.10	8.50	28.30	64.00	0.10	26.60	29.75	17.94
AF	1980	7.60	4.20	22.50	3.40	14.10	10.36	7.30	5.00	28.70	4.90	11.48	10.86
PF	1980	2.20	2.20	4.70	4.60	1.80	3.10	0.40	0.00	0.00	4.60	1.25	2.2[illegible]
ALL	1980	61.20	65.40	74.80	75.10	72.40	69.78	100.30	146.80	102.60	48.40	99.53	83.0[illegible]
AG	1981	74.80	54.60	66.50	49.80	76.20	64.38	77.40	84.00	88.40	48.90	74.68	68.96
PG	1981	0.10	4.70	14.30	5.80	0.00	4.98	19.60	25.90	0.00	36.70	20.55	11.90
AF	1981	5.30	3.50	18.20	1.20	12.50	8.14	15.90	11.90	17.50	5.90	12.80	10.21
PF	1981	0.00	3.20	0.70	4.90	0.50	1.86	0.20	0.00	0.00	1.90	0.53	1.27
ALL	1981	80.20	66.00	99.70	61.70	89.20	79.36	113.10	121.80	105.90	93.40	108.55	92.33
AG	1982	51.50	25.80	36.60	32.70	20.00	33.32	42.20	45.50	51.00	22.90	40.40	36.47
PG	1982	0.40	6.40	17.90	4.30	0.80	5.96	11.20	11.60	0.10	31.30	13.55	9.33
AF	1982	4.60	4.20	7.50	1.60	17.30	7.04	9.70	4.60	4.60	4.10	5.75	6.47
PF	1982	0.20	4.30	0.70	6.20	1.00	2.48	0.30	0.00	1.30	3.80	1.35	1.98
ALL	1982	56.70	40.70	62.70	44.80	39.10	48.80	63.40	61.70	57.00	62.10	61.05	54.24
AG	1983	53.80	37.60	33.65	36.75	31.85	38.73	49.50	39.55	62.75	17.55	42.34	40.33
PG	1983	2.15	7.70	14.45	6.40	1.29	6.40	2.10	15.75	0.00	25.50	10.84	8.37
AF	1983	8.20	7.85	12.55	3.45	22.35	10.88	18.70	8.85	8.65	6.65	10.71	10.81
PF	1983	0.70	3.10	1.05	4.40	1.95	2.24	0.65	0.05	2.10	4.00	1.70	2.00
ALL	1983	64.85	56.25	61.70	51.00	57.44	58.25	70.95	64.20	73.50	53.70	65.59	61.51

Table 5-4 (Continued)

Class	Year	S01	S02	S03	S04	S05	XS	G01	G02	G03	G04	XG	XSG
AG	1984	41.50	32.75	39.35	36.30	36.50	37.28	60.85	71.30	60.85	9.60	50.65	43.22
PF	1984	1.85	8.80	11.55	8.55	0.40	6.23	1.20	4.45		25.00	10.22	6.87
AF	1984	12.35	8.10	11.10	4.00	13.40	9.79	20.65	9.70	19.45	7.95	14.44	11.86
PF	1984	0.30	4.00	0.75	6.55	0.65	2.45	0.70	0.20	1.10	1.25	0.81	1.72
ALL	1984	56.00	53.65	62.75	55.40	50.95	55.75	83.40	85.65	81.40	43.80	73.56	63.67
AG	1985	2.10	2.15	14.60	4.95	27.05	10.17	8.00	8.10	18.30	7.25	10.41	10.28
PG	1985	1.05	4.70	17.85	2.40	1.85	5.57	9.20	17.95	0.00	13.90	10.26	7.66
AF	1985	0.70	1.35	9.40	2.30	4.75	3.70	18.20	8.15	7.55	3.05	9.24	6.16
PF	1985	0.00	1.35	1.15	3.00	0.25	1.15	0.80	0.10	2.35	0.90	1.04	1.10
ALL	1985	3.85	9.55	43.00	12.65	33.90	20.59	36.20	34.30	28.20	25.10	30.95	25.19
AG	1986	17.45	1.95	7.20	11.45	13.05	10.22	9.40	4.65	13.25	7.35	8.66	9.53
PG	1986	2.20	10.75	17.25	9.85	1.30	8.27	19.85	38.65	0.00	26.00	21.13	13.98
AF	1986	25.40	16.65	38.10	10.25	16.70	21.42	27.65	34.15	25.45	8.70	23.99	22.56
PF	1986	1.15	5.35	2.30	9.15	1.25	3.84	1.80	1.95	0.05	2.55	1.59	2.84
ALL	1986	46.20	34.70	64.85	40.70	32.30	43.75	58.70	79.40	38.75	44.60	55.36	48.91
AG	1987	28.90	9.95	7.80	19.05	33.40	19.82	23.85	9.45	51.65	4.65	22.40	20.97
PG	1987	3.60	21.90	42.65	19.55	2.30	18.00	32.45	58.79	0.05	45.95	34.31	25.25
AF	1987	12.56	8.50	10.80	6.55	11.40	9.96	10.30	11.32	14.00	3.25	9.72	9.85
PF	1987	5.00	6.00	2.00	10.40	1.75	5.03	0.90	1.90	0.15	1.55	1.13	3.29
ALL	1987	50.06	46.35	63.25	55.55	48.85	52.81	67.50	81.46	65.85	55.40	67.55	59.36
AG	1988	13.80	5.05	8.10	13.80	10.15	10.18	22.95	10.10	16.75	4.80	13.65	11.72
PG	1988	1.75	8.40	11.95	9.40	3.35	6.97	17.85	21.70	0.05	30.20	17.45	11.63
AF	1988	6.08	5.25	3.60	3.10	4.00	4.41	6.30	16.15	7.55	1.80	7.95	5.98
PF	1988	11.55	15.75	2.10	4.85	3.25	7.50	0.20	2.00	0.00	4.40	1.65	4.90
ALL	1988	33.18	34.45	25.75	31.15	20.75	29.06	47.30	49.95	24.35	41.20	40.70	34.23

*AG - Annual Grass
PG - Perennial Grass
AF - Annual Forb
PF - Perennial Forb

Table 5-5 Mean Frequency Valves (%) by Species for Each Sampling Station - 1988

	G01	G02	G03	G04	S01	S02	S03	S04	S05
Annual Grasses									
Bromus tectorum	100	100	96	84	86	56	100	98	94
Festuca octoflora								50	
Perennial Grasses									
Agropyron spicatum						34			4
Oryzopis hymenoides						2		2	
Poa sandbergii	92	100	2	88	20	28	100	48	2
Stipa comata				78					4
Annual Forbs									
Amsinckia lycopsoides	2	4	2	4	4	4			8
Cryptantha circumscissa					22	2		14	14
Cryptantha pterocarya					14				
Descurainia pinnata					16			6	
Draba verna	30	62	18		12	12	12	2	8
Franseria acanthacarpa			28	24	30	2		10	24
Gilia sinuata									4
Holosteum umbellatum	22	2			2	16	2		10
Layia glandulosa	2				2				4
Mentzelia albicaulis					24	24	2	4	
Microsteris gracilis	52	92	98		38	2	8	40	28
Phacelia linearis						10	2	2	
Plantago patagonica	34	8		18			72		26
Salsola kali	8	18	2	4	14	2		6	8
Sisymbrium altissimum	22	16	14		6			20	6
Perennial Forbs									
Achillea millefolium						10		8	
Aster canescens		4		32	36	2	2	18	34
Astragulus purshii									
Astragulus sclerocarpus								2	
Balsamorhiza careyana								10	2
Comandra umbellata									
Crepis atrabarba							8		
Cynopterus terebinthinus						14			
Oenothera pallida				6	32				2
Phlox longifolia	4	66		20		24	24	4	
Rumex venosus	4								
Total Species per Site	12	11	8	10	16	17	11	18	18

Table 5-6. Mean Terrestrial-Phytomass for 1988

DATE	SITE	PLOT	WT. (g)	Wt./Sq. METER
5/88	G01	27-4	4.90	49.00
	G01	41-3	2.59	25.90
	G01	46-9	3.99	39.90
	G01	16-8	3.24	32.40
	G01	9-6	2.28	22.80
		AVG	3.40	34.00
		STD	0.95	9.52

DATE	SITE	PLOT	WT. (g)	Wt./Sq. METER
5/88	S01	45-9	12.89	128.90
	S01	27-3	1.68	16.80
	S01	34-7	2.80	28.00
	S01	2-6	5.98	59.80
	S01	18-4	6.39	63.90
		AVG	5.95	59.48
		STD	3.91	39.12

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	G02	27-4	1.55	15.50
	G02	9-6	0.75	7.50
	G02	16-8	1.59	15.90
	G02	46-9	1.85	18.50
	G02	41-3	1.30	13.00
		AVG	1.41	14.08
		STD	0.37	3.72

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	S02	16-9	5.17	51.70
	S02	6-8	1.82	18.20
	S02	13-3	27.13	271.30
	S02	17-3	1.21	12.10
	S02	27-8	1.38	13.80
		AVG	7.34	73.42
		STD	10.00	99.99

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	G03	45-9	2.29	22.90
	G03	27-3	2.55	25.50
	G03	2-3	0.03	0.30
	G03	34-7	0.66	6.60
	G03	18-4	2.46	24.60
		AVG	1.60	15.98
		STD	1.05	10.46

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	S03	45-9	0.45	4.50
	S03	2-6	1.74	17.40
	S03	27-3	2.32	23.20
	S03	34-7	2.69	26.90
	S03	18-4	0.38	3.80
		AVG	1.52	15.16
		STD	0.95	9.49

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	G04	18-4	0.78	7.80
	G04	45-9	7.57	75.70
	G04	2-6	7.50	75.00
	G04	34-7	2.78	27.80
	G04	27-3	12.08	120.80
		AVG	6.14	61.42
		STD	3.98	39.80

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	S04	18-7	2.56	25.60
	S04	46-4	4.21	42.10
	S04	39-7	2.74	27.40
	S04	42-8	0.35	3.50
	S04	2-3	2.33	23.30
		AVG	2.44	24.38
		STD	1.23	12.34

DATE	SITE	PLOT	Wt. (g)	Wt./Sq. METER
5/88	S05	45-9	2.69	26.90
	S05	2-6	0.72	7.20
	S05	27-3	2.46	24.60
	S05	18-4	0.21	2.10
	S05	34-7	3.21	32.10
		AVG	1.86	18.58
		STD	1.17	11.74

1988 Phytomass Summary

MEAN G01-G04	31.37	Grams/Sq. meter
MEAN S01-S05	38.20	Grams/Sq. meter

Table 5-7. Comparison of Herbaceous Phytomass for 1975-1988

Mean Dry Weight (g/m^2)

SITE	1975	1976	1977	1978	1979	1980	1981	1982	1983	1948	1985	1986	1987	1988
G01	359	108	21	166	64	160	200	90	77	94	70	50	83	34
G02	302	258	11	162	37	68	255	60	137	116	27	61	77	14
G03	-	-	-	-		53	261	62	64	133	12	32	134	16
G04	-	-	-	-	-	79	159	113	82	67	37	35	90	61
S01	126	137	4	173	21	36	180	98	171	104	5	35	62	59
S02	144	98	7	128	28	63	115	24	232	57	1	112	144	73
S03	88	177	7	115	16	43	31	22	54	95	27	25	48	15
S04	-	-	-	-	-	78	52	39	68	93	11	176	108	24
S05	-	-	-	-	-	71	81	184	136	43	61	42	145	19

Table 5-8. Summary of Shrub Density for 1988

Station	Species	1	2	3	4	Total	S/Ha	S/a
S01	*Artemisia tridentata*	4	1	4	0	9	90	36
	Chrysothamnus nauseosus	0	0	0	0	0	0	0
	Chrysothamnus viscidiflorus	0	0	0	0	0	0	0
	Purshia tridentata	2	1	2	0	5	50	20
						14	140	56
S02	*Artemisia tridentata*	1	1	0	0	2	20	8
	Chrysothamnus nauseosus	0	0	0	0	0	0	0
	Chrysothamnus viscidiflorus	0	0	0	0	0	0	0
	Purshia tridentata	0	0	0	0	0	0	0
						2	20	8
S03	*Artemisia tridentata*	5	9	14	18	46	460	184
	Chrysothamnus nauseosus	5	2	3	1	11	110	44
	Chrysothamnus viscidiflorus	0	0	0	0	0	0	0
	Purshia tridentata	0	0	0	0	0	0	0
						57	570	228
S04	*Artemisia tridentata*	0	3	1	6	10	100	40
	Chrysothamnus nauseosus	0	0	0	0	0	0	0
	Chrysothamnus viscidiflorus	0	0	0	0	0	0	0
	Purshia tridentata	0	0	0	0	0	0	0
						10	100	40
S05	*Artemisia tridentata*	0	0	0	0	0	0	0
	Chrysothamnus nauseosus	0	0	1	1	2	20	8
	Chrysothamnus viscidiflorus	0	0	0	1	1	10	4
	Purshia tridentata	1	3	4	0	8	80	32
						11	110	44

Table 5-9. Summary of Shrub Cover (%) at Five Station for 1988

Shrubs	S01	S02	S03	S04	S05	X
Artemisia tridentata	0.10	0.10	6.52	-	-	1.34
Chrysothamnus nauseosus	-	-	1.17	-	0.56	0.35
Chrysothamnus viscidiflorus	-	-	-	-	0.30	0.06
Purshia tridentata	-	-	-	-	-	0.00
Total Shrub Cover	0.10	0.10	7.69	0.00	0.86	1.75

Table 5-10. Summary of Soil Chemistry for 1988

	G01	G02	G03	G04	S01	S02	S03	S04	S05
pH (1:2 soil-water)	6.92	6.99	6.71	6.78	6.86	7.20	6.77	6.75	6.99
Conductivity (1:2 soil-water) microsiemens/cm	35.3	46.6	125.6	21.2	23.2	61.4	43.8	49.9	40.5
Sulfate ug/gm	0.40	3.54	18.56	0.84	1.44	3.72	3.82	4.06	4.26
Chloride ug/gm	1.20	1.44	2.48	0.48	0.96	1.44	1.84	2.40	1.28
Copper ug/gm	12.04	12.90	11.08	9.97	10.55	9.50	12.32	14.04	9.74
Lead ug/gm	4.59	4.27	3.73	3.08	3.50	2.21	2.60	3.65	2.29
Cadmium ug/gm	0.0800	0.064	0.064	0.063	0.069	0.039	0.085	0.088	0.070
Chromium ug/gm	12.00	11.90	9.48	8.97	4.77	4.69	6.47	8.46	7.08
Nickel ug/gm	11.93	10.02	8.64	7.78	12.96	12.98	10.83	13.34	9.67
Zinc ug/gm	48.72	50.56	47.18	45.31	47.79	28.12	47.04	48.51	44.54
Sodium %	0.109	0.150	0.108	0.111	0.054	0.030	0.089	0.067	0.081
Potassium %	0.272	0.274	0.192	0.154	0.175	0.110	0.210	0.201	0.155
Calcium %	0.23	0.23	0.24	0.23	0.22	0.30	0.24	0.24	0.23
Bicarbonate (meq/HCO3/gm)	0.0014	0.0023	0.0018	0.0009	0.0009	0.0035	0.0022	0.0016	0.0025
Magnesium %	0.53	0.57	0.47	0.44	0.52	0.43	0.48	0.49	0.45

Table 5-11 Summary of Vegetation Chemistry for 1988

	STATION	POSA	BRTE	SIAL	PHLO	PUTR	ARTR
Copper (ug/gm)	G01	4.25	6.00	6.75	6.15	-	-
	G02	3.45	5.80	6.00	4.45	-	-
	G03	-	4.80	4.60	4.85	6.50	-
	G04	4.35	4.80	-	4.20	4.90	-
	S01	4.25	4.95	4.40	4.85	-	-
	S02	-	5.40	-	3.75	5.75	5.40
	S03	3.85	5.10	-	4.65	-	10.95
	S04	-	5.80	5.05	4.50	-	25.50
	S05	3.95	4.40	-	-	4.15	16.55
Extractable Sulfate (%)	G01	0.019	0.018	0.115	0.117	-	-
	G02	0.019	0.019	0.103	0.018	-	-
	G03	-	0.019	0.115	0.020	0.021	-
	G04	-	0.020	0.086	0.018	0.021	-
	S01	0.018	0.018	0.121	0.018	-	-
	S02	-	0.021	-	0.018	0.021	0.018
	S03	0.020	0.019	-	0.020	-	0.024
	S04	-	0.021	0.086	0.020	-	0.022
	S05	0.018	0.017	-	-	0.018	0.024
Extractable Chloride (%)	G01	0.27	0.28	0.54	0.12	-	-
	G02	0.25	0.30	0.90	0.14	-	
	G03	-	0.26	0.64	0.16	0.12	
	G04	-	0.17	0.49	0.10	0.11	
	S01	0.19	0.27	0.50	0.09	-	-
	S02	-	0.17	-	0.10	0.12	0.75
	S03	0.27	0.14	-	0.09	-	0.50
	S04	-	0.23	0.57	0.13	-	1.38
	S05	0.22	0.21	-	-	0.14	0.84

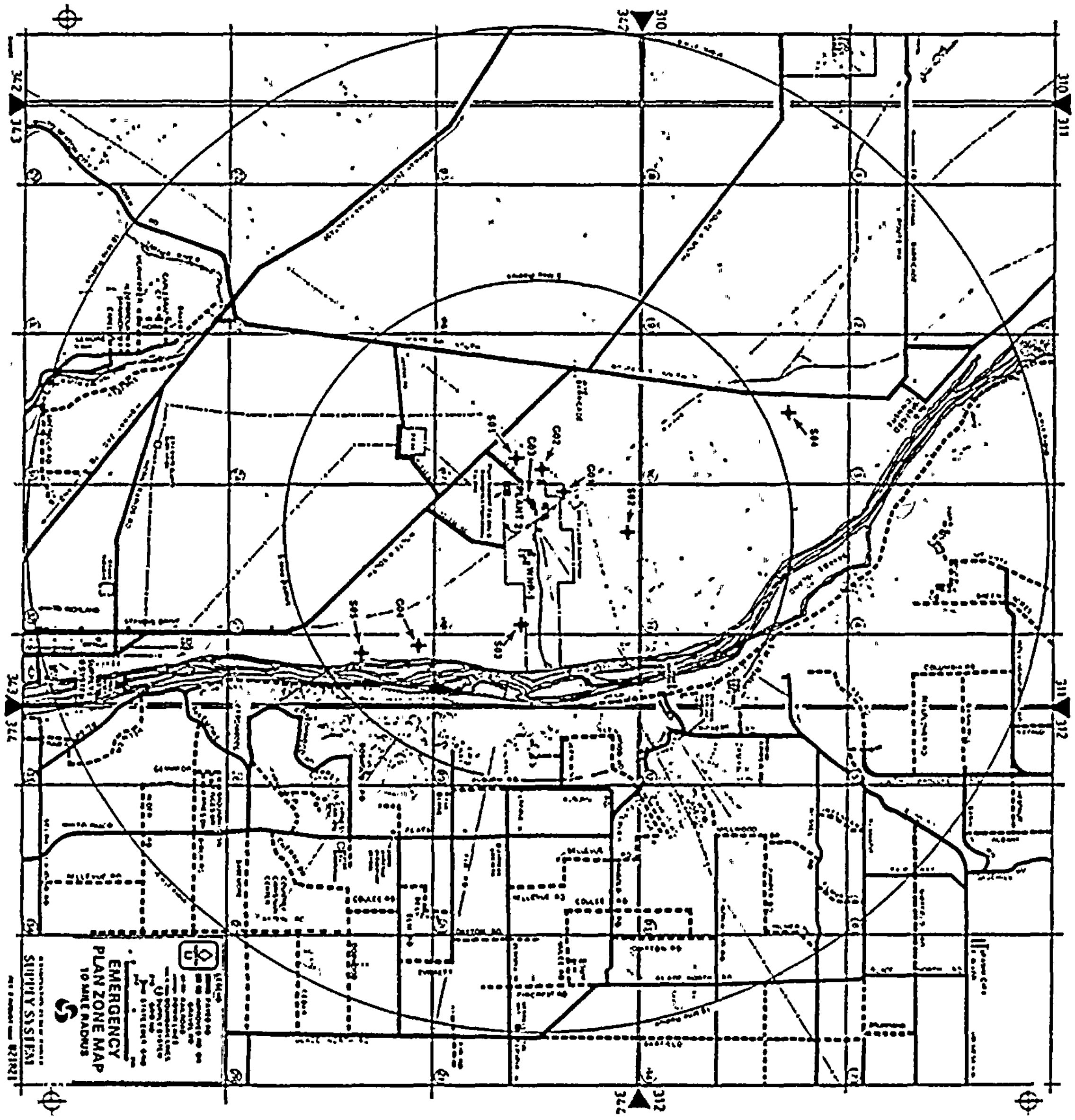


Figure 5-1. Soil and Vegetation Sampling Location Map

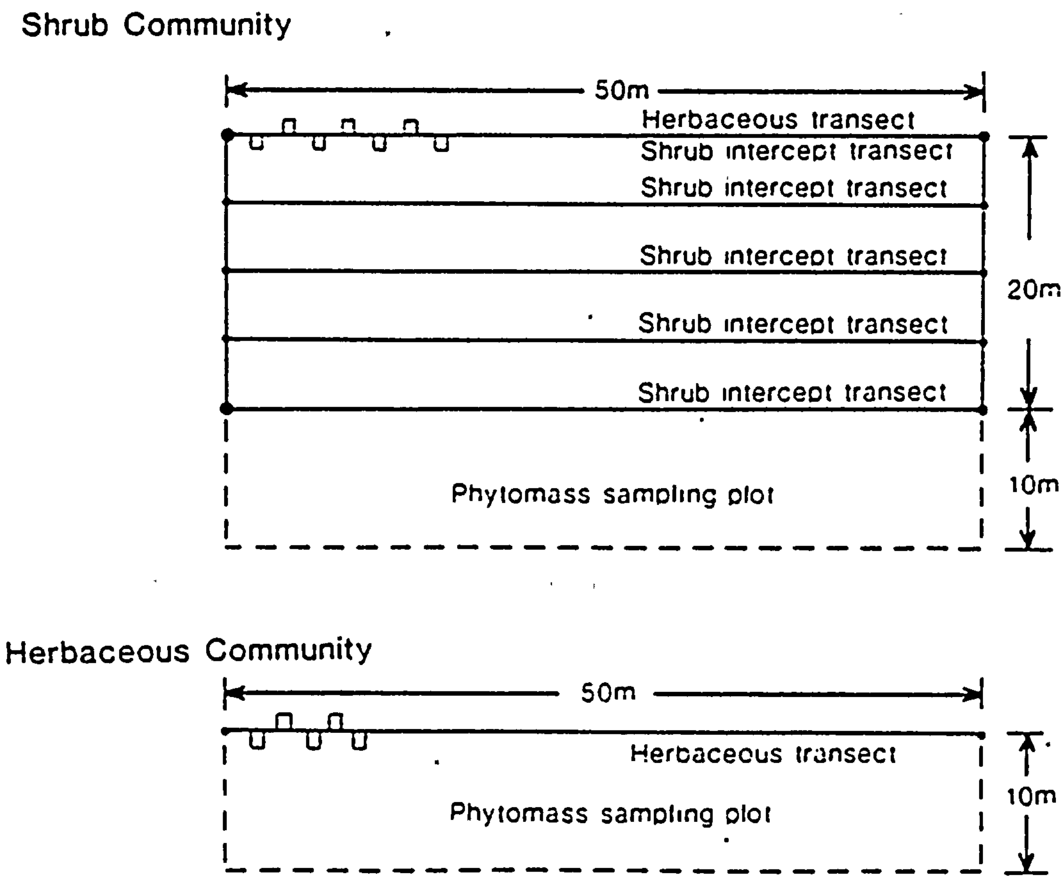


Figure 5-2. Layout of Vegetation and Solid Sampling Plots

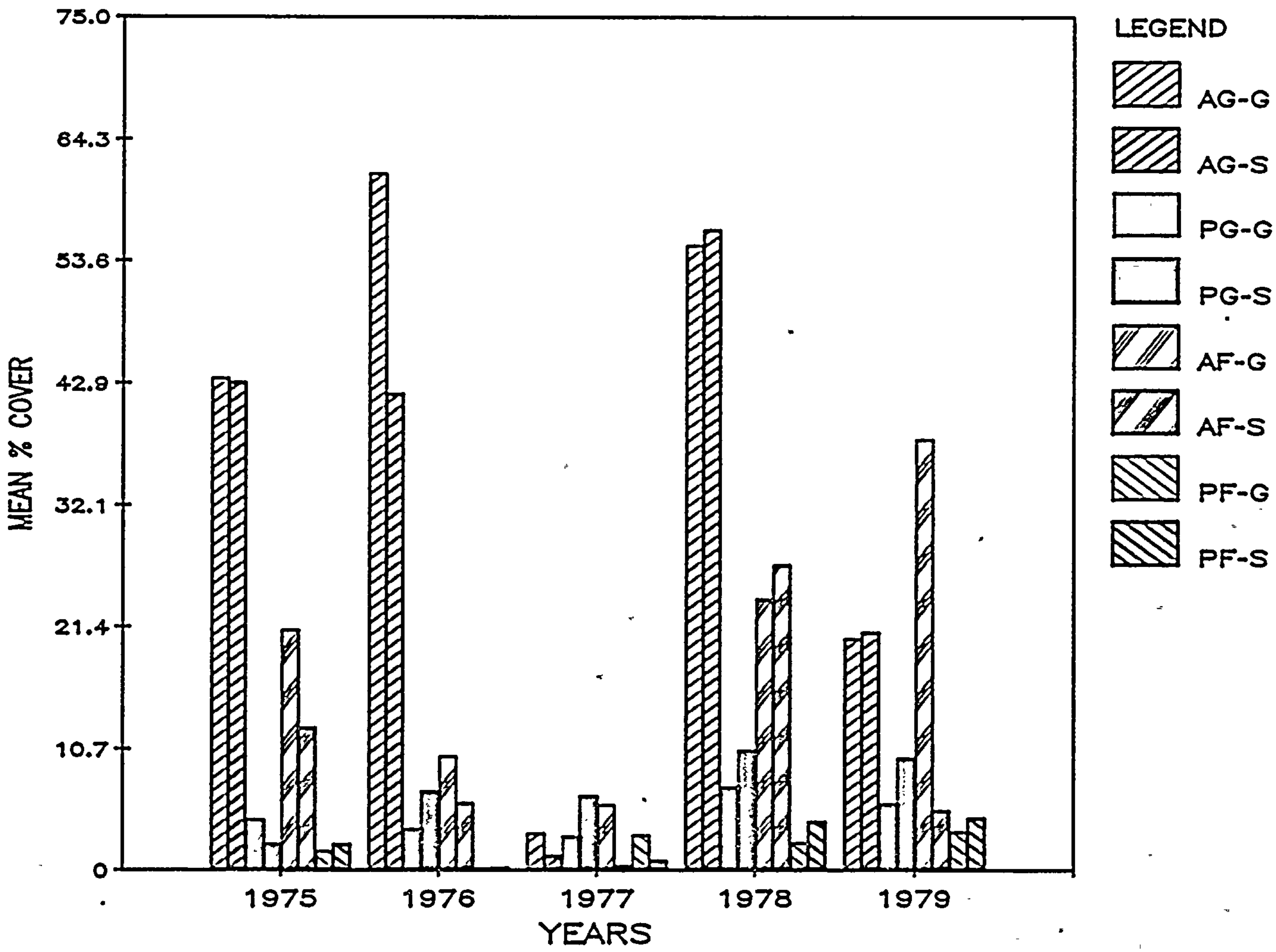


Figure 5-3. Mean Herbaceous Cover for 1975 Through 1979

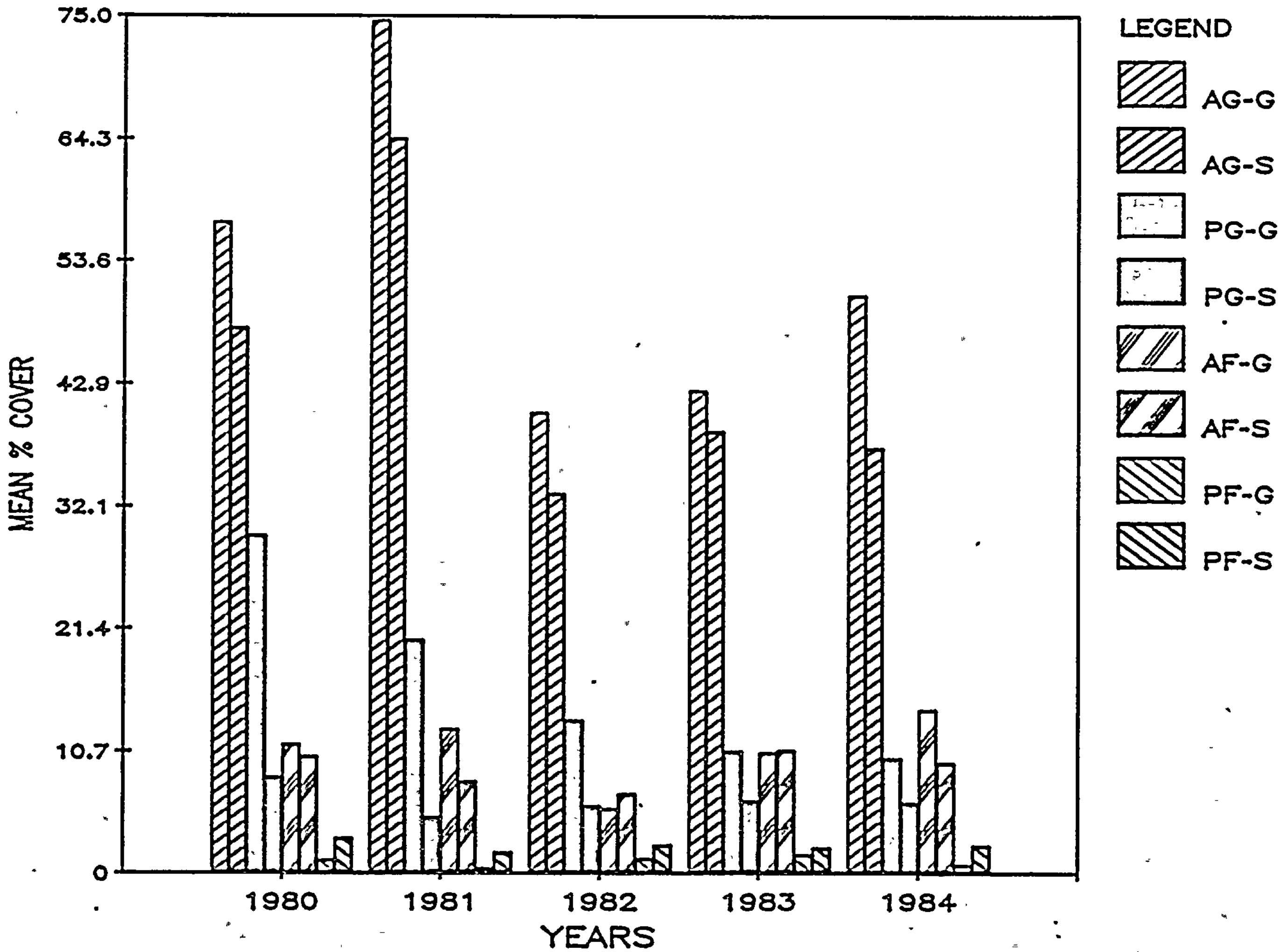


Figure 5-4. Mean Herbaceous Cover for 1980 Through 1984

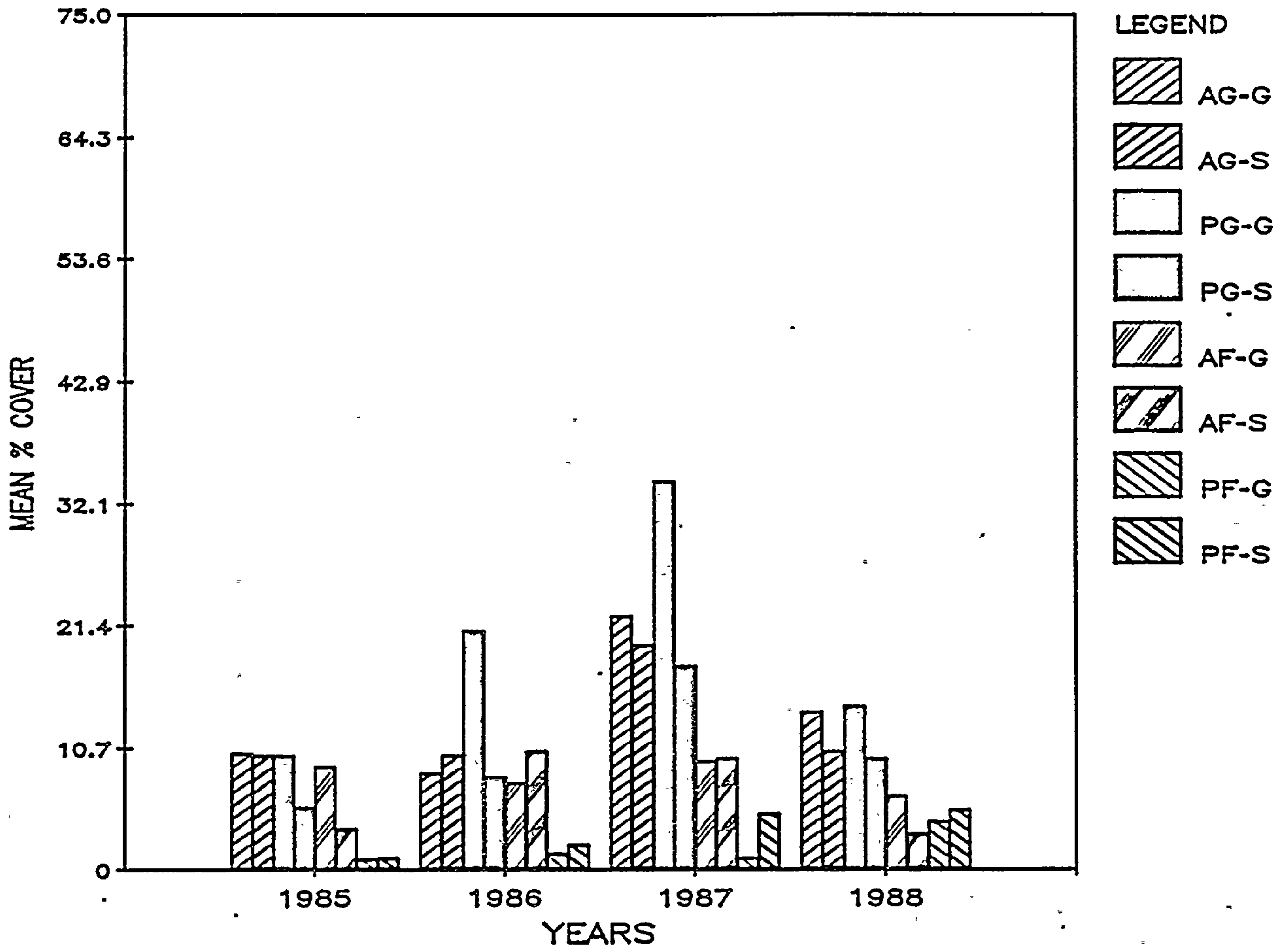


Figure 5-5. Mean Herbaceous Cover for 1985 Through 1988

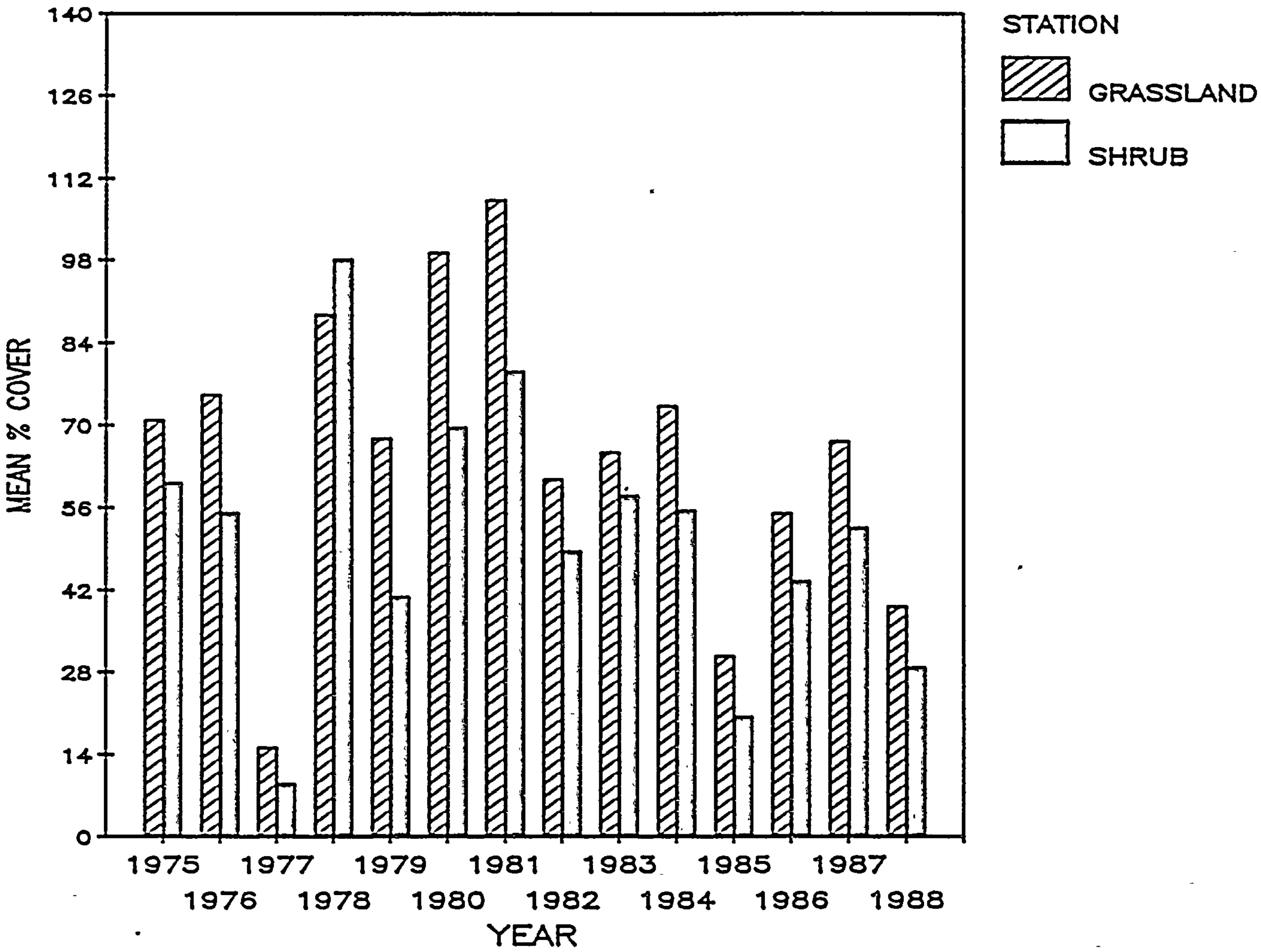


Figure 5-6. Mean (%) Herbaceous Cover for 1975 Through 1988

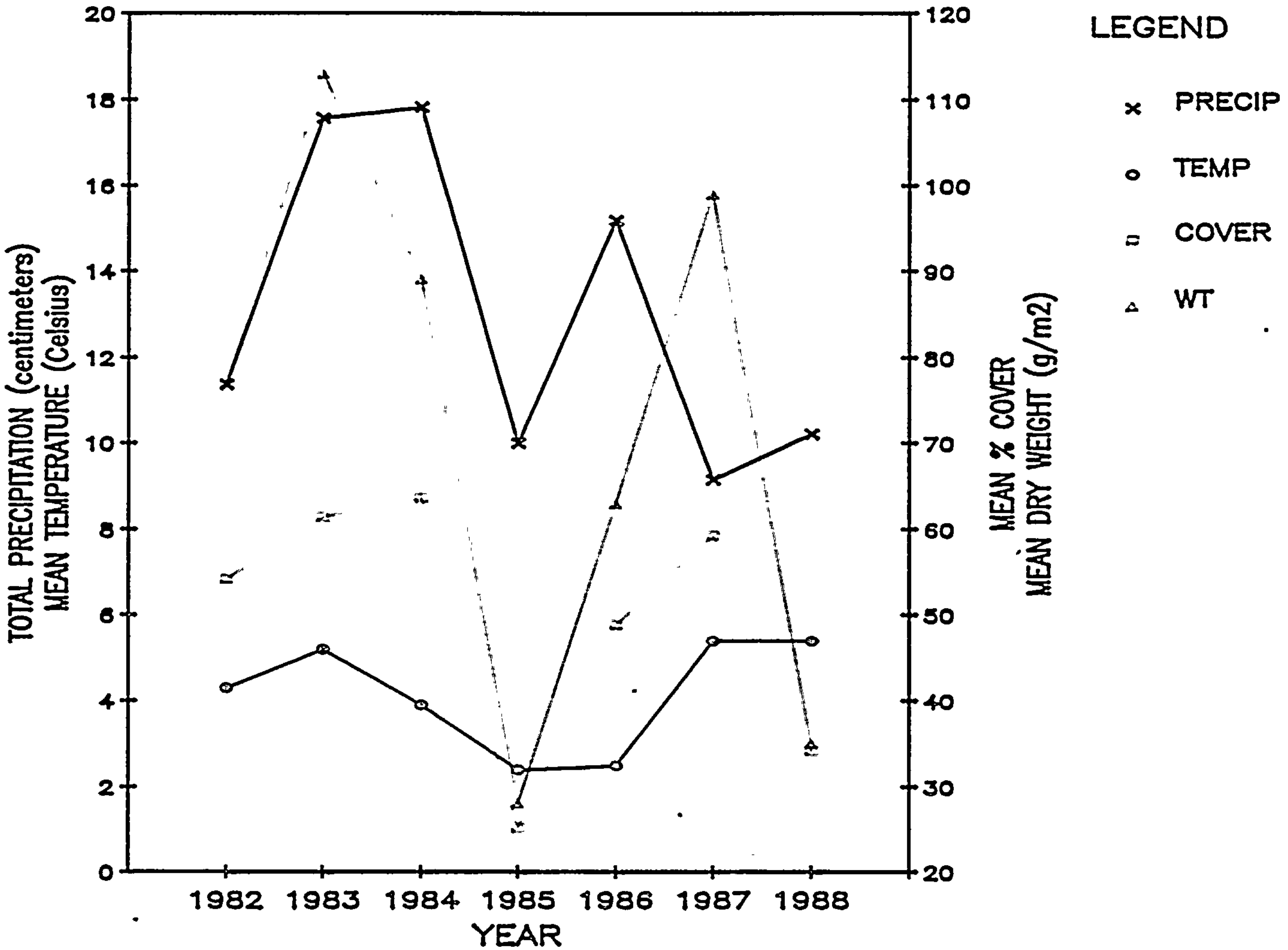


Figure 5-7. Mean Herbaceous Cover, Total Precipitation, and Mean Temperature From 1982 Through 1988

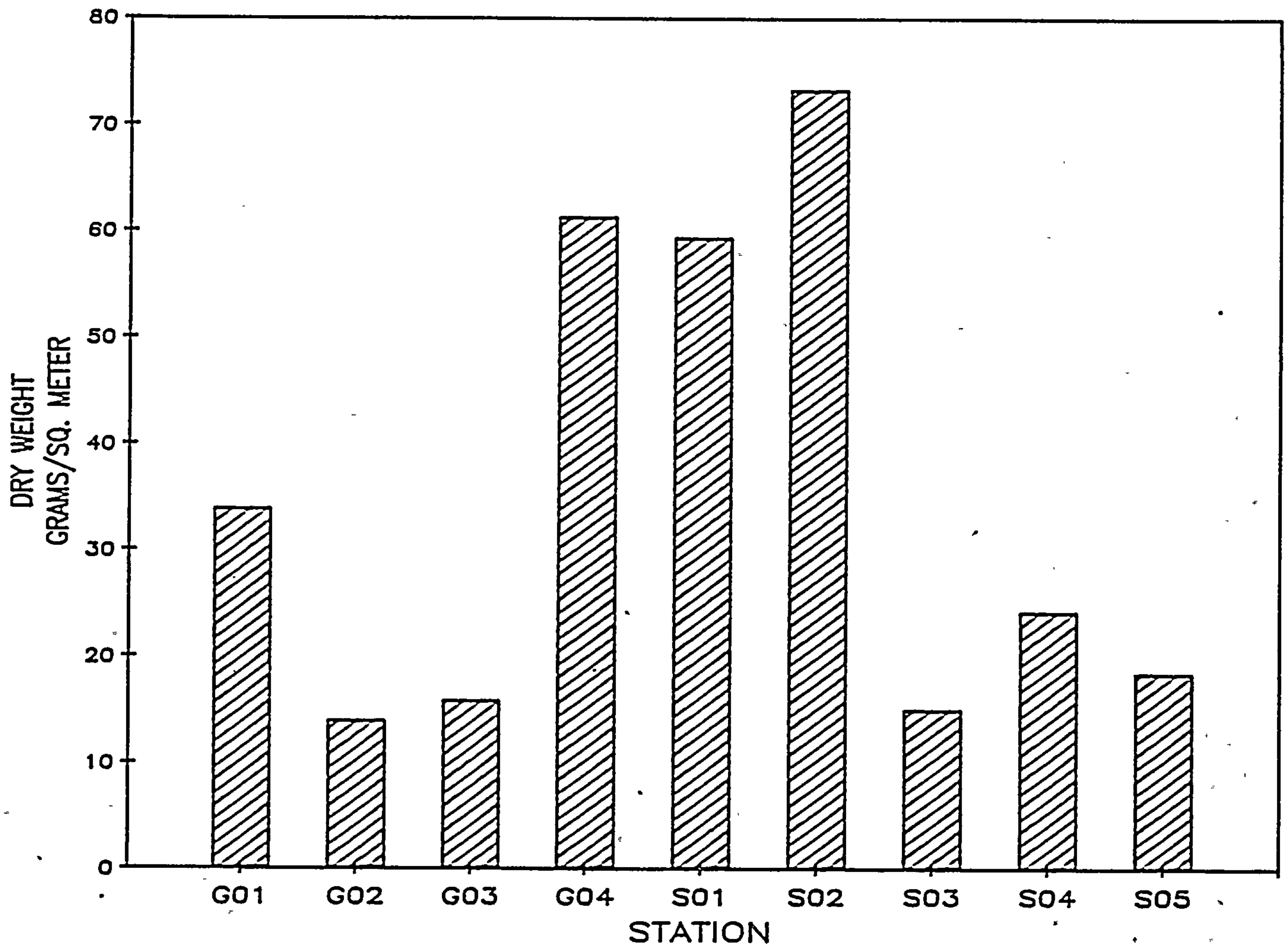


Figure 5-8. Mean Herbaceous Phytomass for May 1988

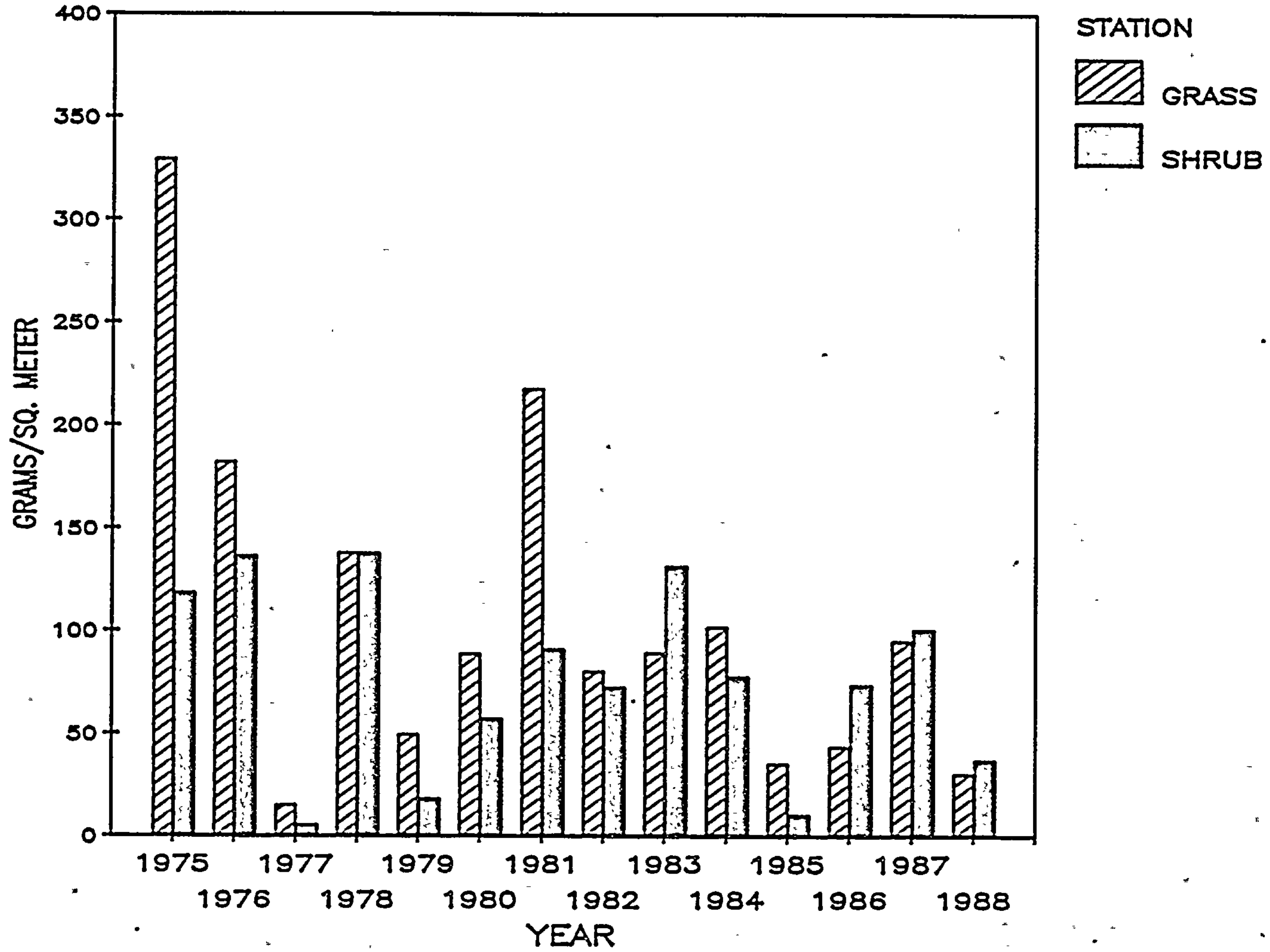


Figure 5-9. Mean Herbaceous Phytomass at Grassland and Shrub Stations for 1975 Through 1988

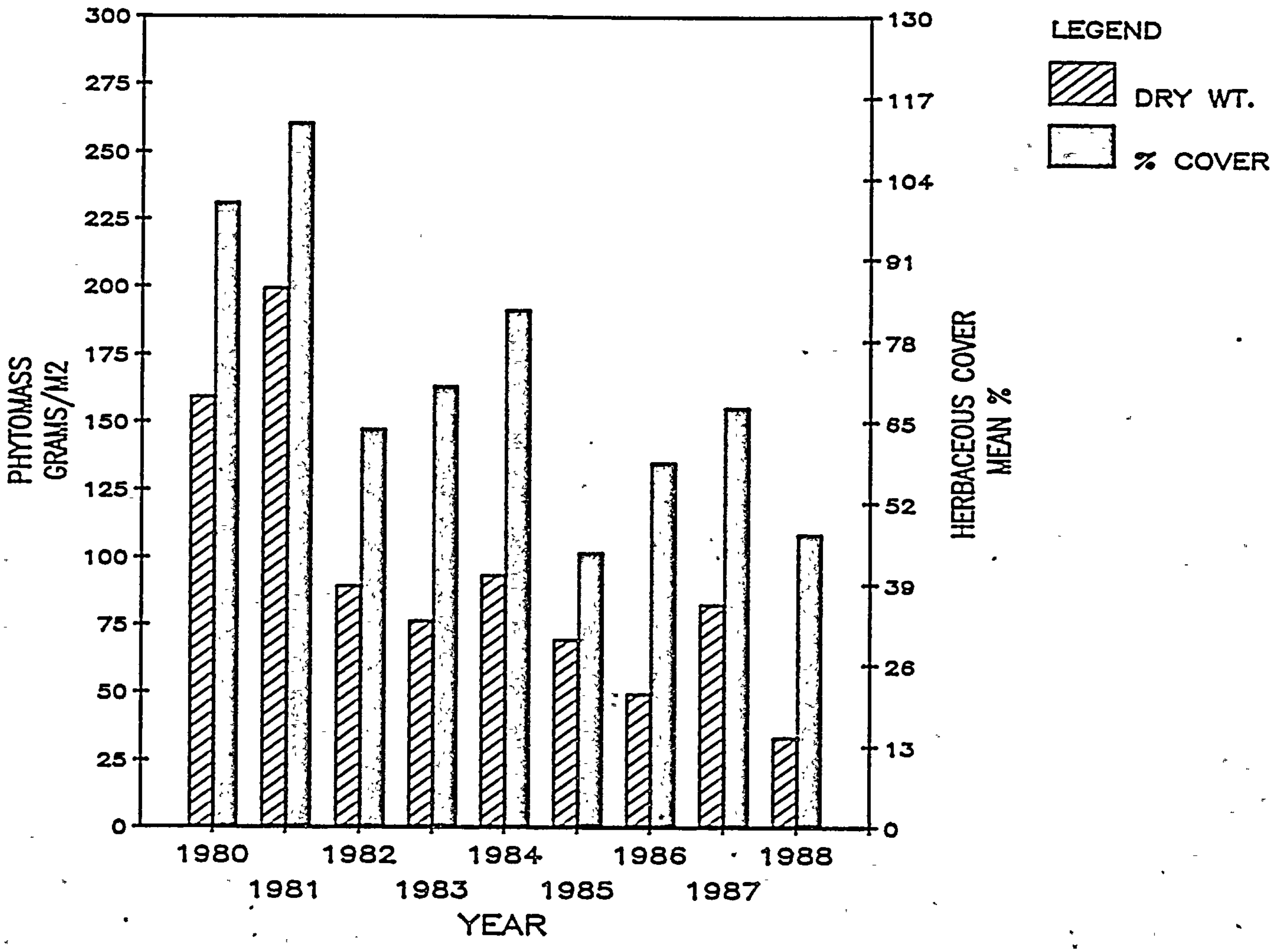


Figure 5-10. Mean Herbaceous Cover and Phytomass for Station G01 for 1980 Through 1988

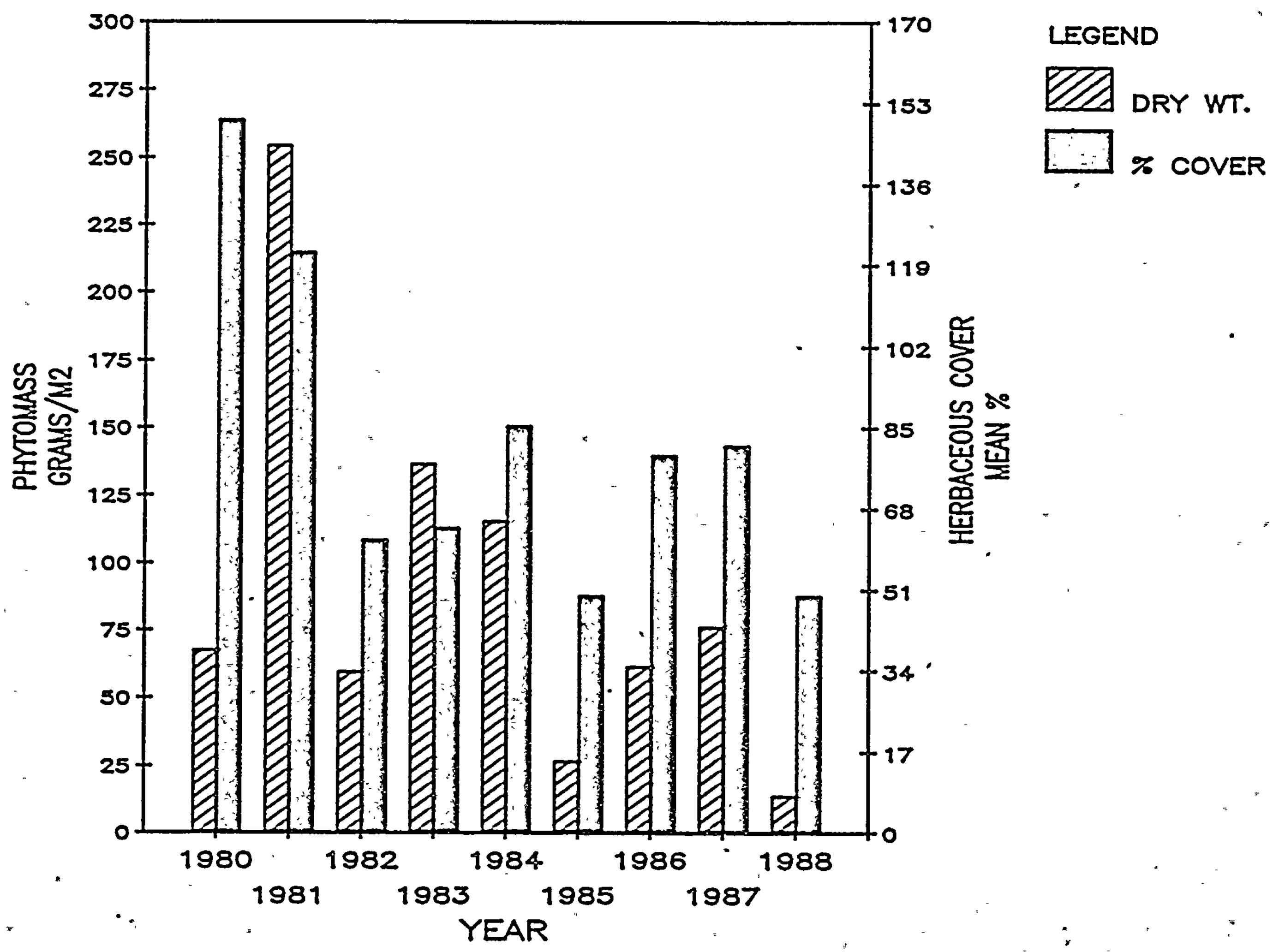


Figure 5-11. Mean Herbaceous Cover and Phytomass for Station G02 for 1980 Through 1988

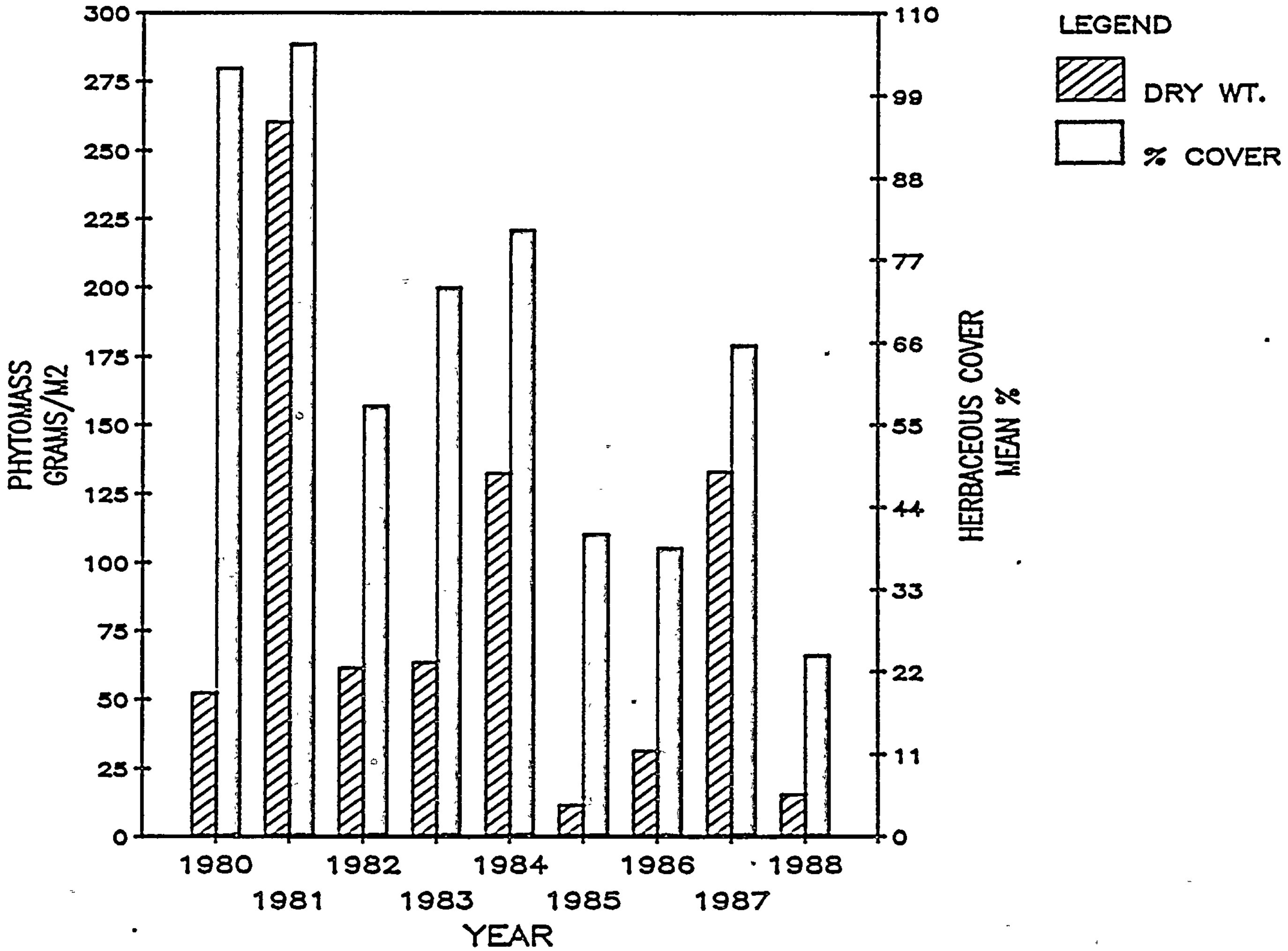


Figure 5-12. Mean Herbaceous Cover and Phytomass for Station G03 for 1980 Through 1988

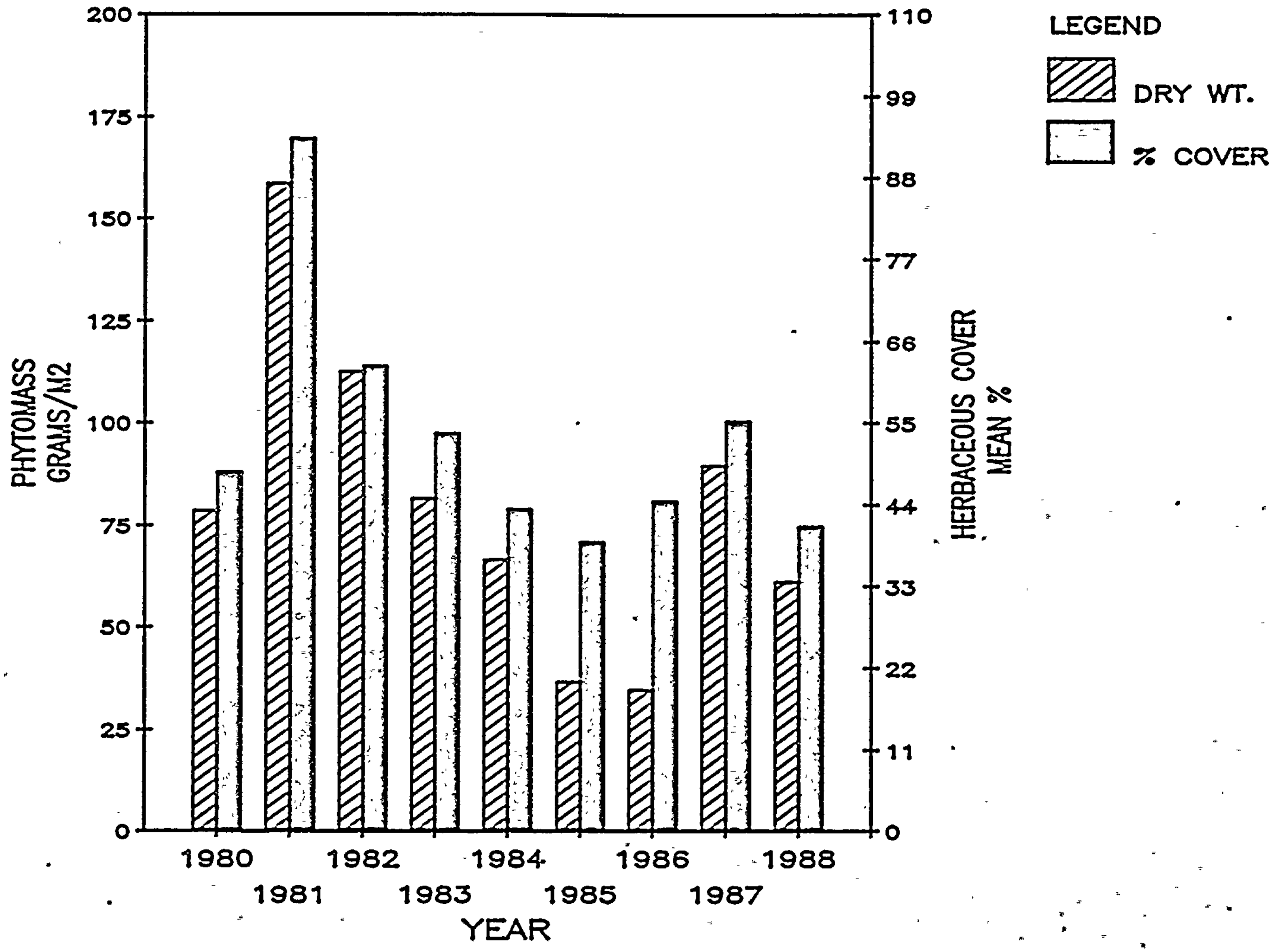


Figure 5-13. Mean Herbaceous Cover and Phytomass for Station G04 for 1980 Through 1988

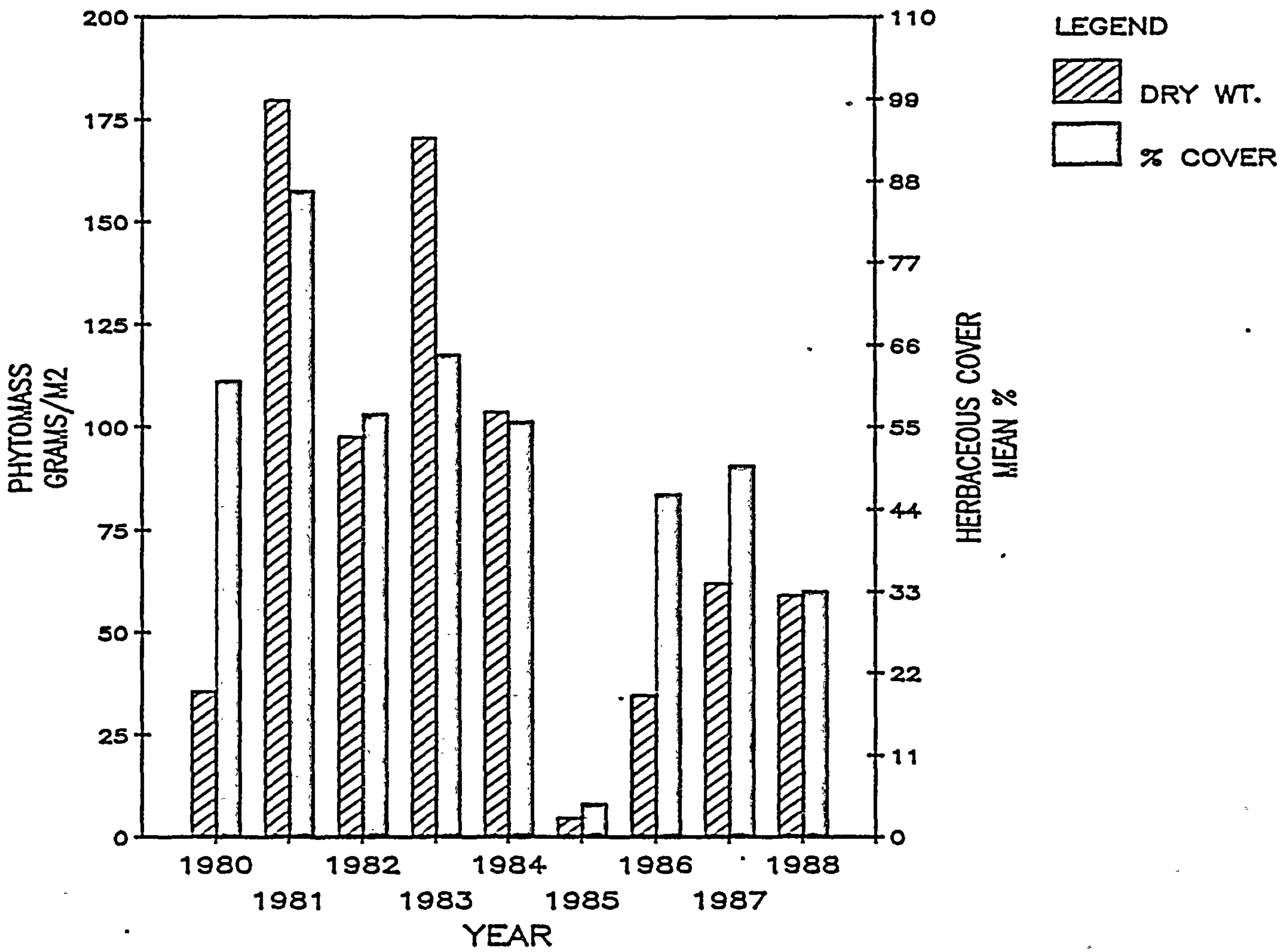


Figure 5-14. Mean Herbaceous Cover and Phytomass for Station S01 for 1980 Through 1988

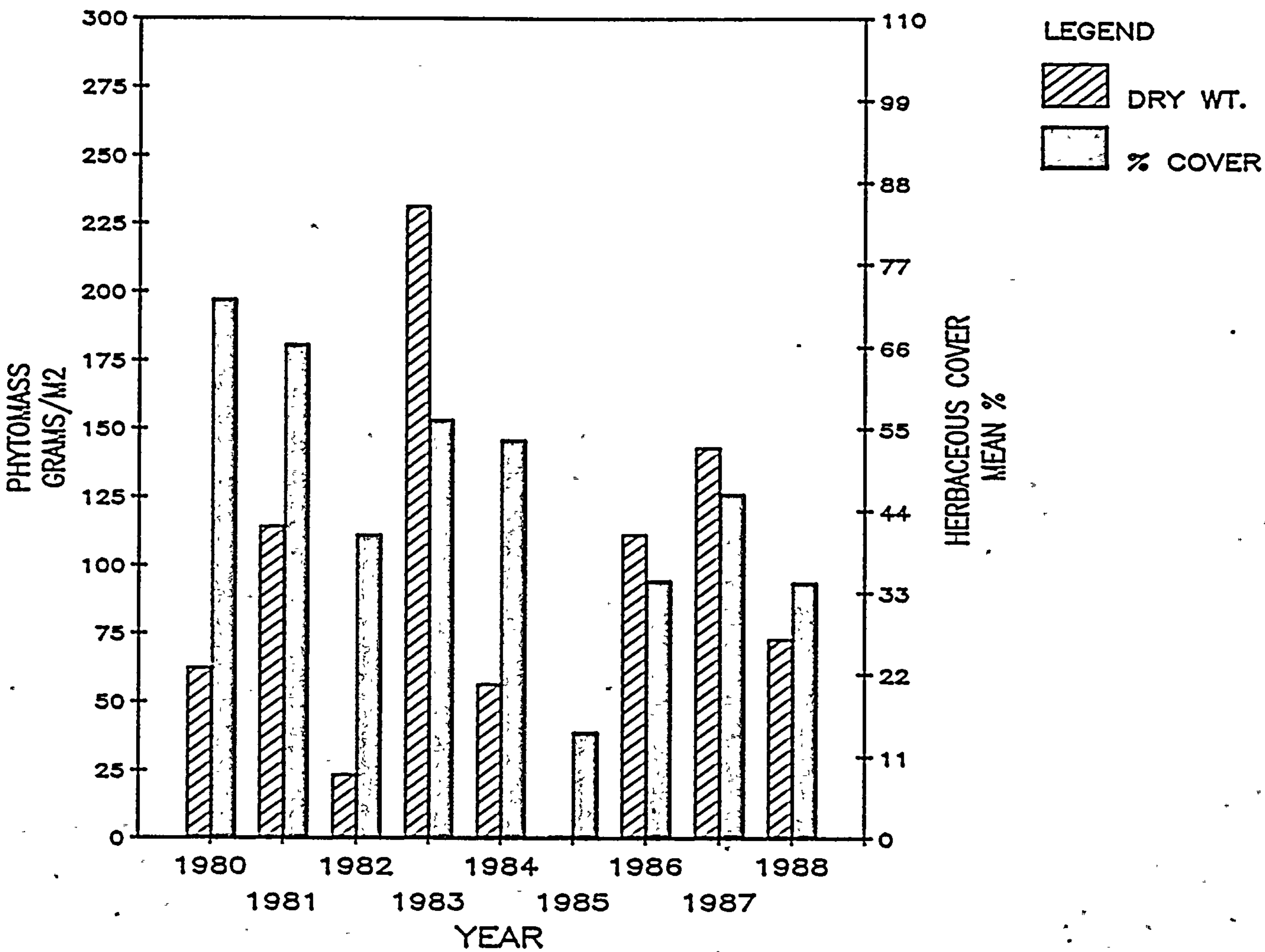


Figure 5-15. Mean Herbaceous Cover and Phytomass for Station S02 for 1980 Through 1988

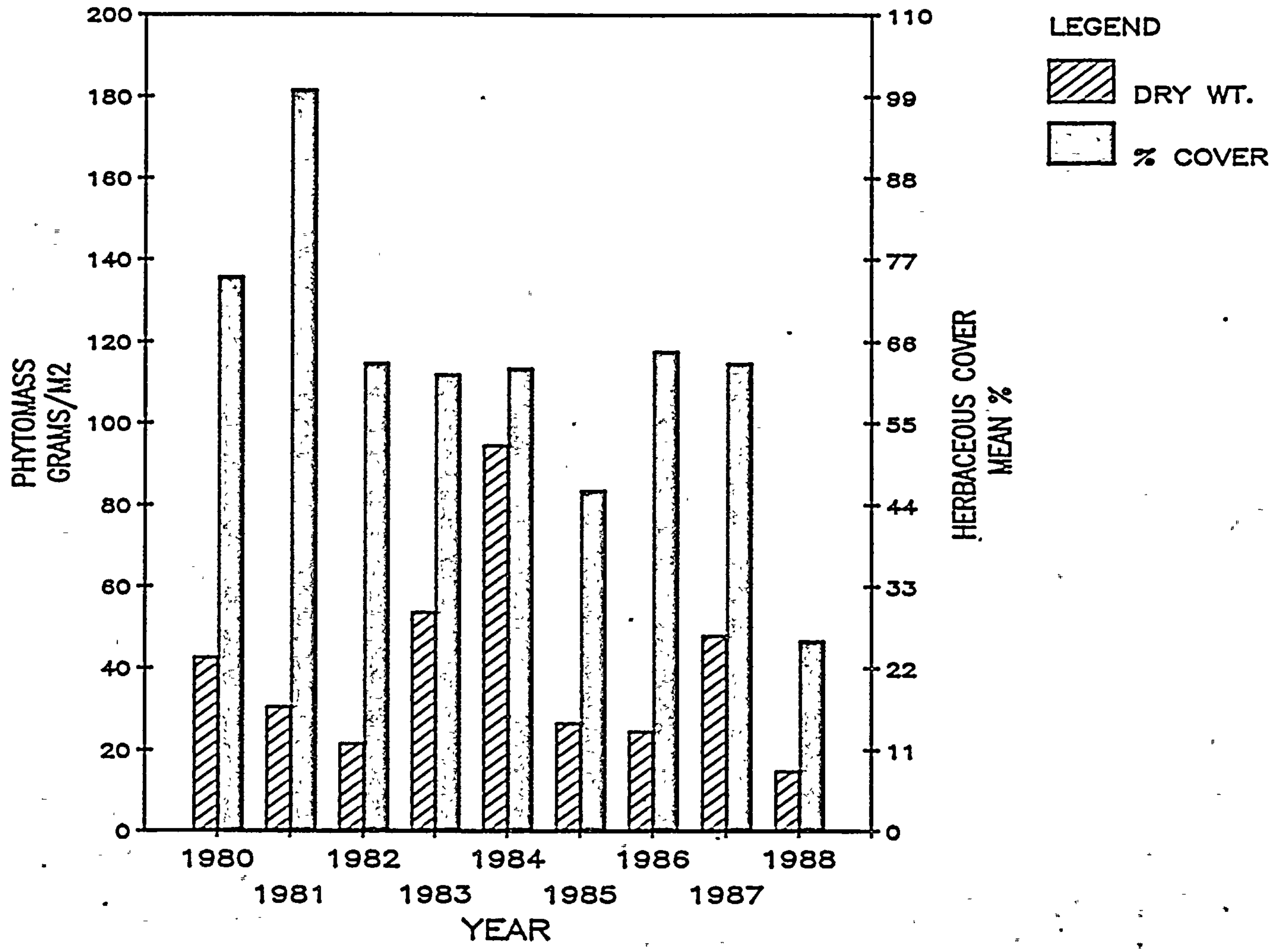


Figure 5-16. Mean Herbaceous Cover and Phytomass for Station S03 for 1980 Through 1988

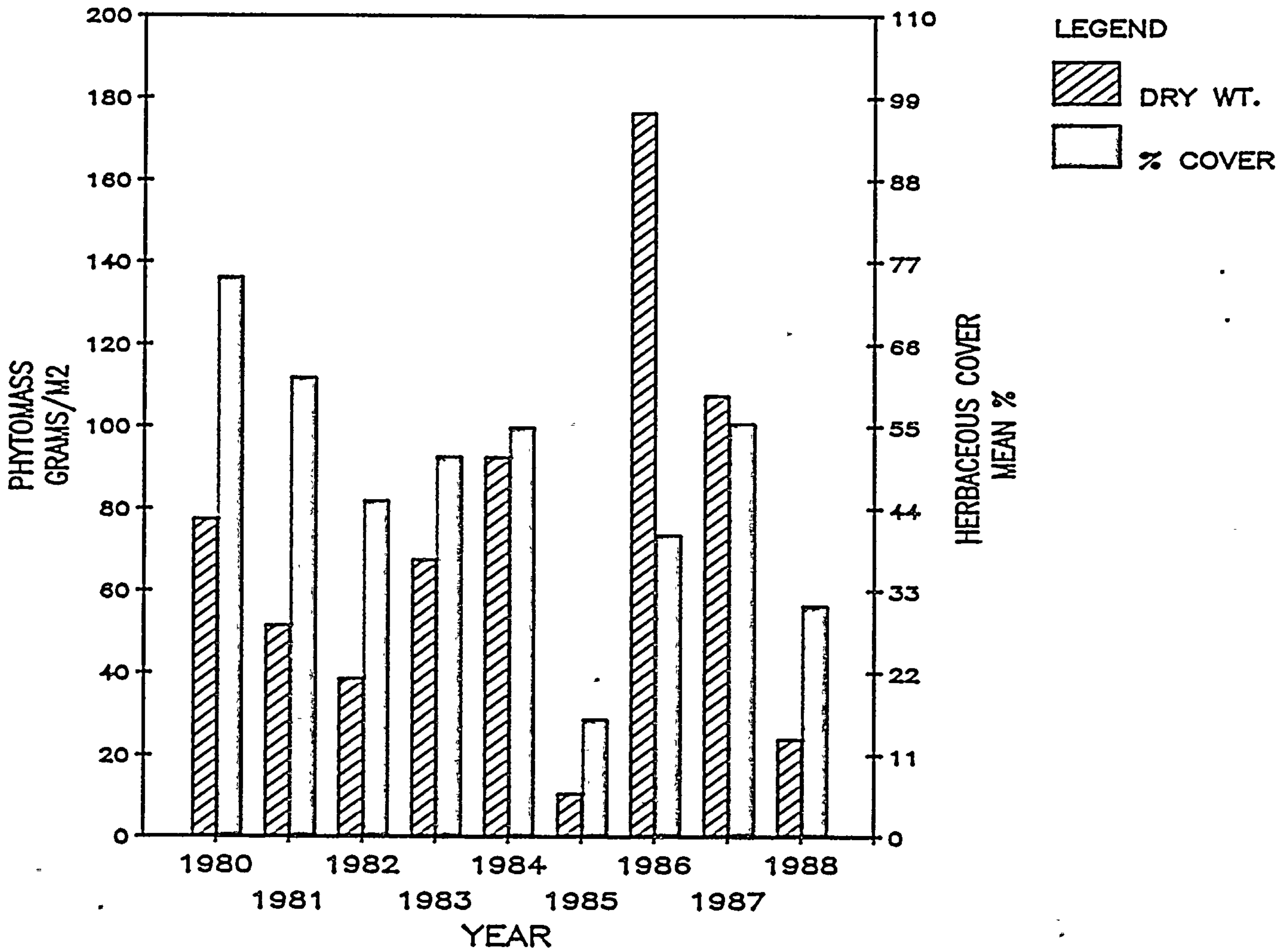


Figure 5-17. Mean Herbaceous Cover and Phytomass for Station S04 for 1980 Through 1988

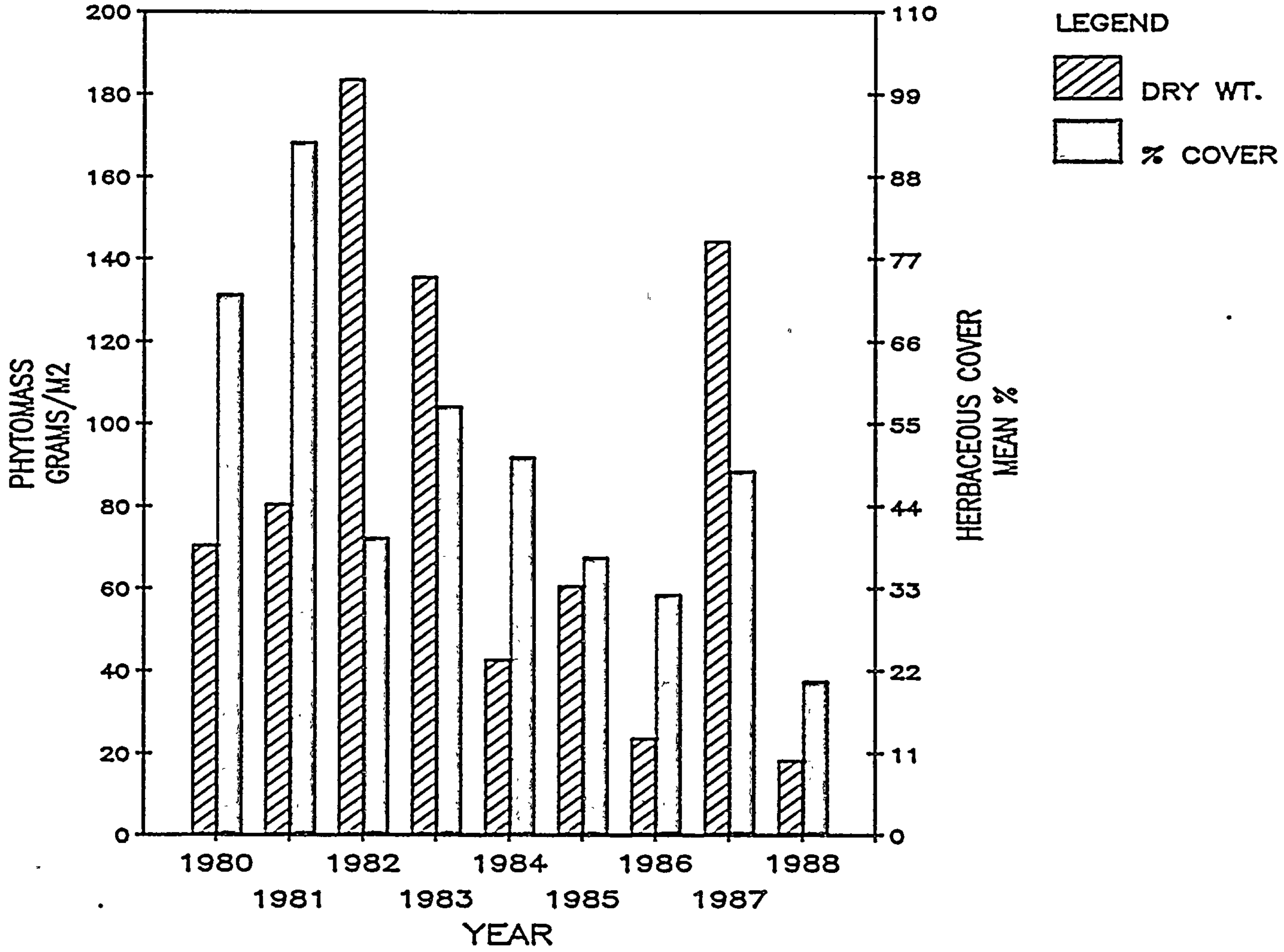


Figure 5-18. Mean Herbaceous Cover and Phytomass for Station S05 for 1980 Through 1988

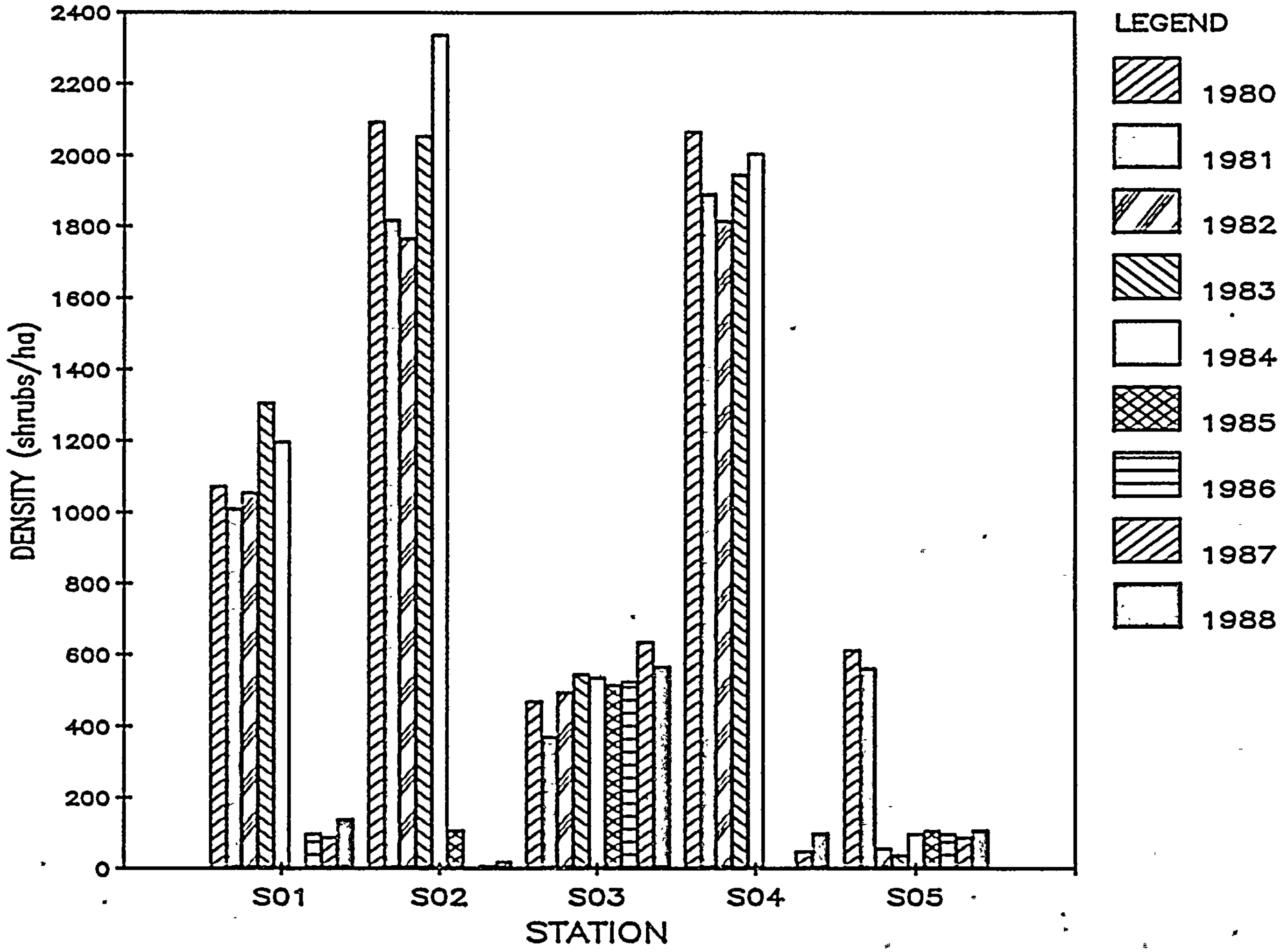


Figure 5-19. Shrub Density at Five Stations for 1980 Through 1988

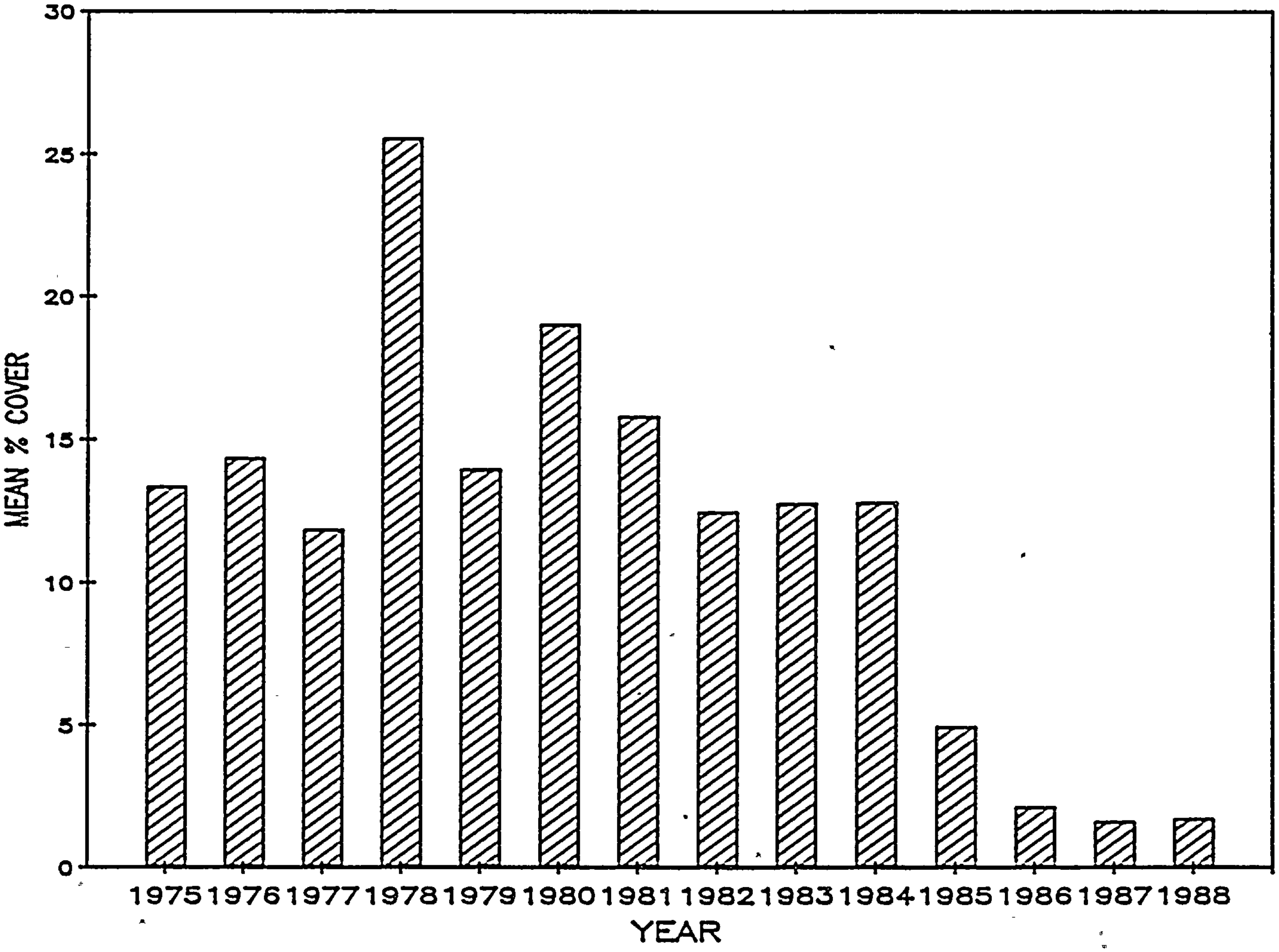


Figure 5-20. Mean Total Shrub Cover for 1975 Through 1988

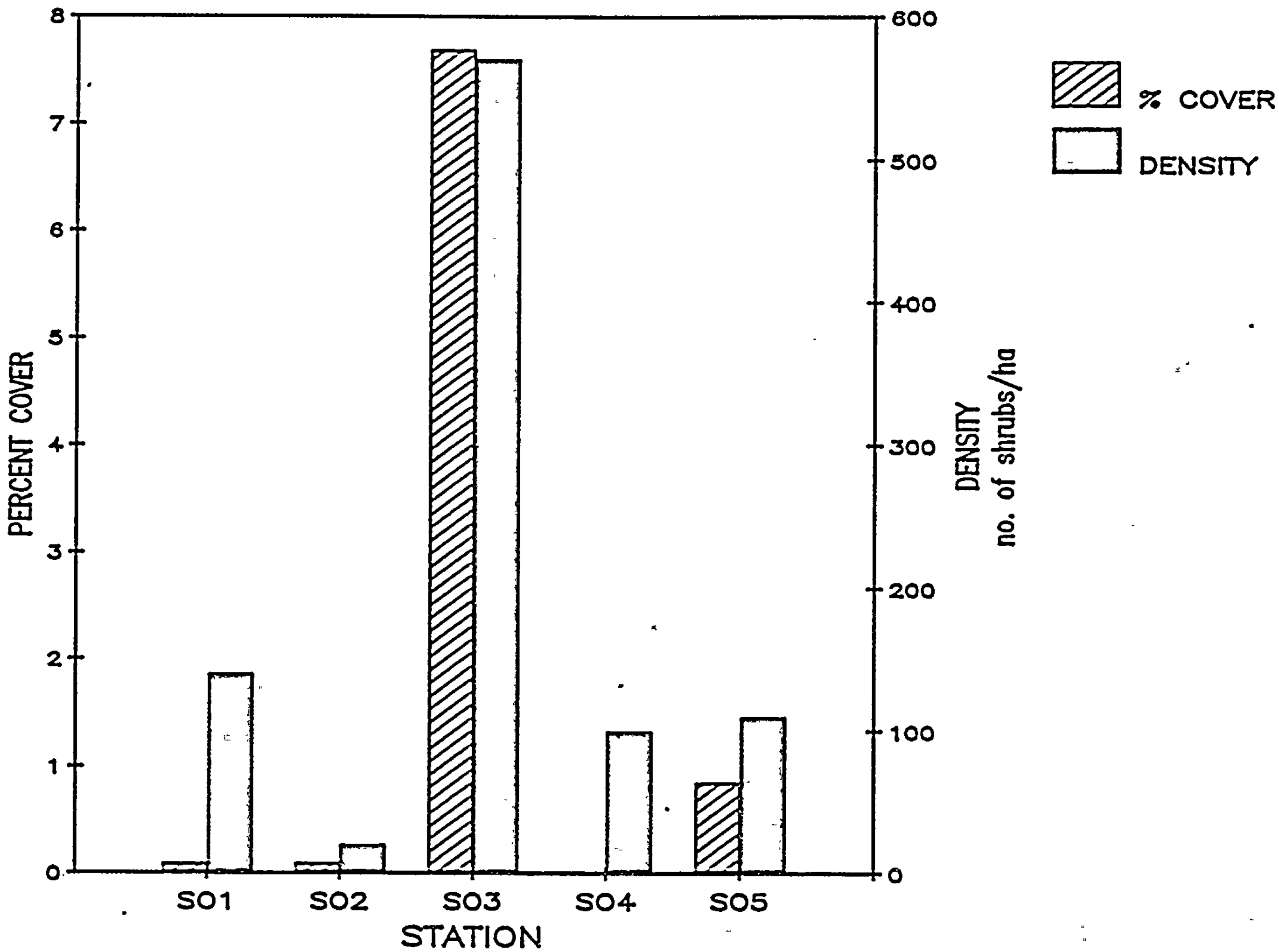


Figure 5-21. Shrub Cover and Density for Five Stations for 1988

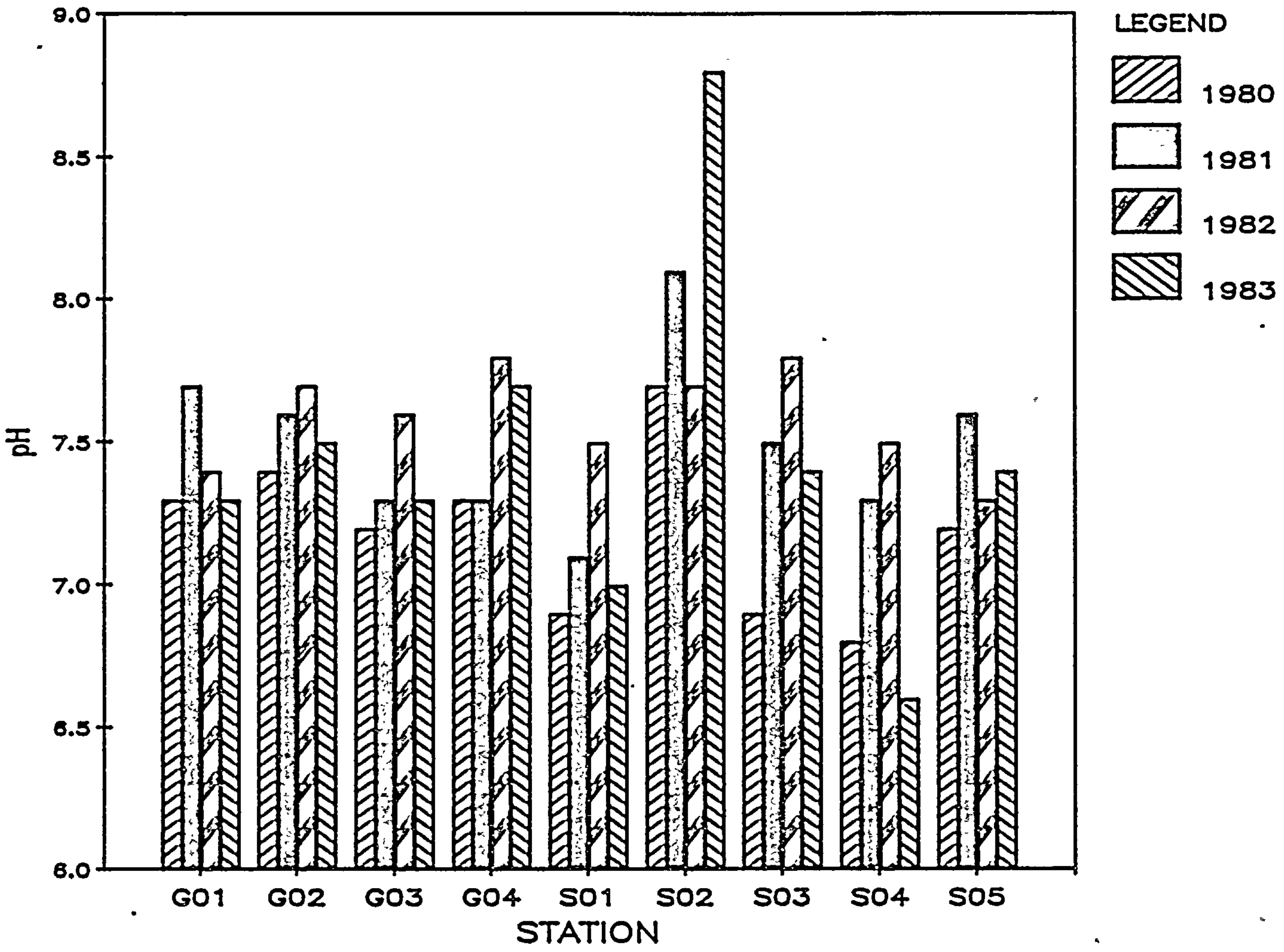


Figure 5-22. Soil pH for 1980 Through 1983

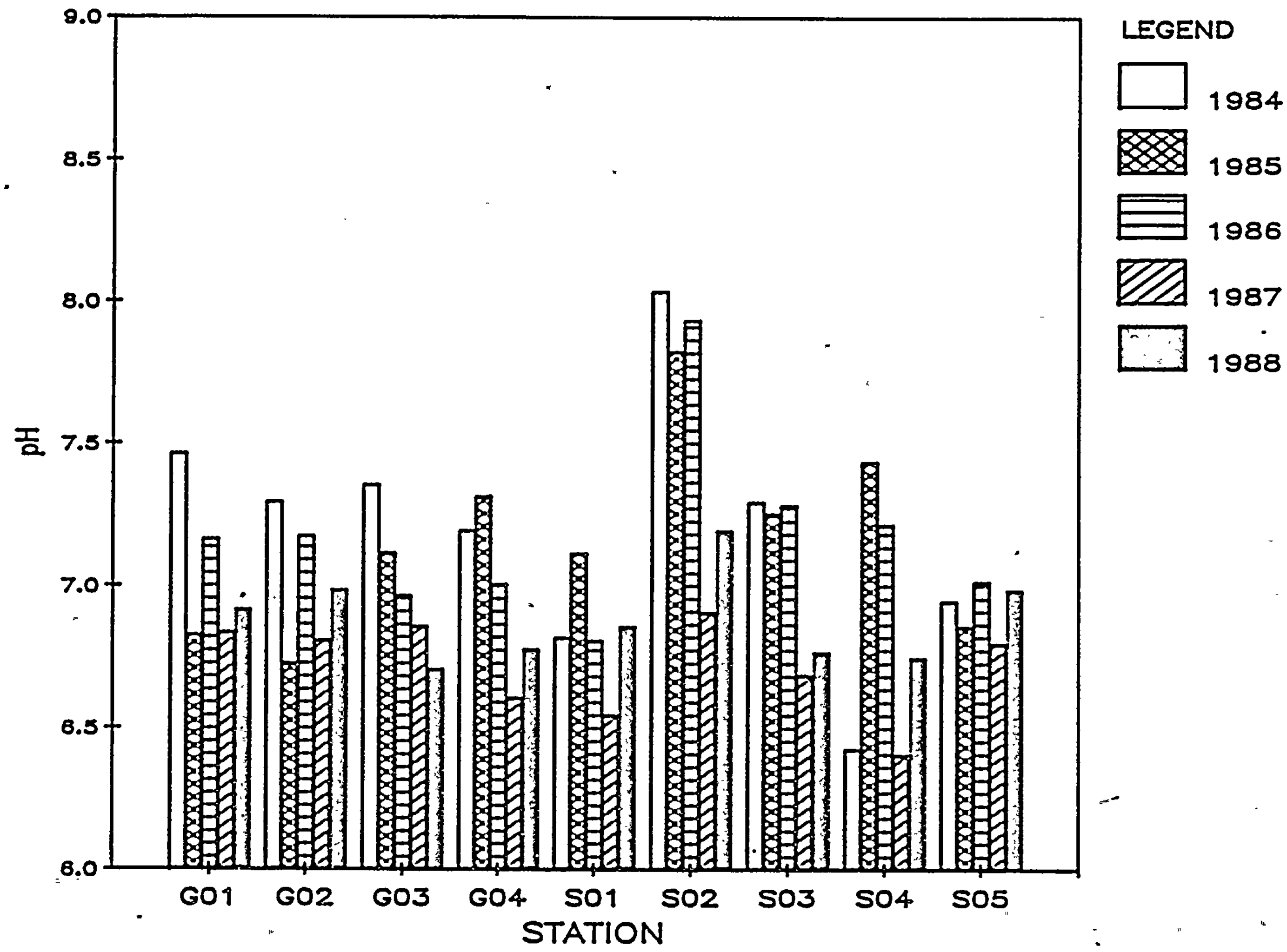


Figure 5-23. Soil pH for 1984 through 1988

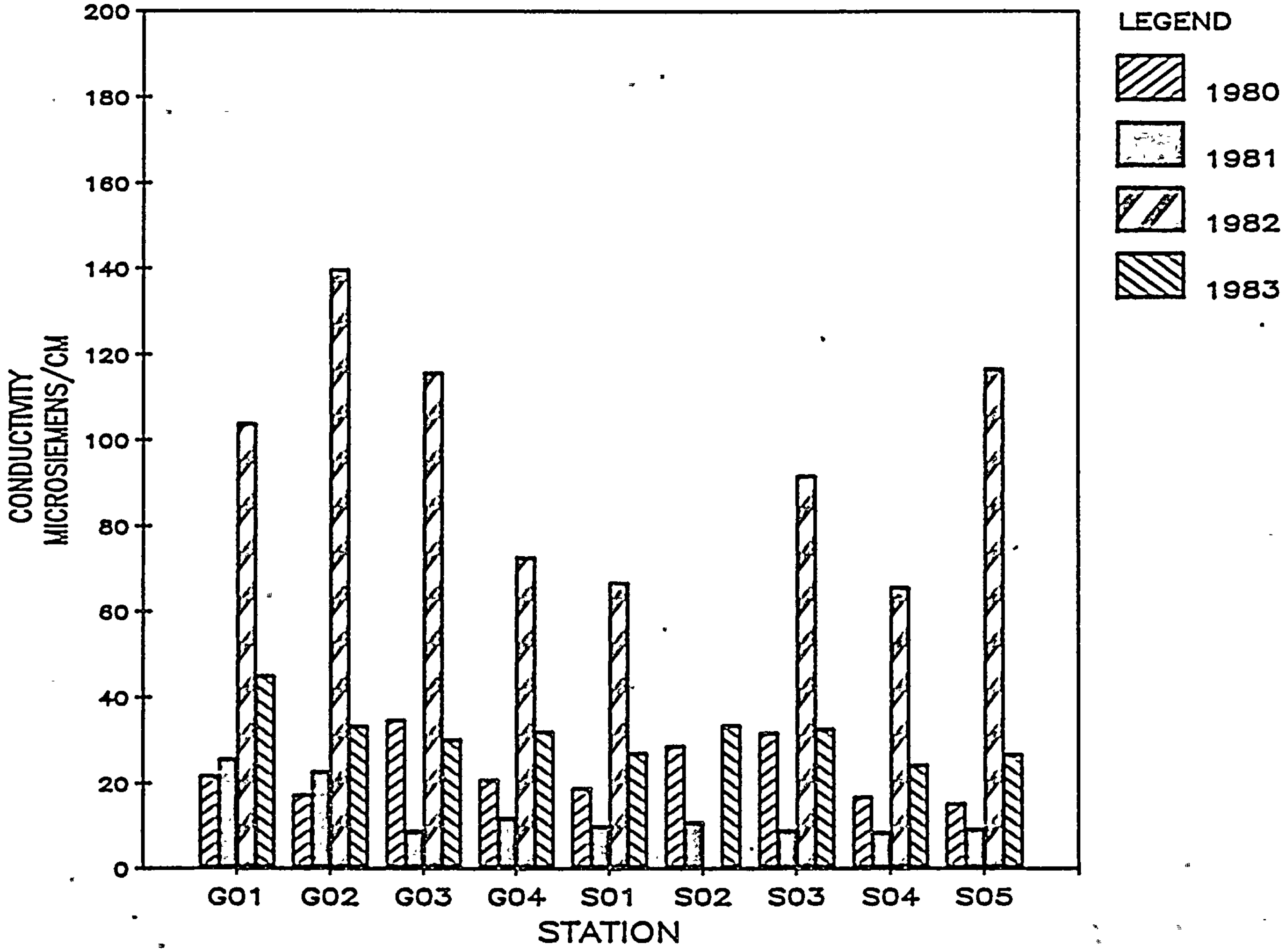


Figure 5-24. Soil Conductivity for 1980 Through 1983

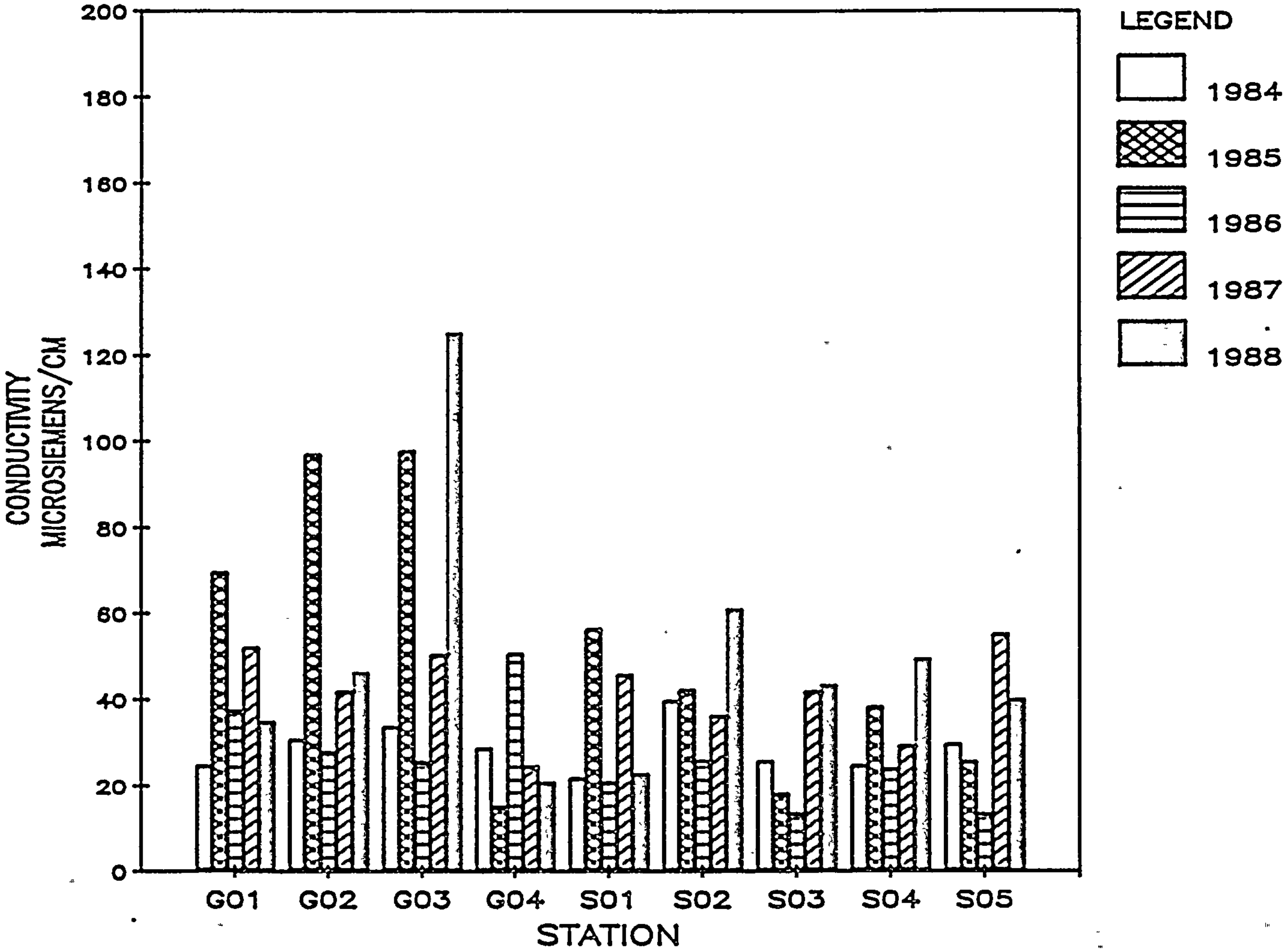


Figure 5-25. Soil Conductivity for 1984 Through 1988

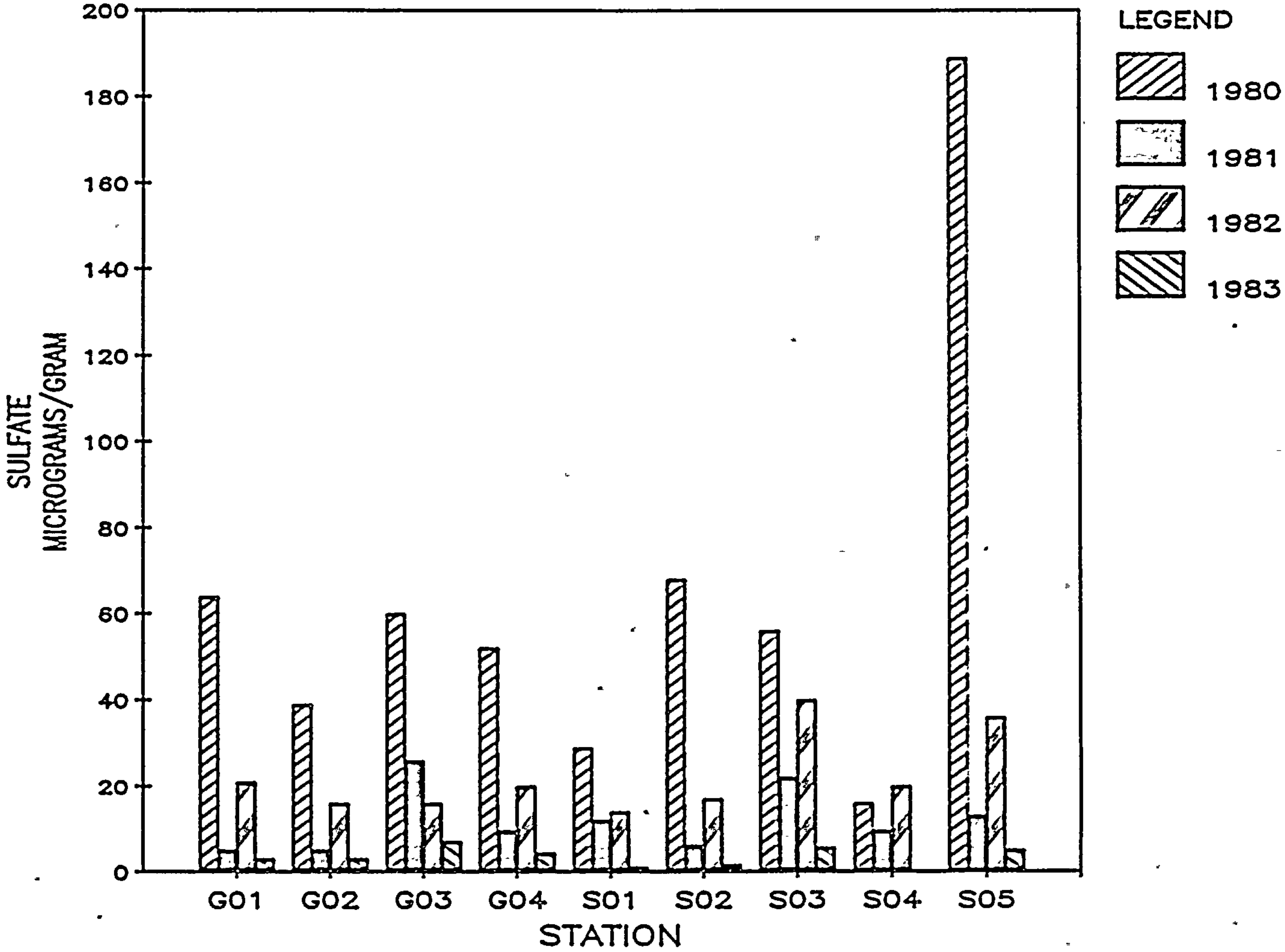


Figure 5-26. Soil Sulfate for 1980 Through 1983

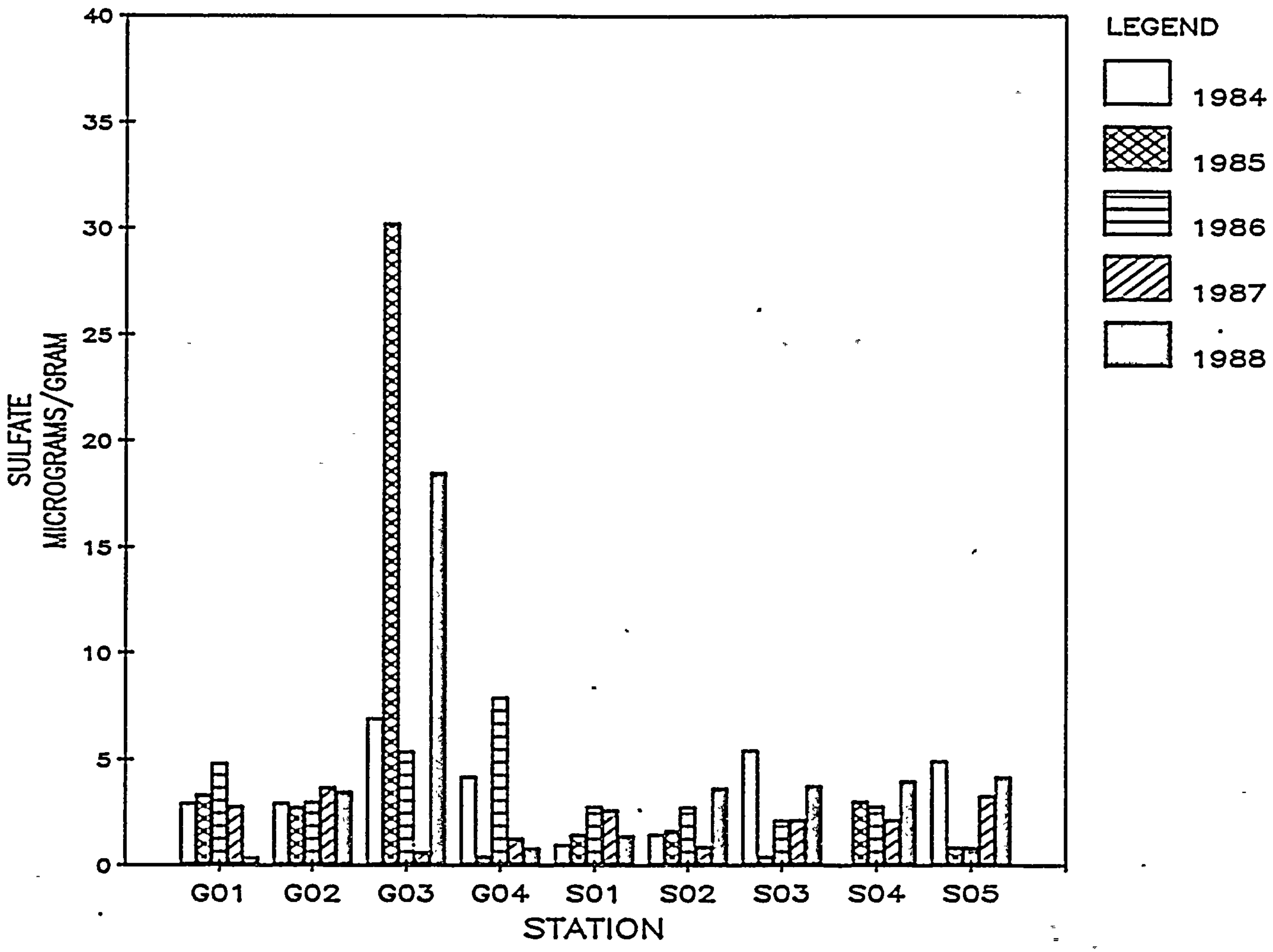


Figure 5-27. Soil Sulfate for 1984 Through 1988

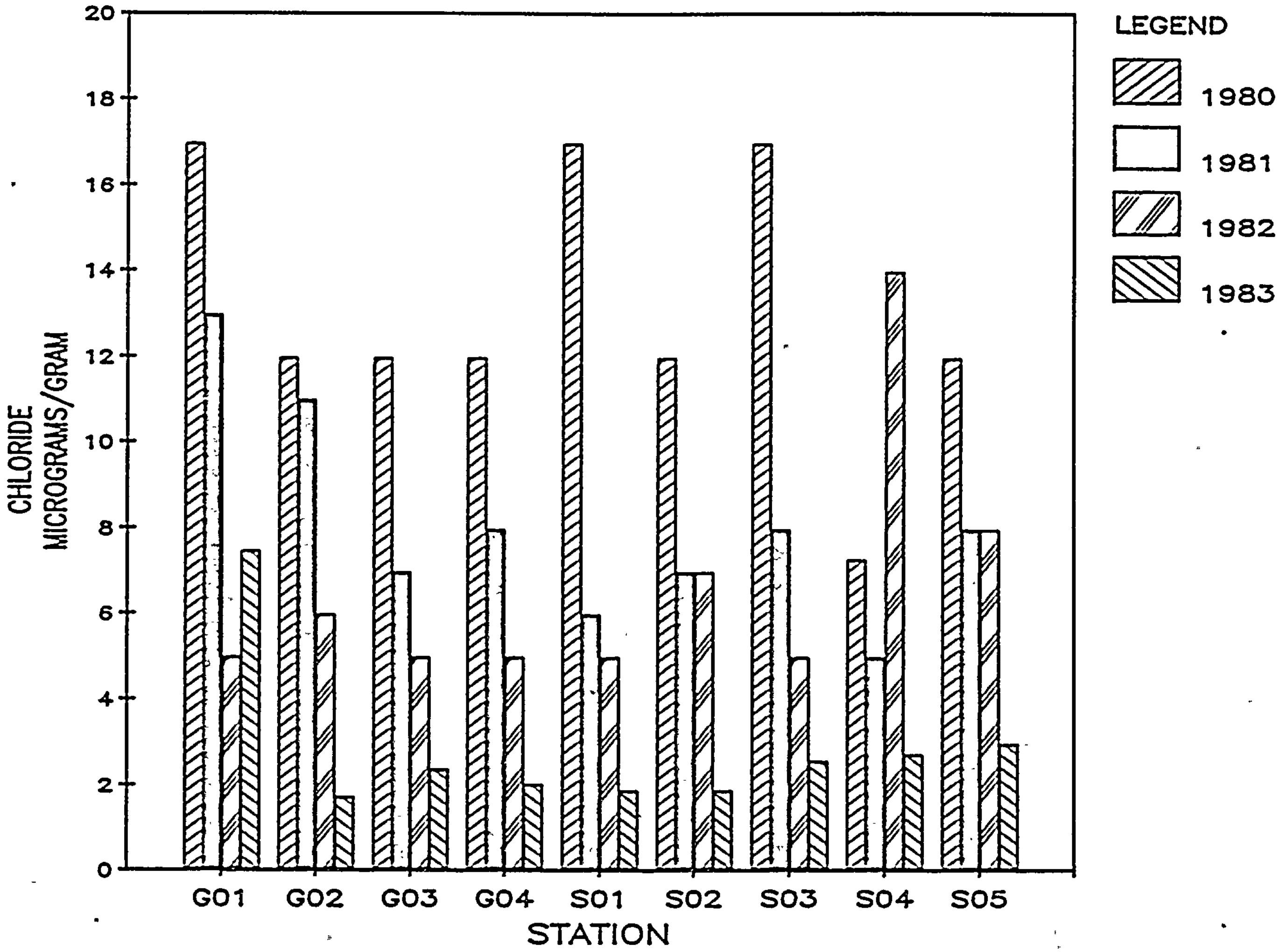


Figure 5-28. Soil Chloride for 1980 Through 1983

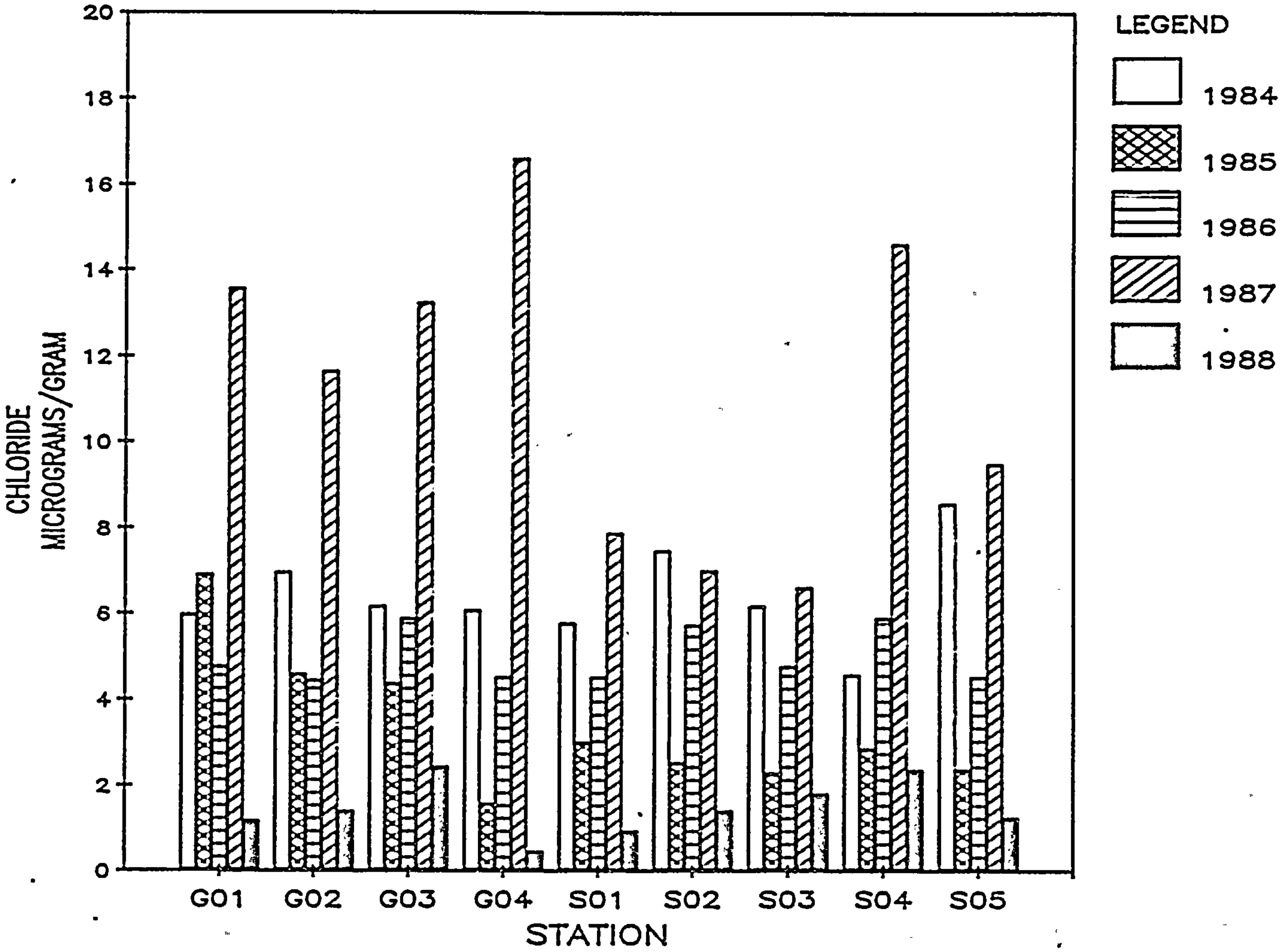


Figure 5-29. Soil Chloride for 1984 Through 1988

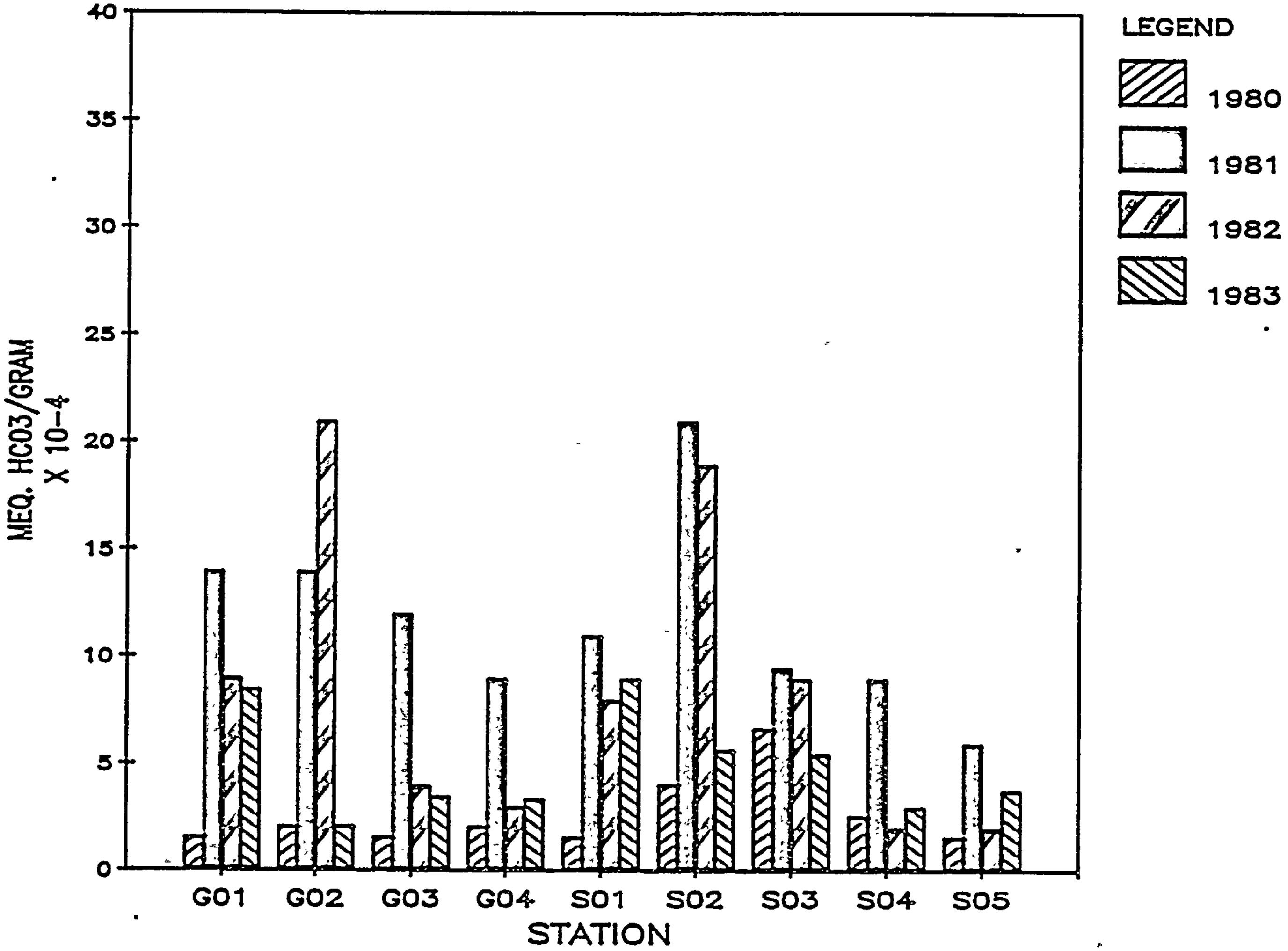


Figure 5-30. Soil Bicarbonate for 1980 Through 1983

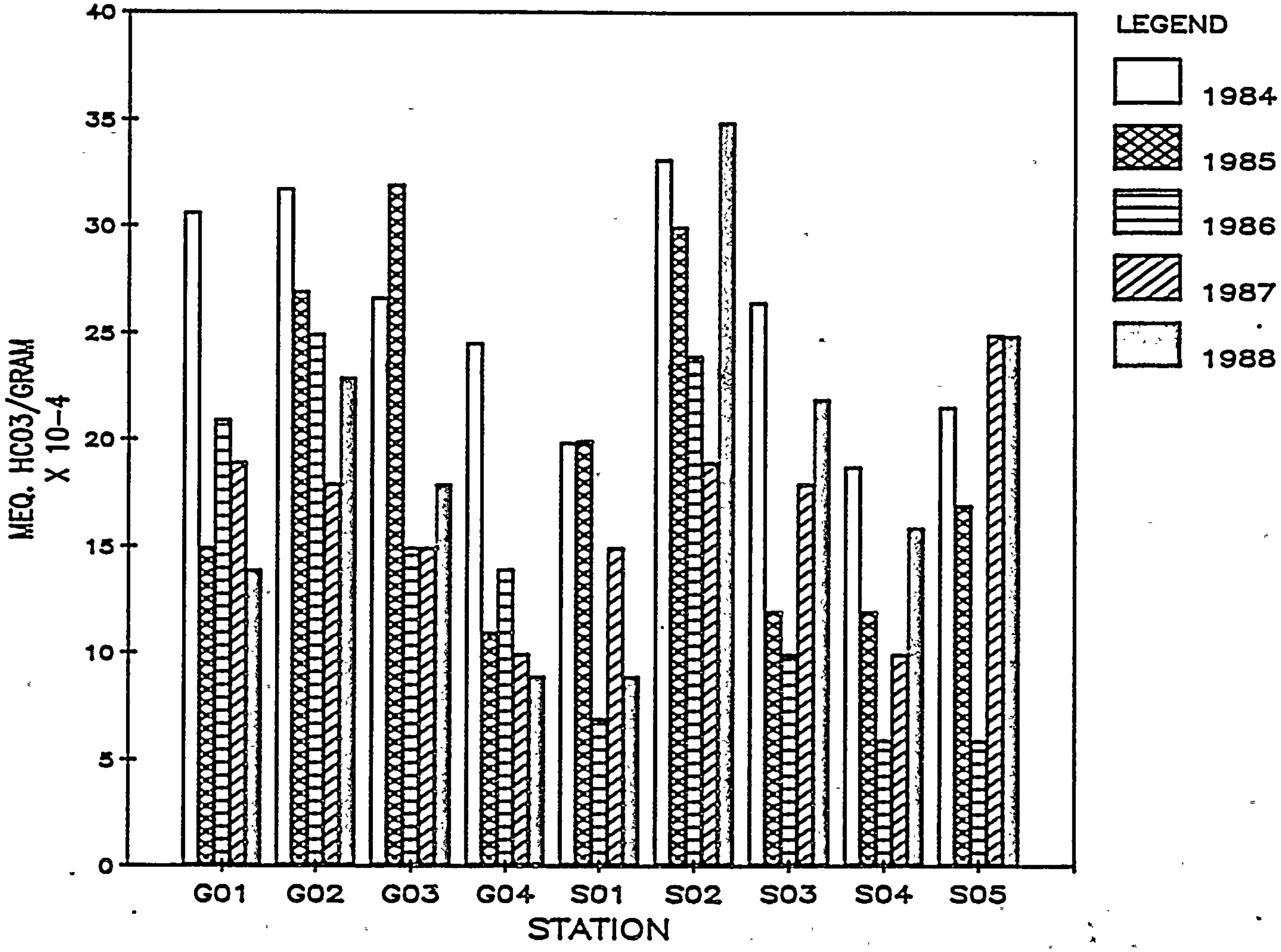


Figure 5-31. Soil Bicarbonate for 1984 Through 1988

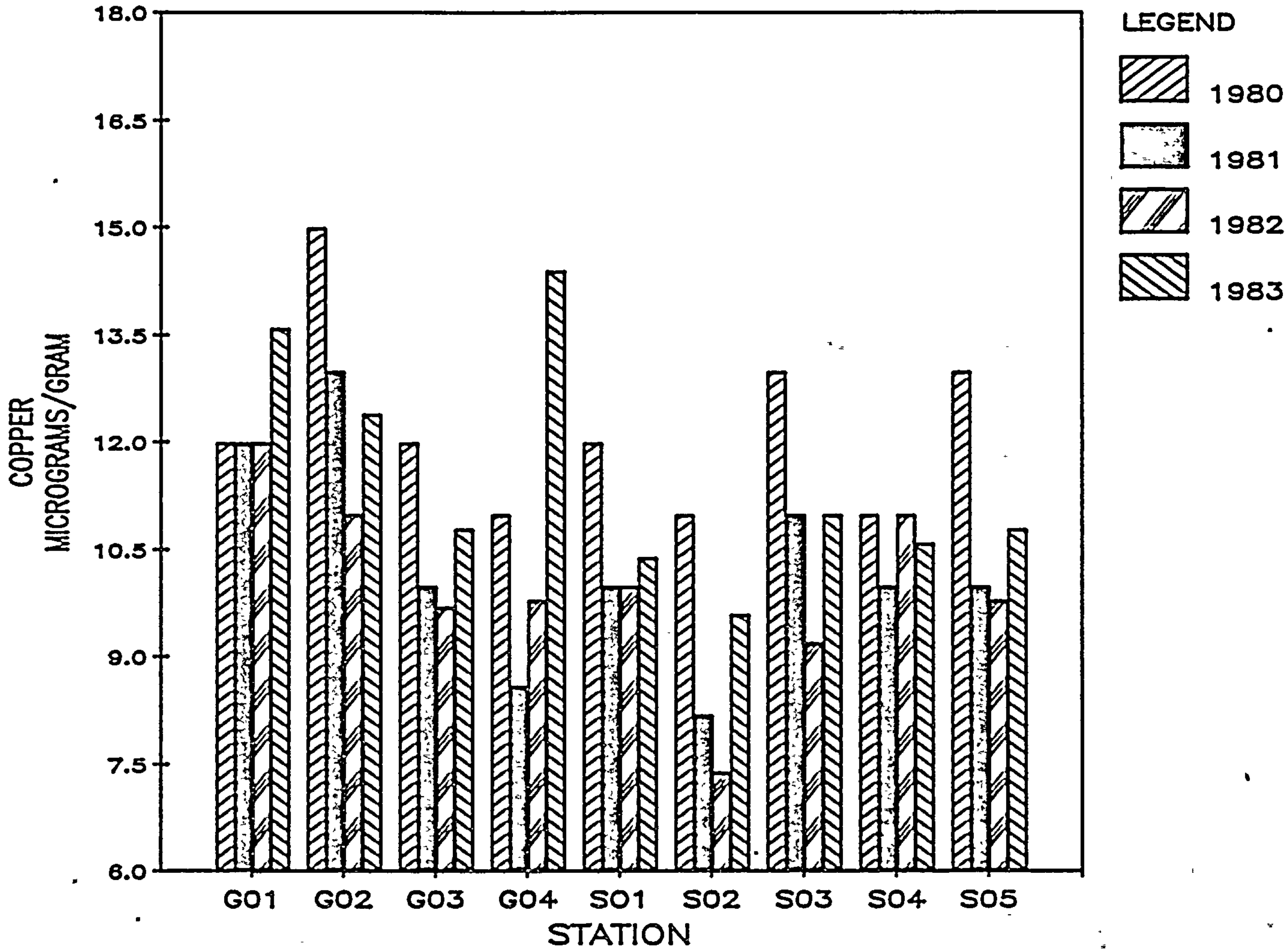


Figure 5-32. Soil Copper for 1980 Through 1983

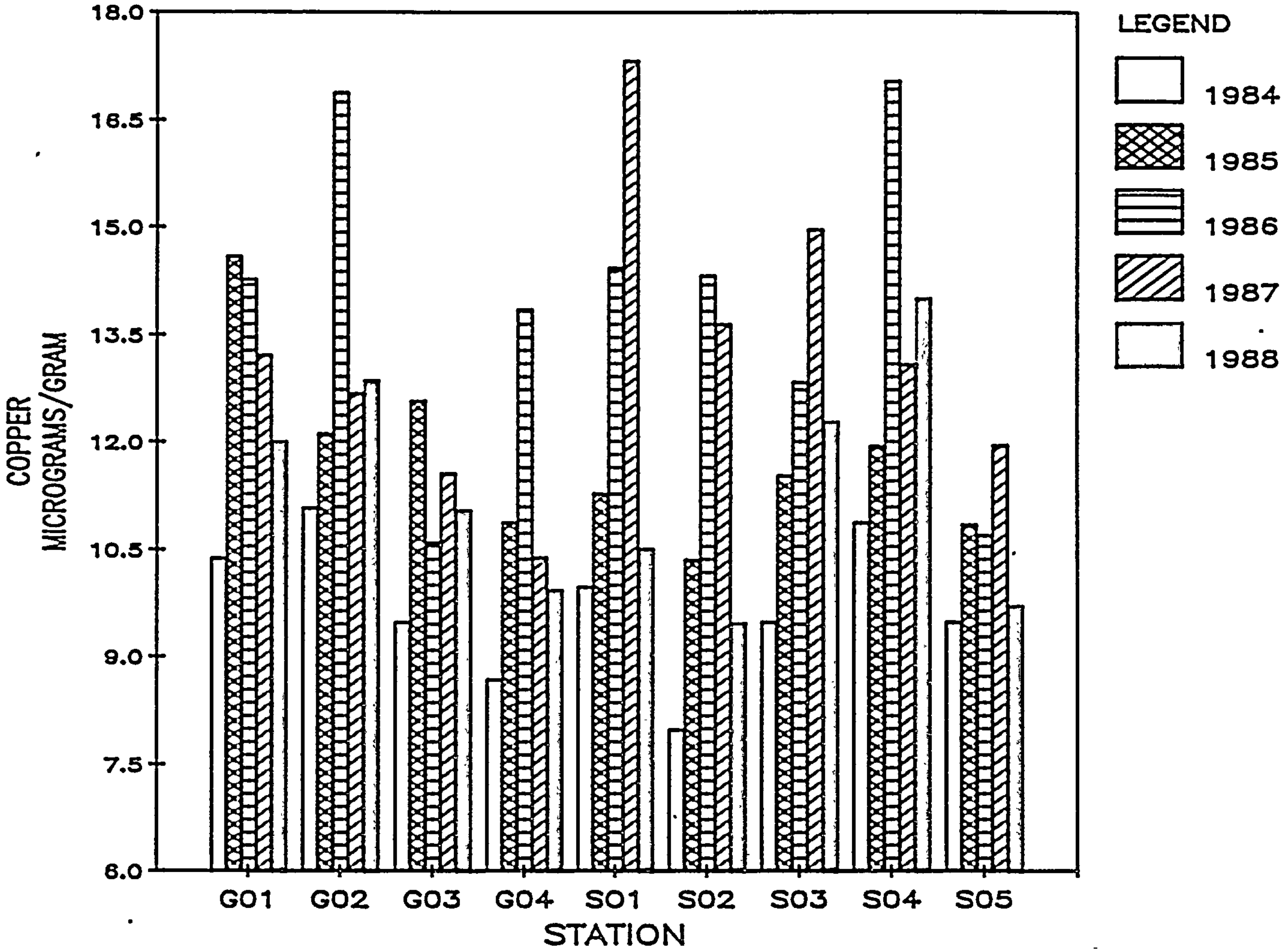


Figure 5-33. Soil Copper for 1984 Through 1988

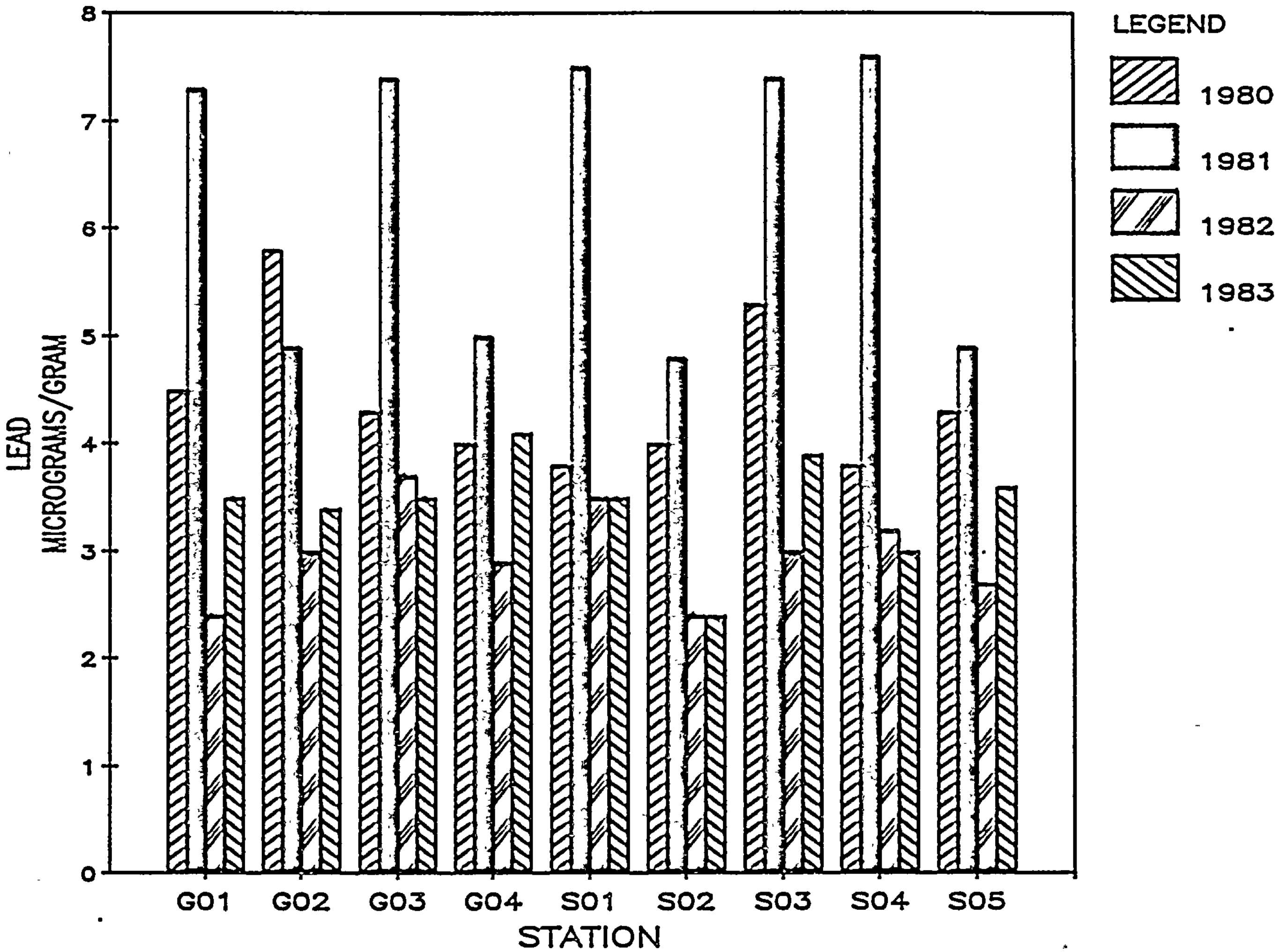


Figure 5-34. Soil Lead for 1980 Through 1983

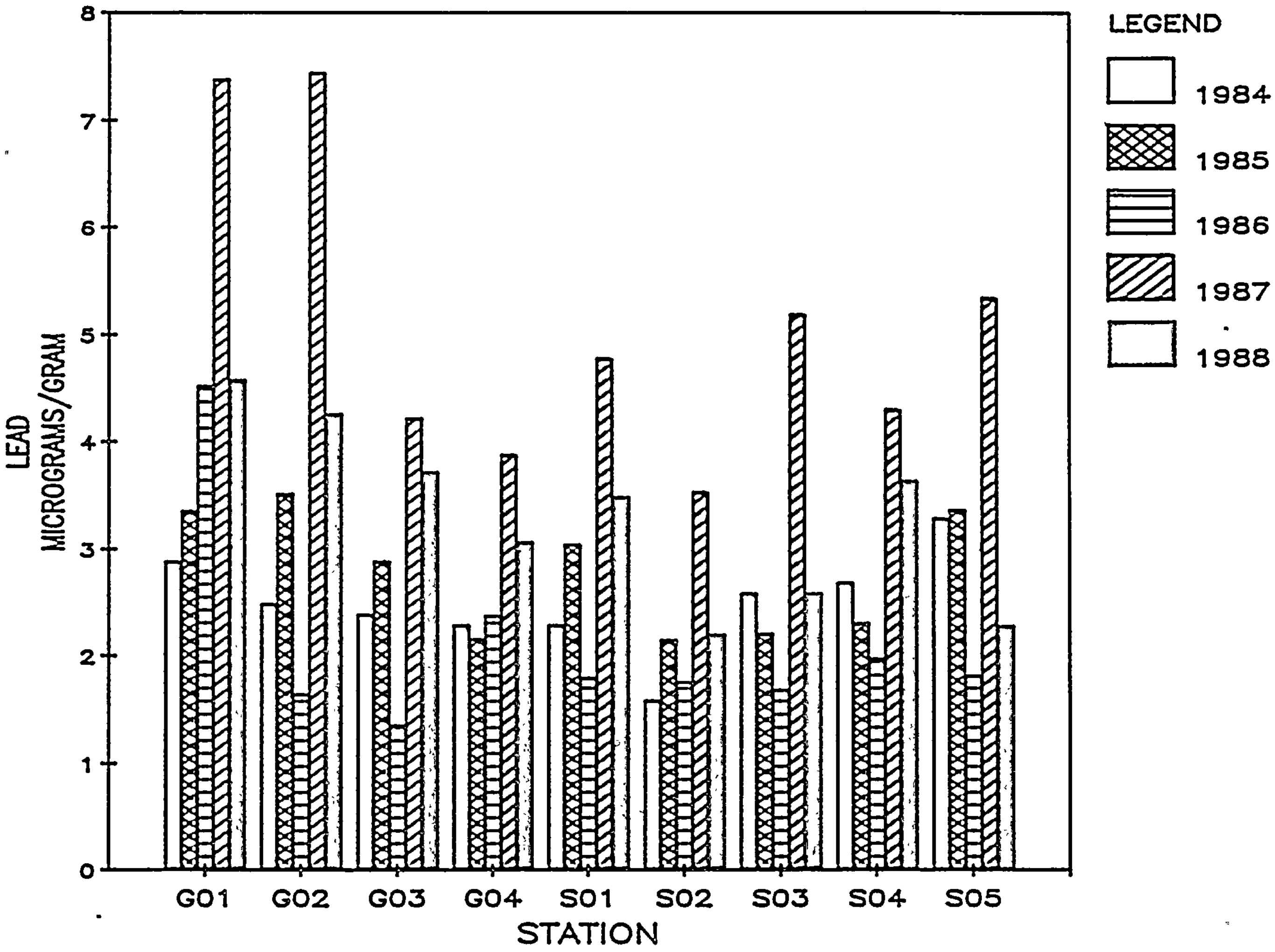


Figure 5-35. Soil Lead for 1984 Through 1988

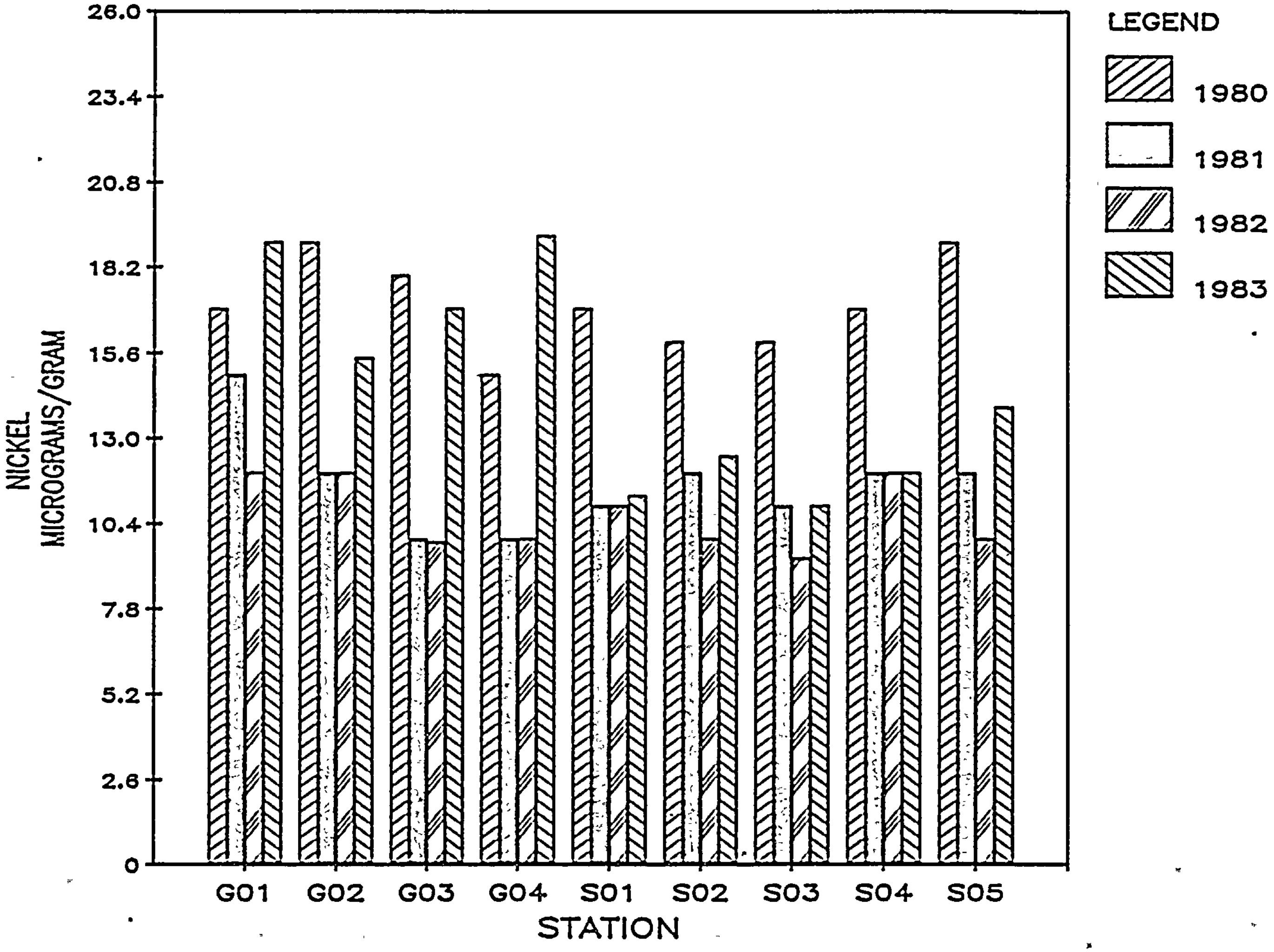


Figure 5-36. Soil Nickel for 1980 Through 1983

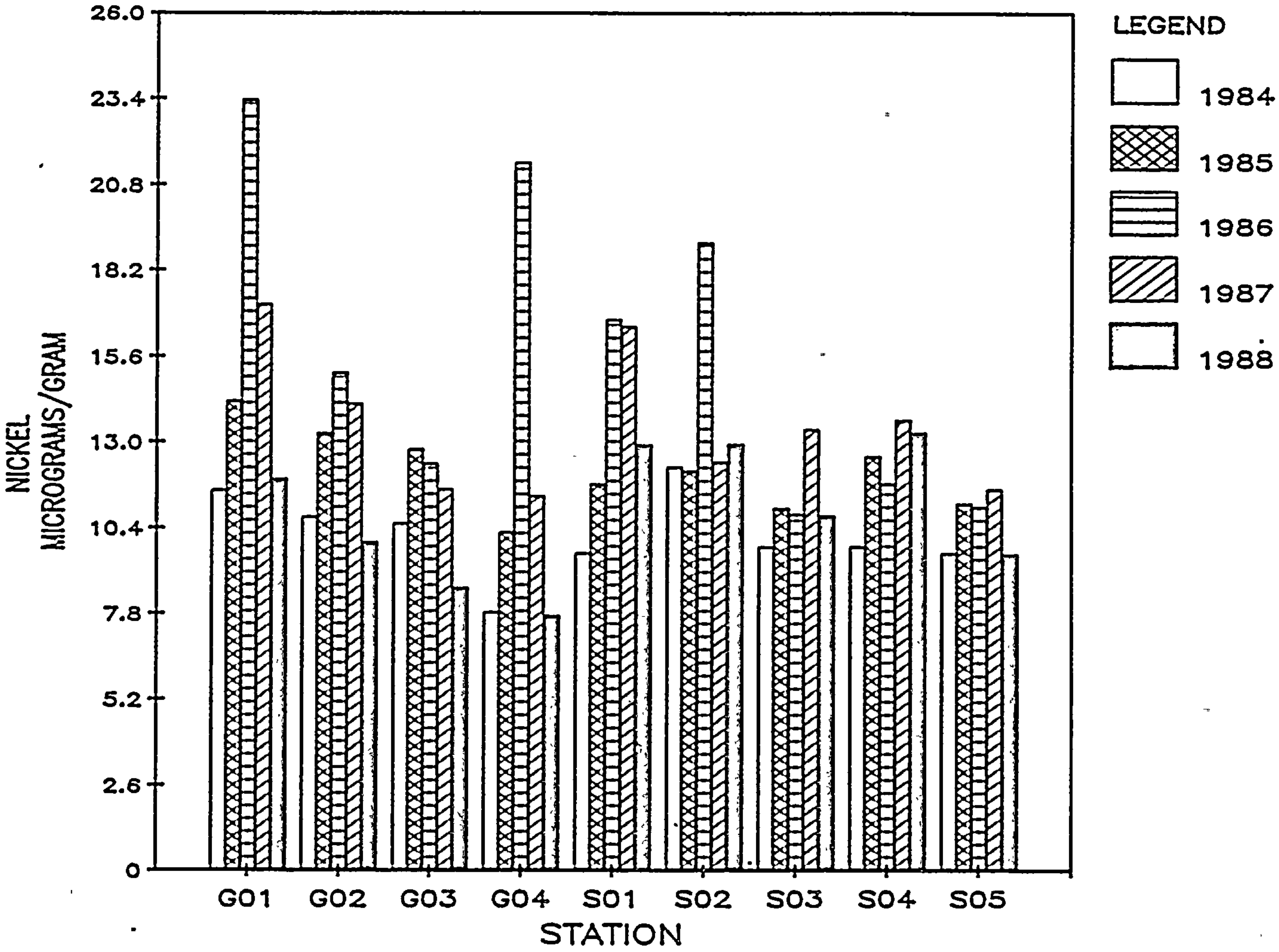


Figure 5-37. Soil Nickel for 1984 Through 1988

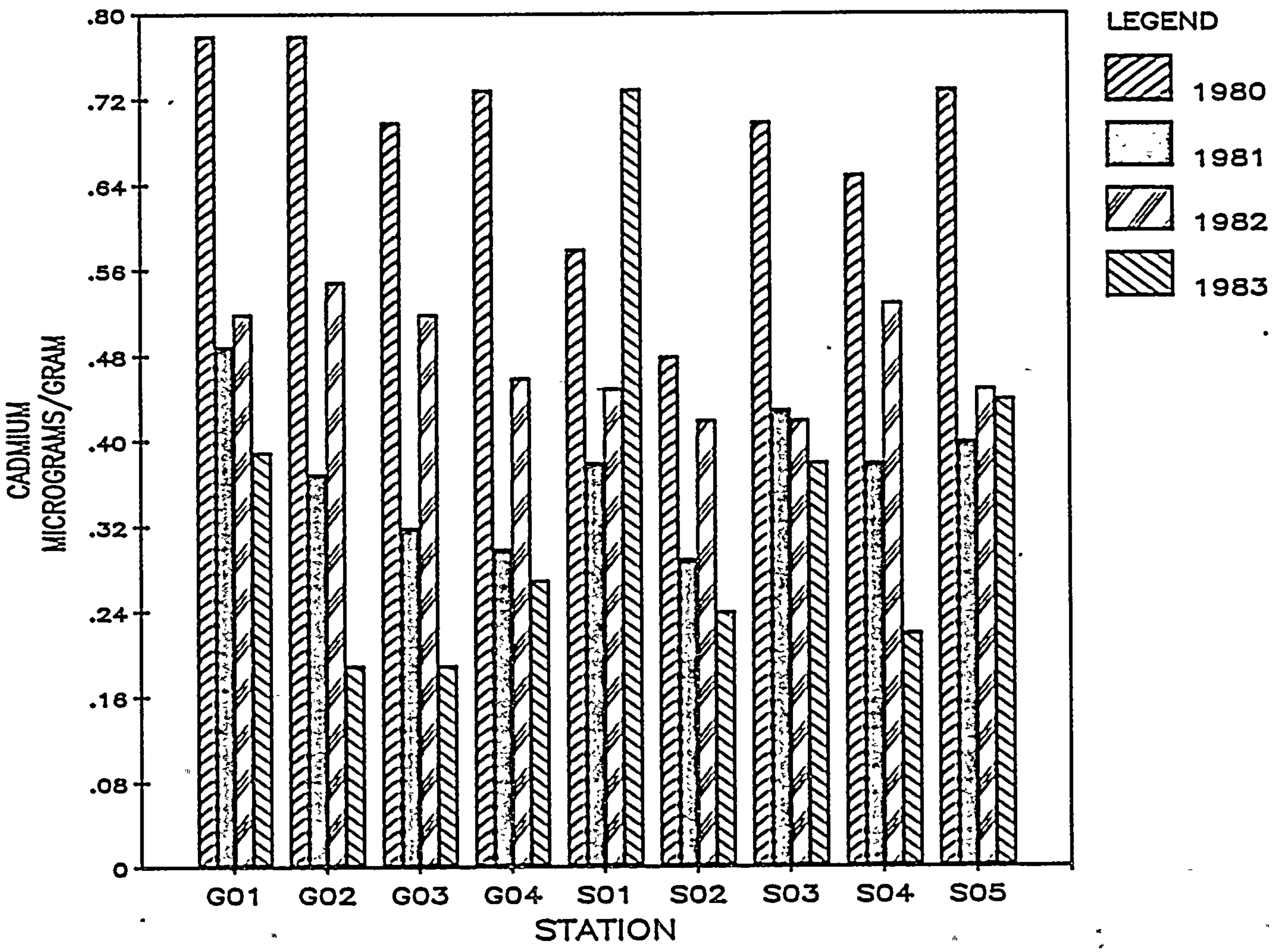


Figure 5-38. Soil Cadmium for 1980 Through 1983

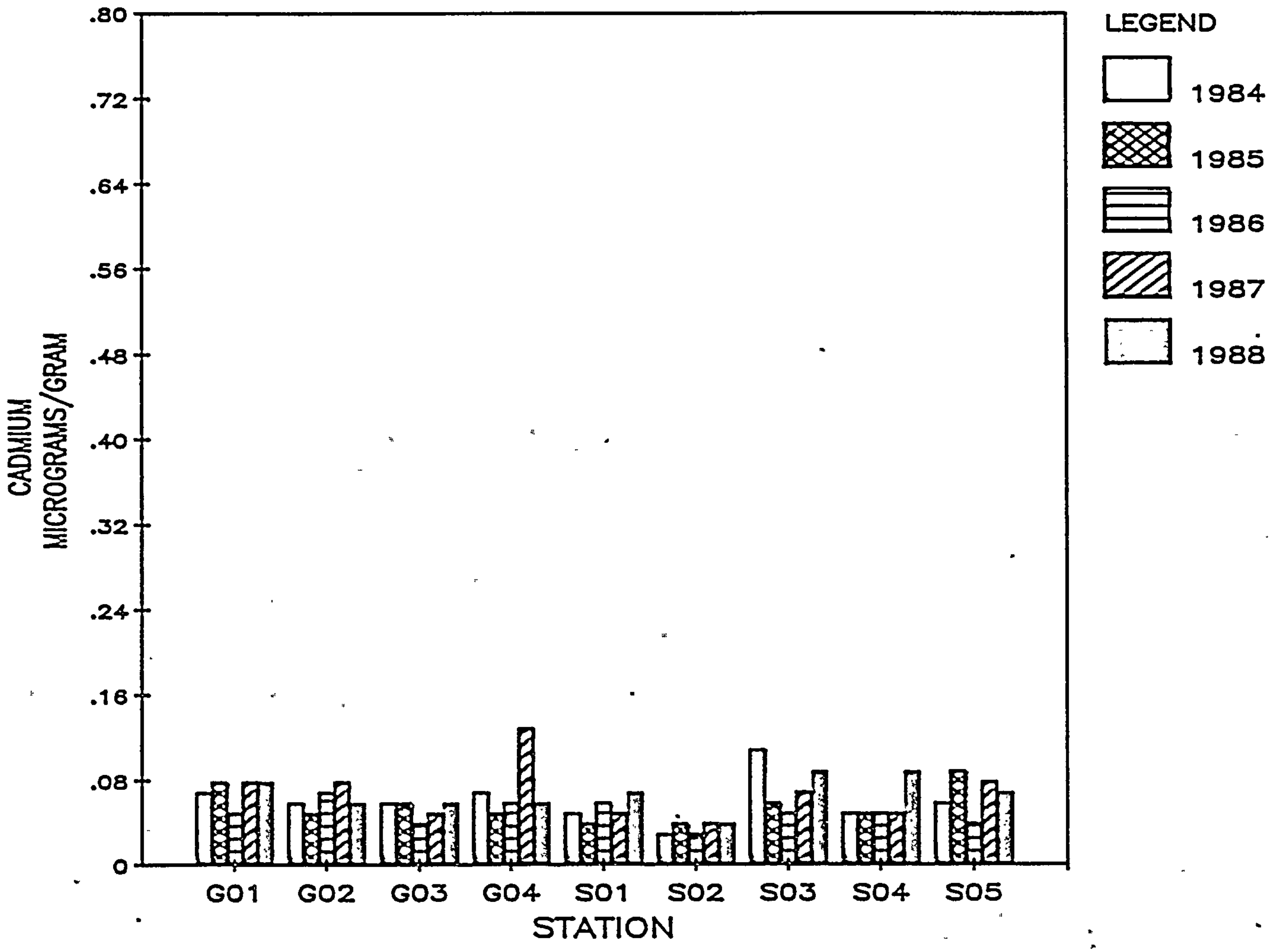


Figure 5-39. Soil Cadmium for 1984 Through 1988

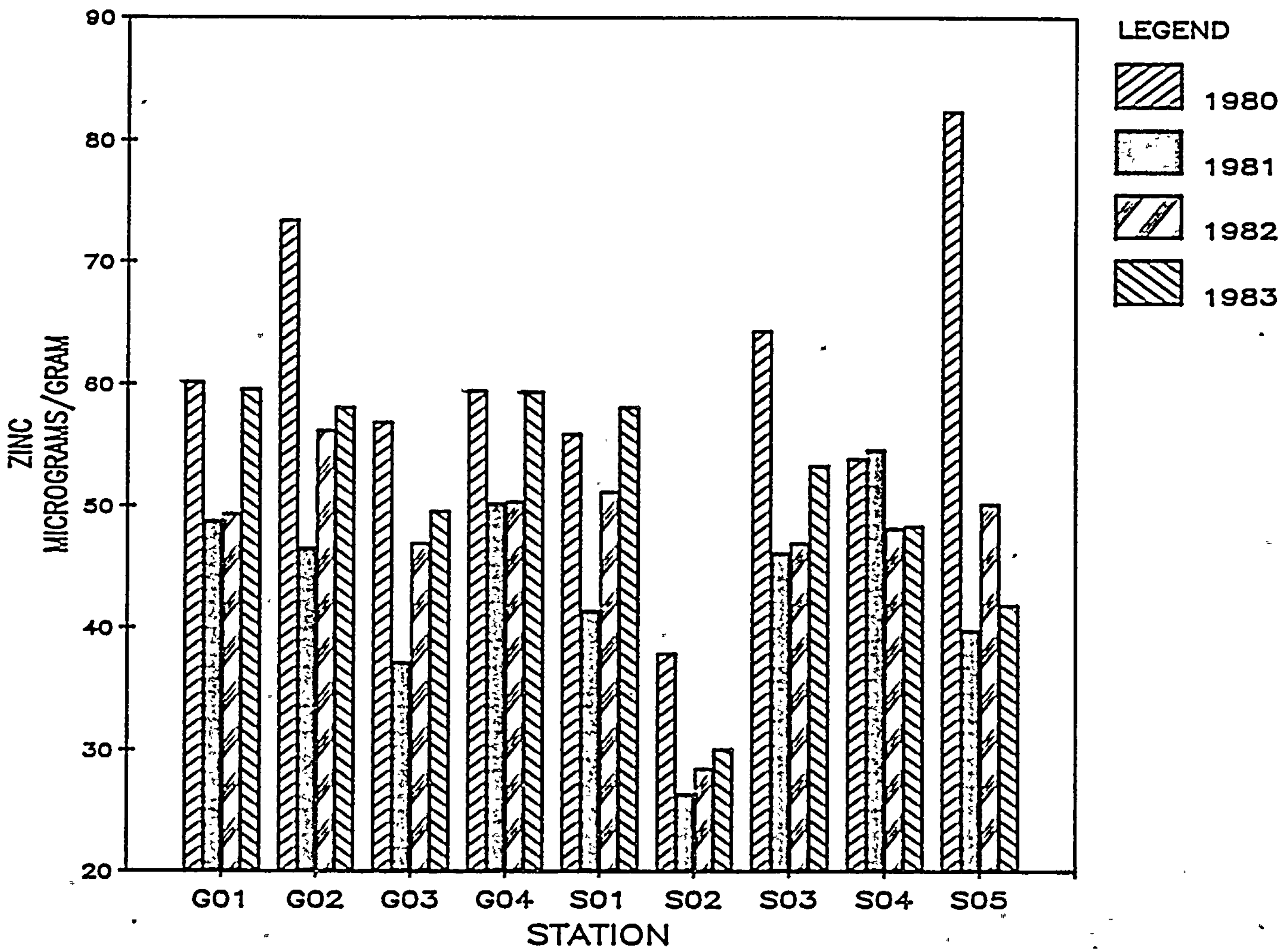


Figure 5-40. Soil Zinc for 1980 Through 1983

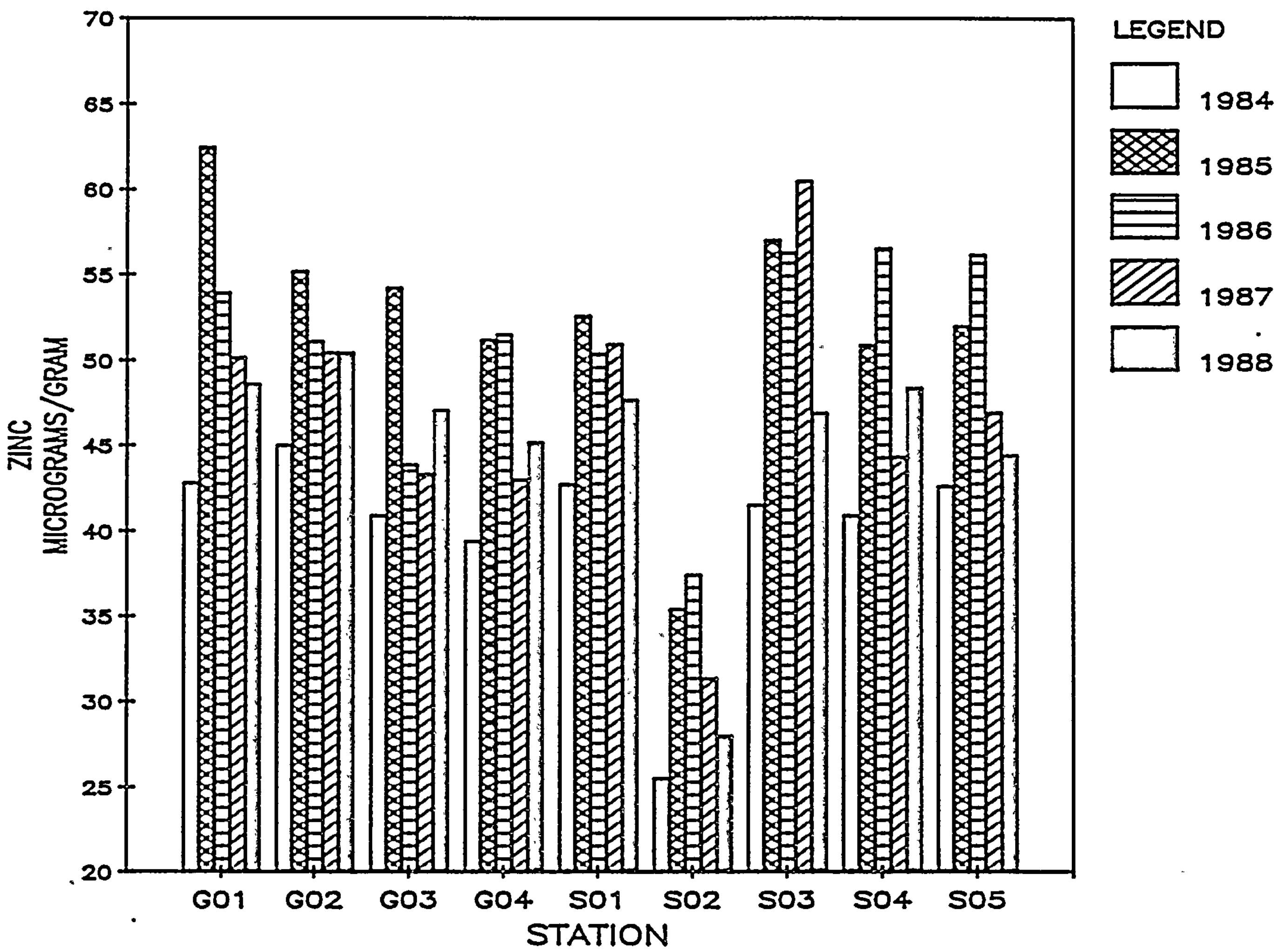


Figure 5-41. Soil Zinc for 1984 Through 1988

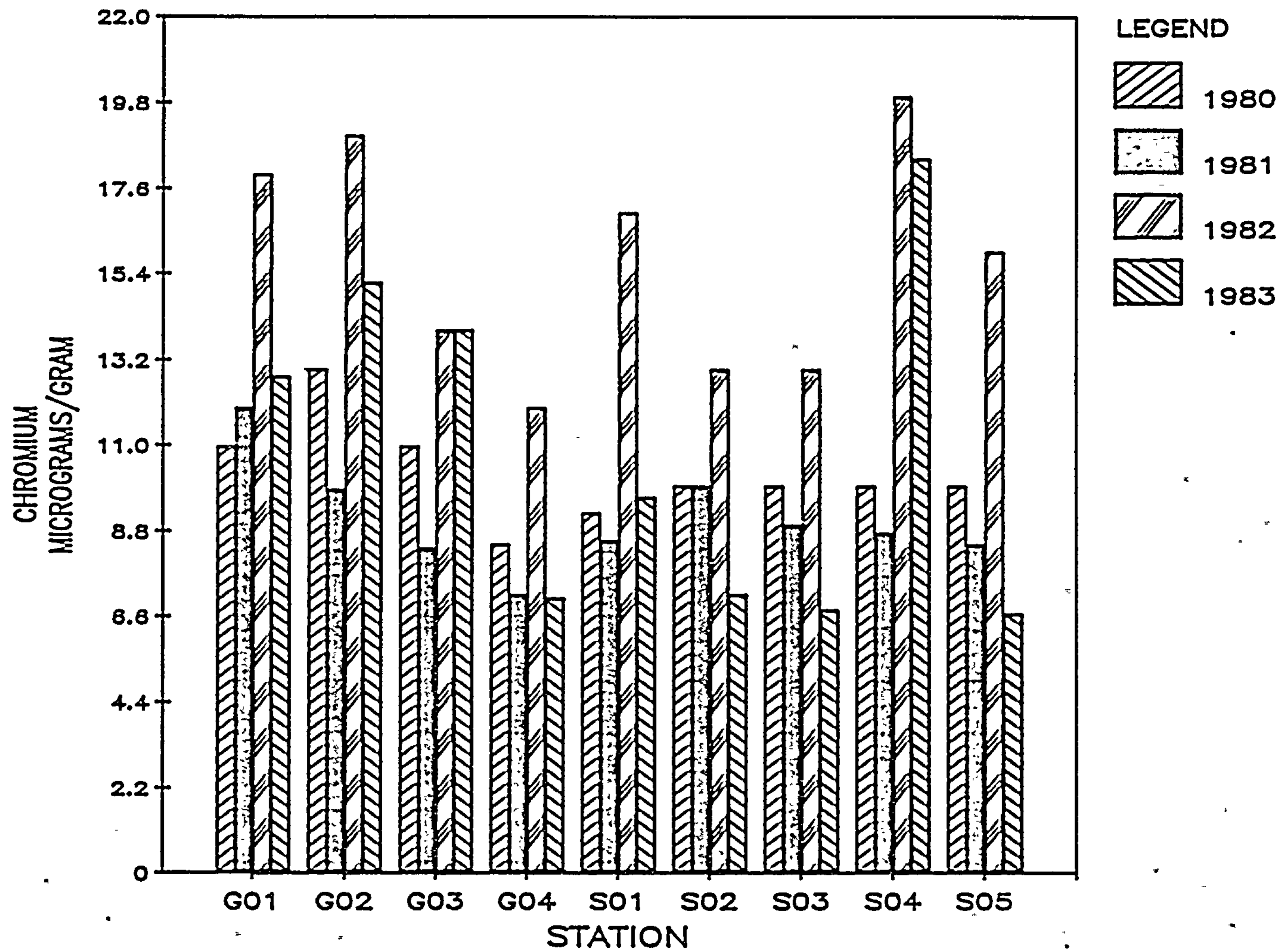


Figure 5-42. Soil Chromium for 1980 Through 1983

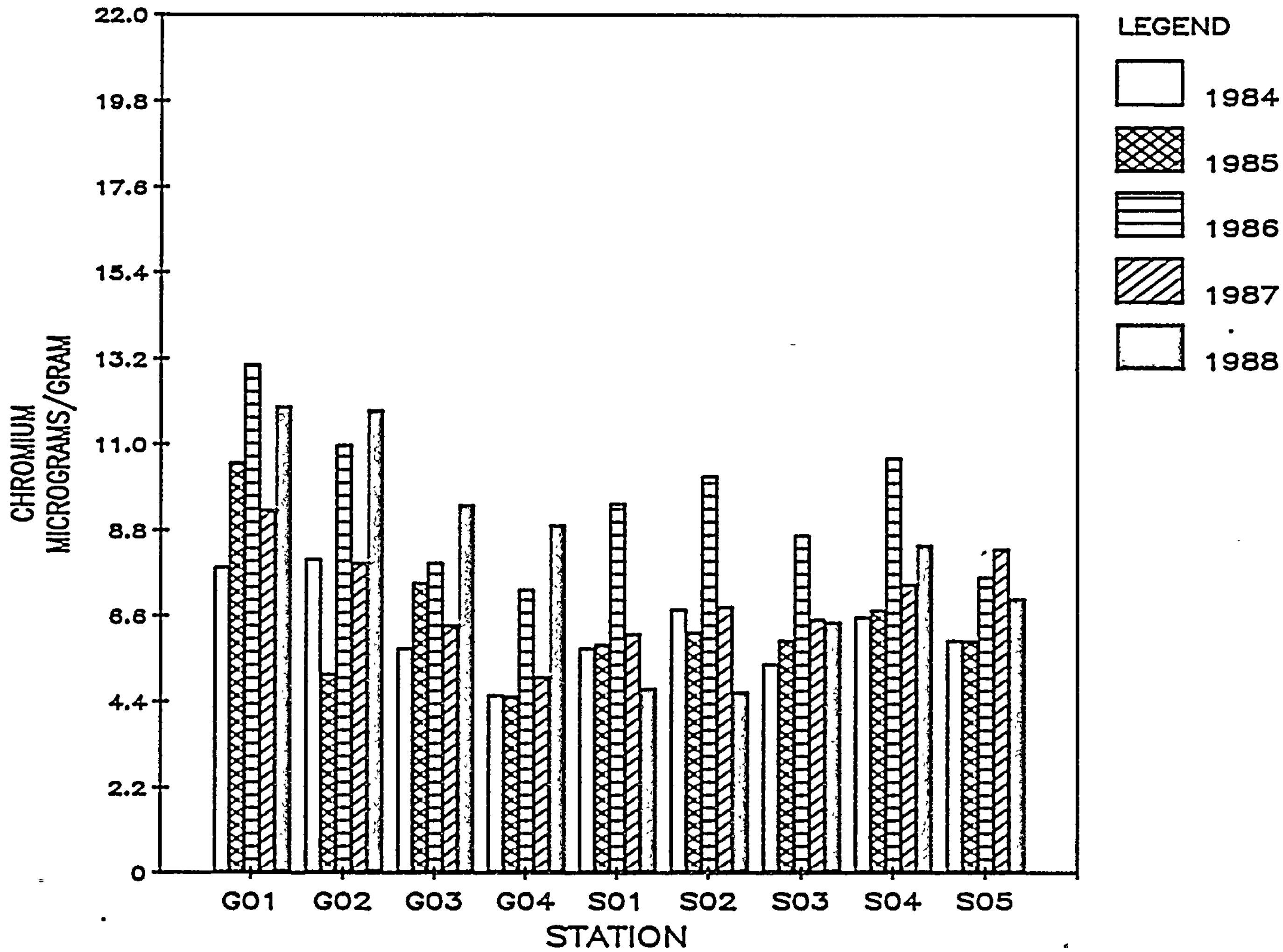


Figure 5-43. Soil Chromium for 1984 Through 1988

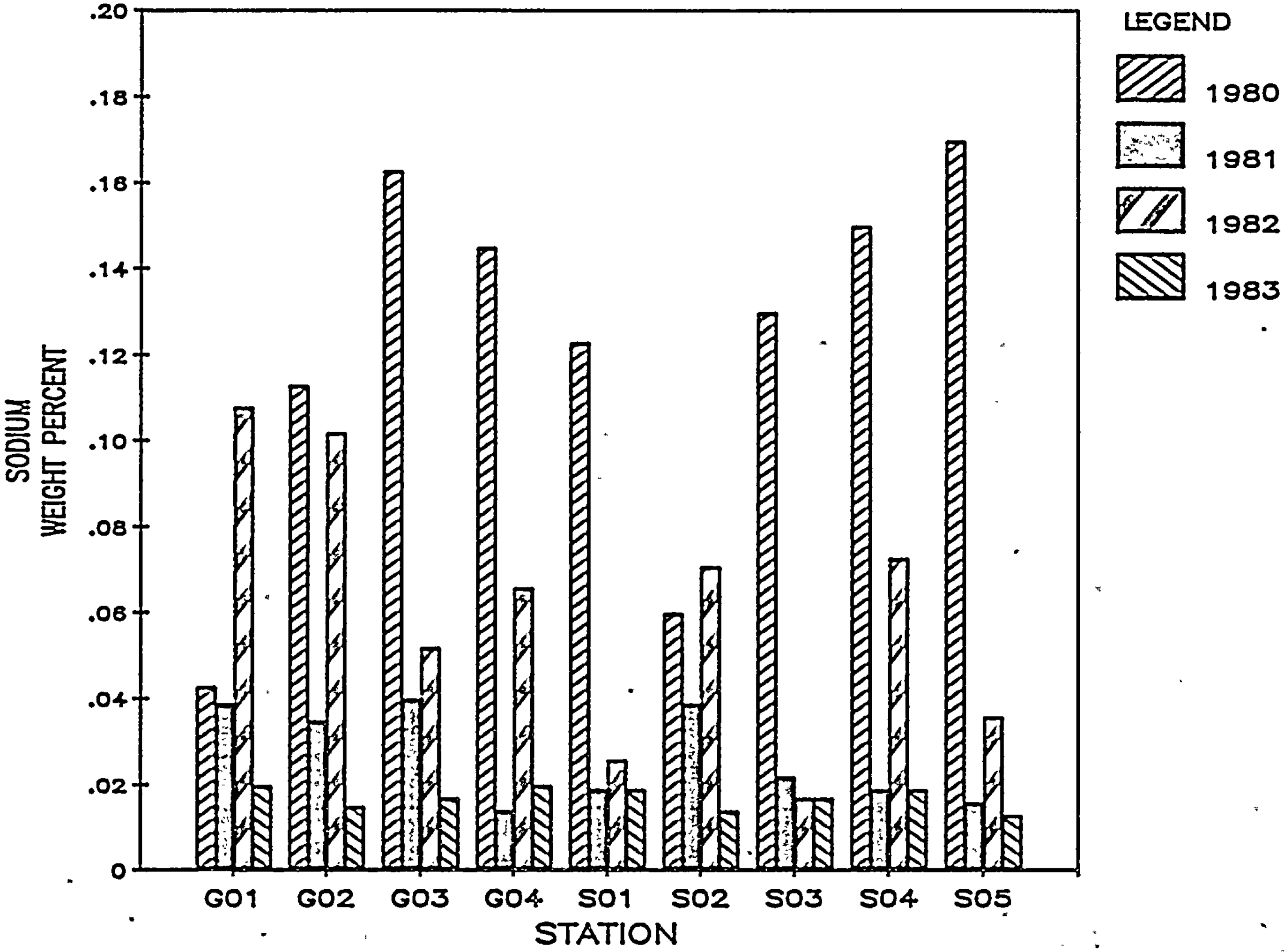


Figure 5-44. Soil Sodium for 1980 Through 1983

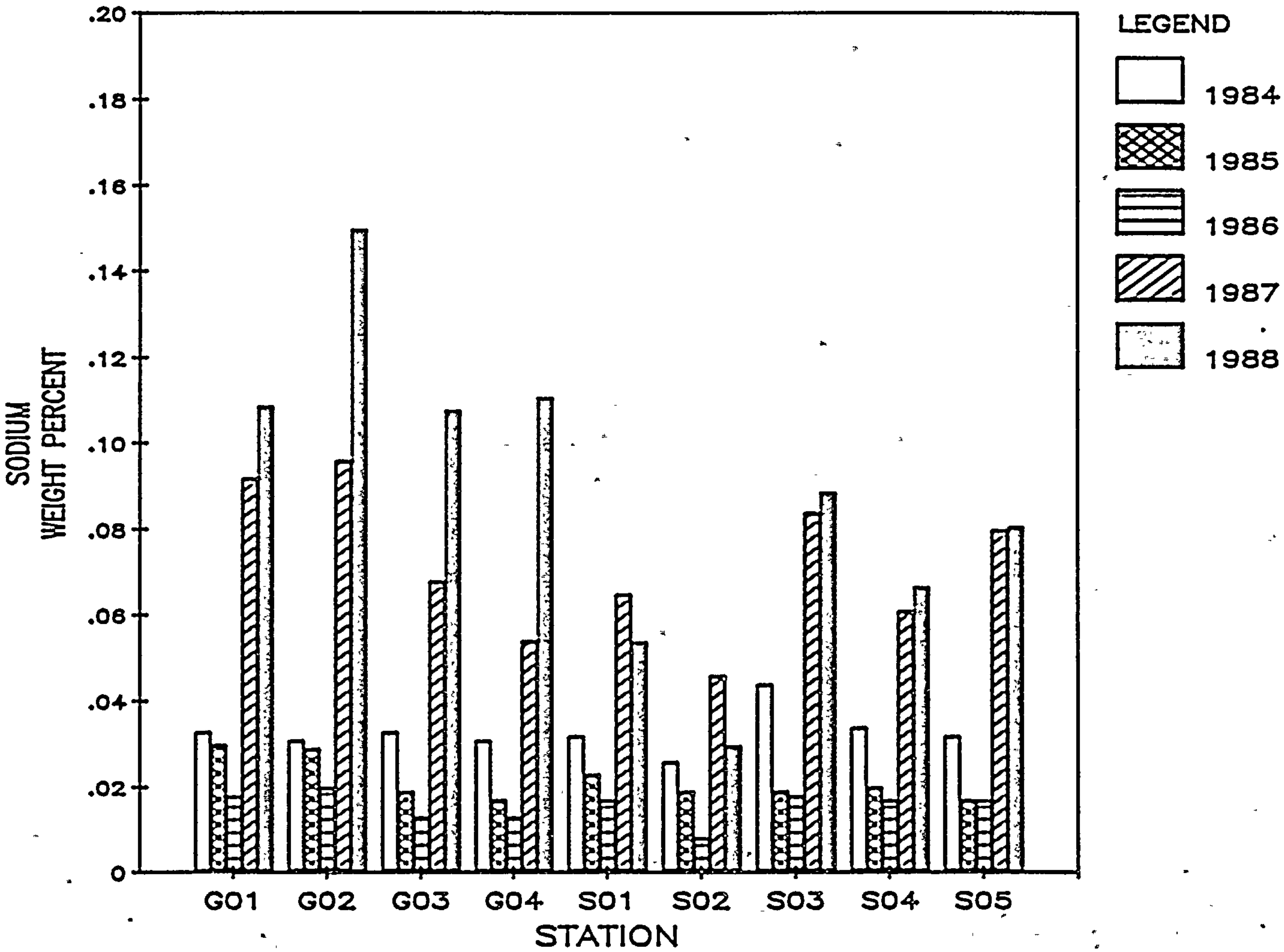


Figure 5-45. Soil Sodium for 1984 Through 1988

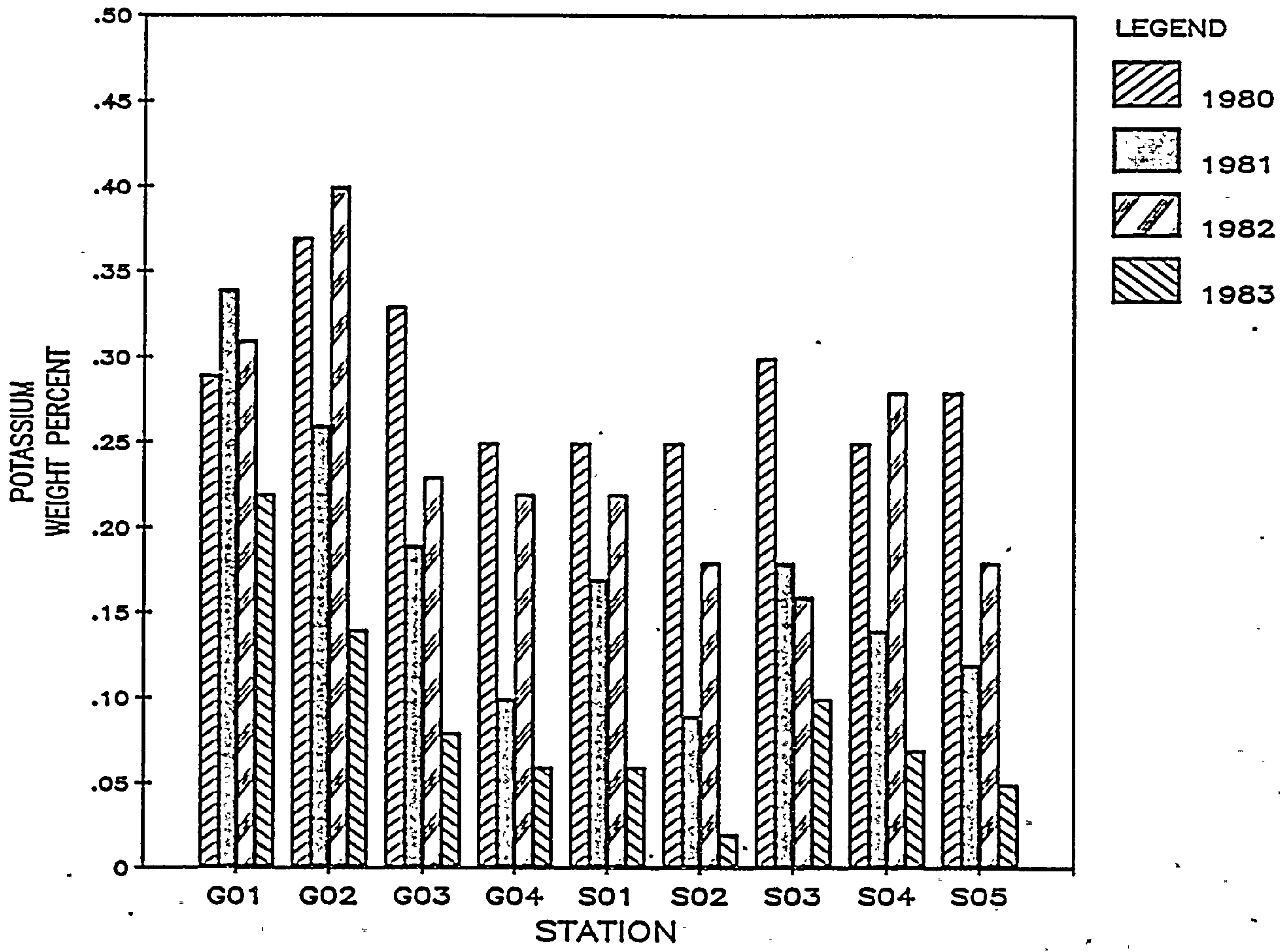


Figure 5-46. Soil Potassium for 1980 Through 1983

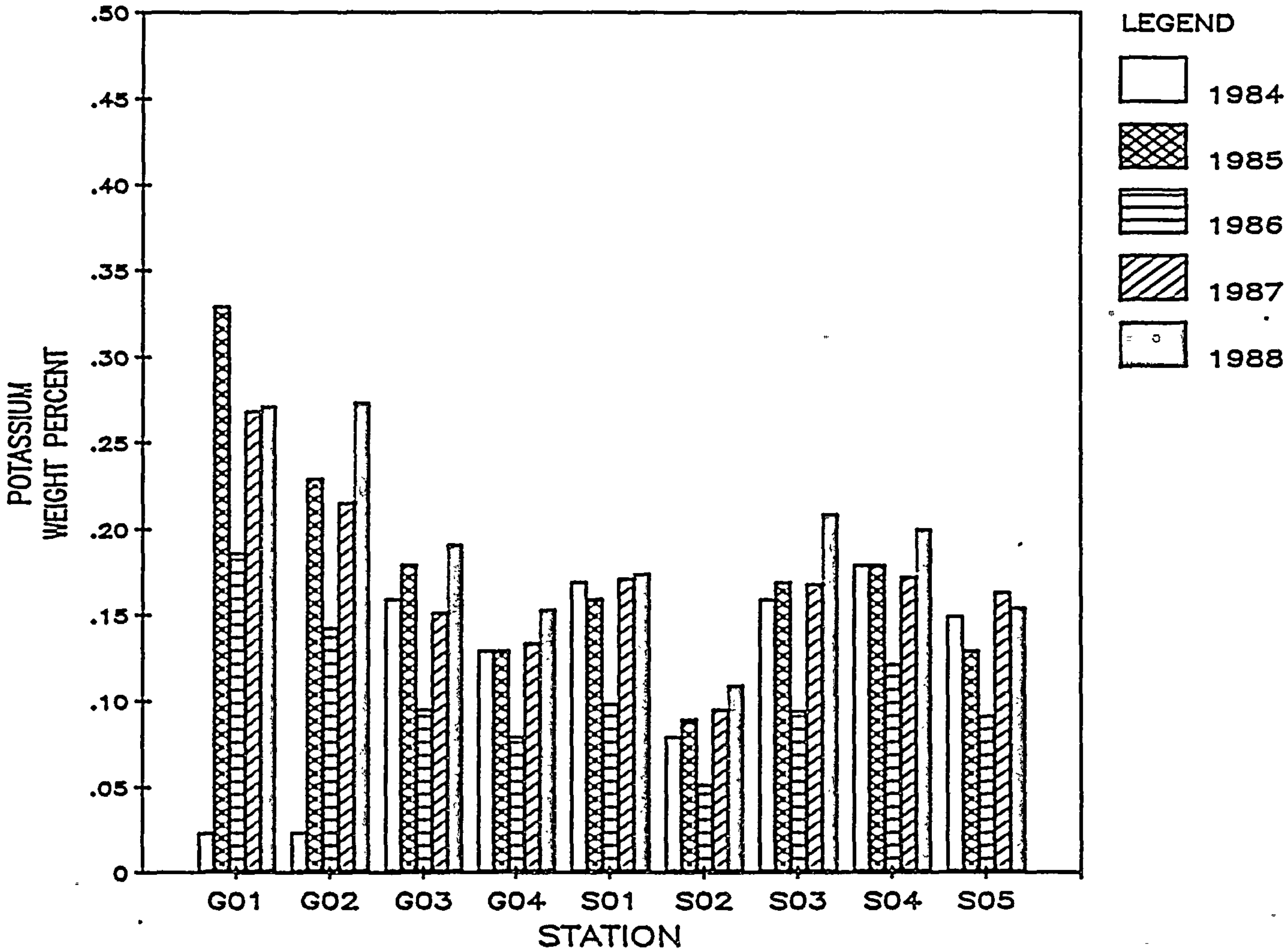


Figure 5-47. Soil Potassium for 1984 Through 1988

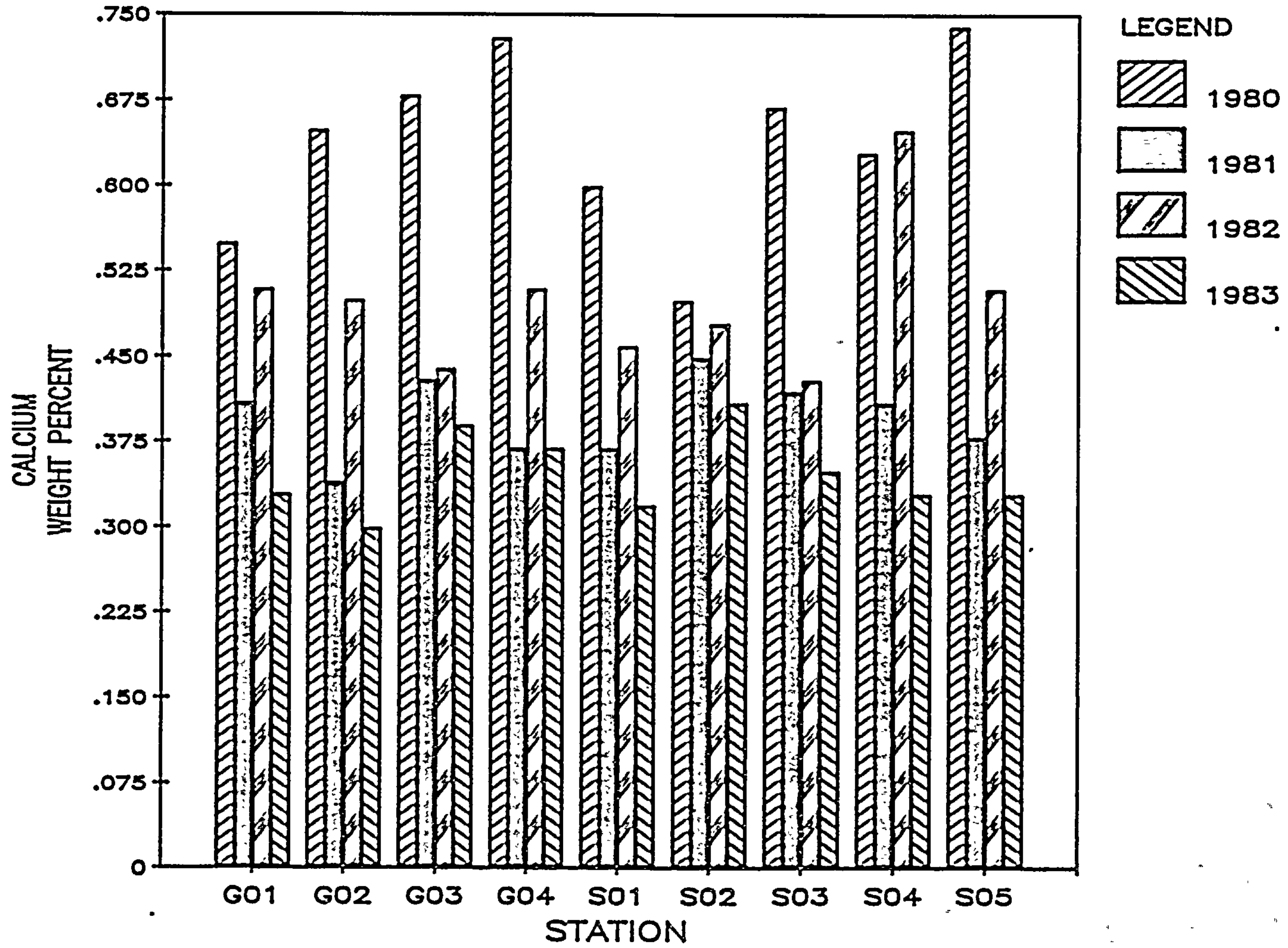


Figure 5-48. Soil Calcium for 1980 Through 1983

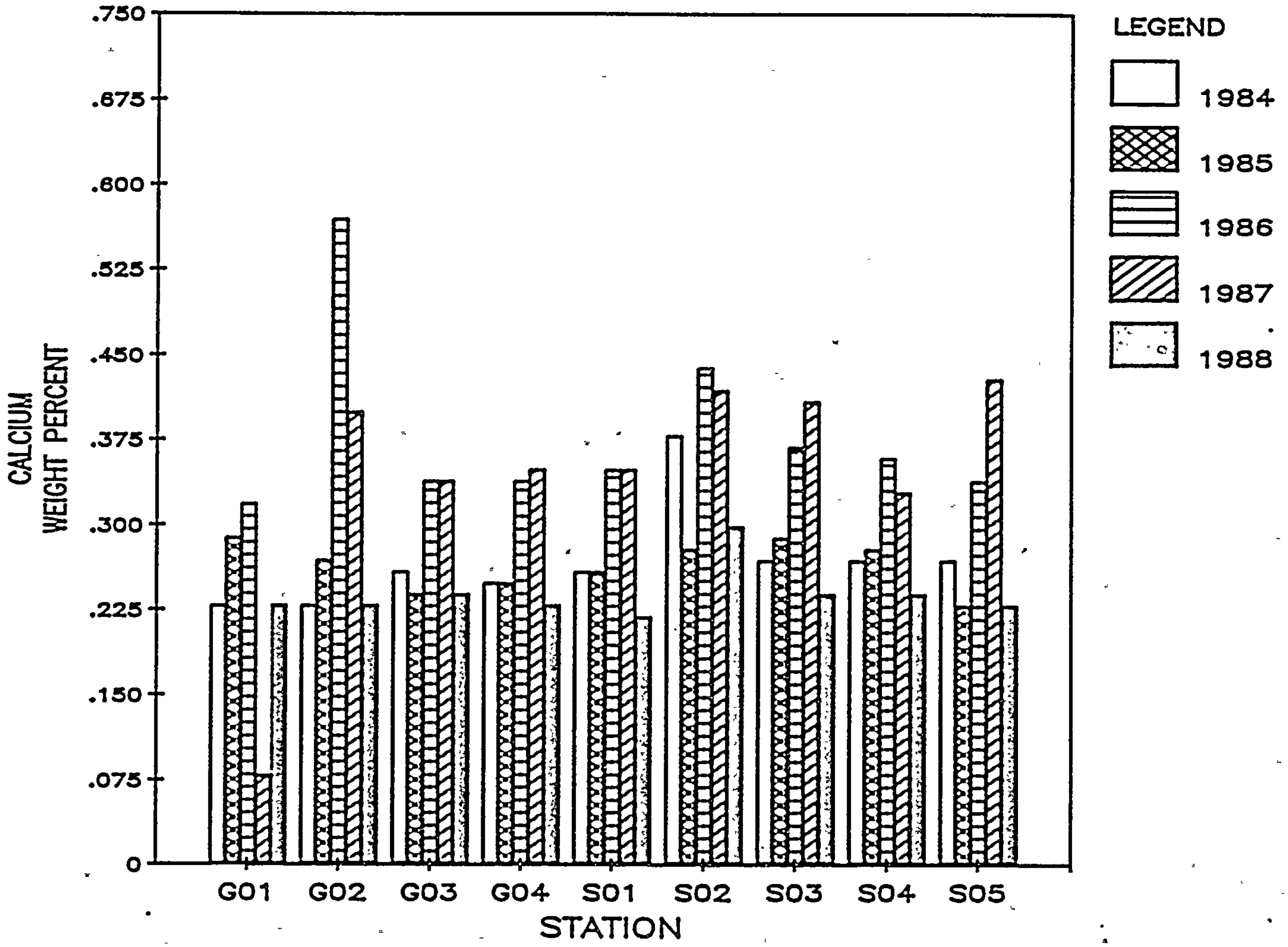


Figure 5-49. Soil Calcium for 1984 Through 1988

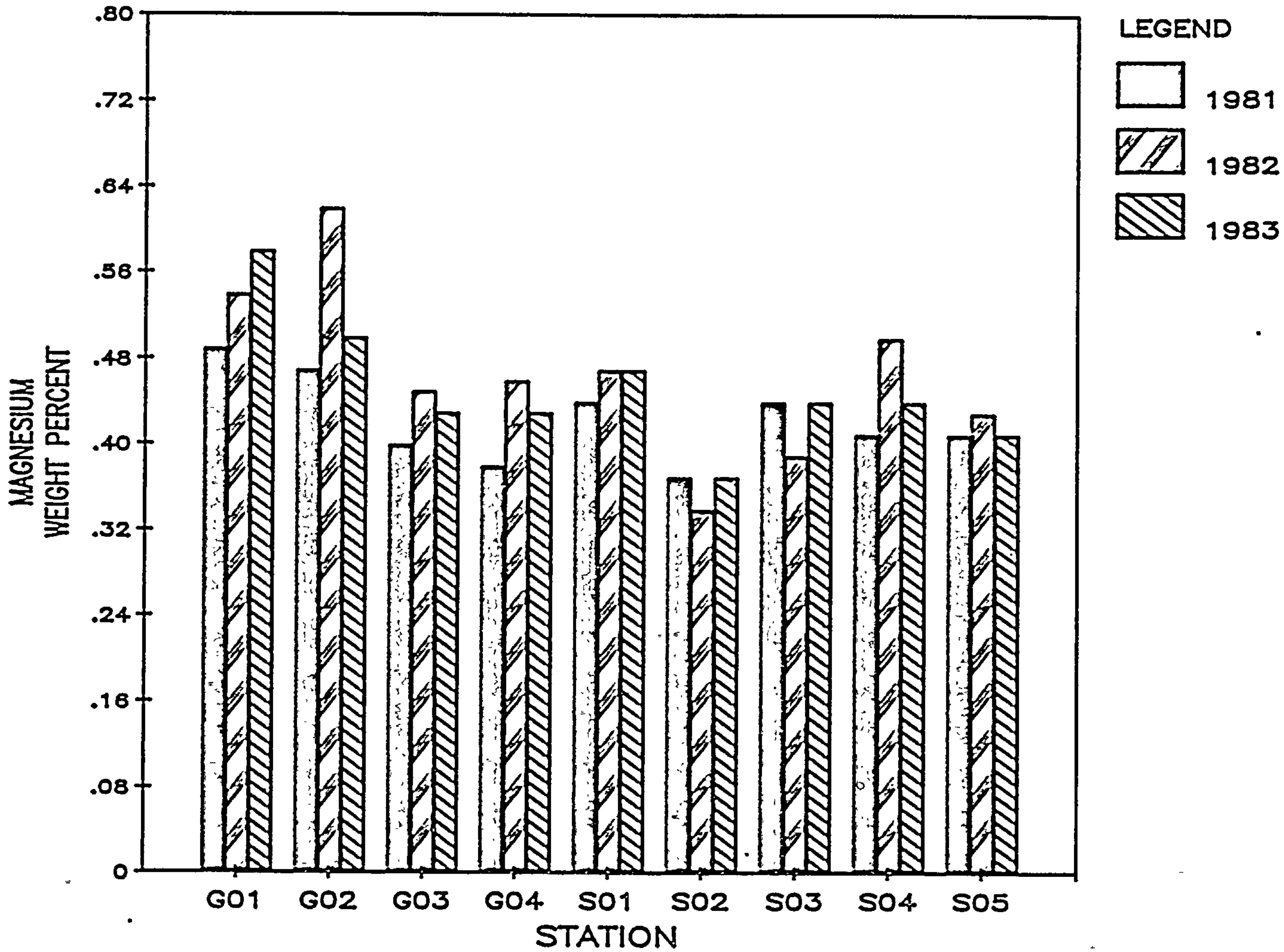


Figure 5-50. Soil Magnesium for 1980 Through 1983

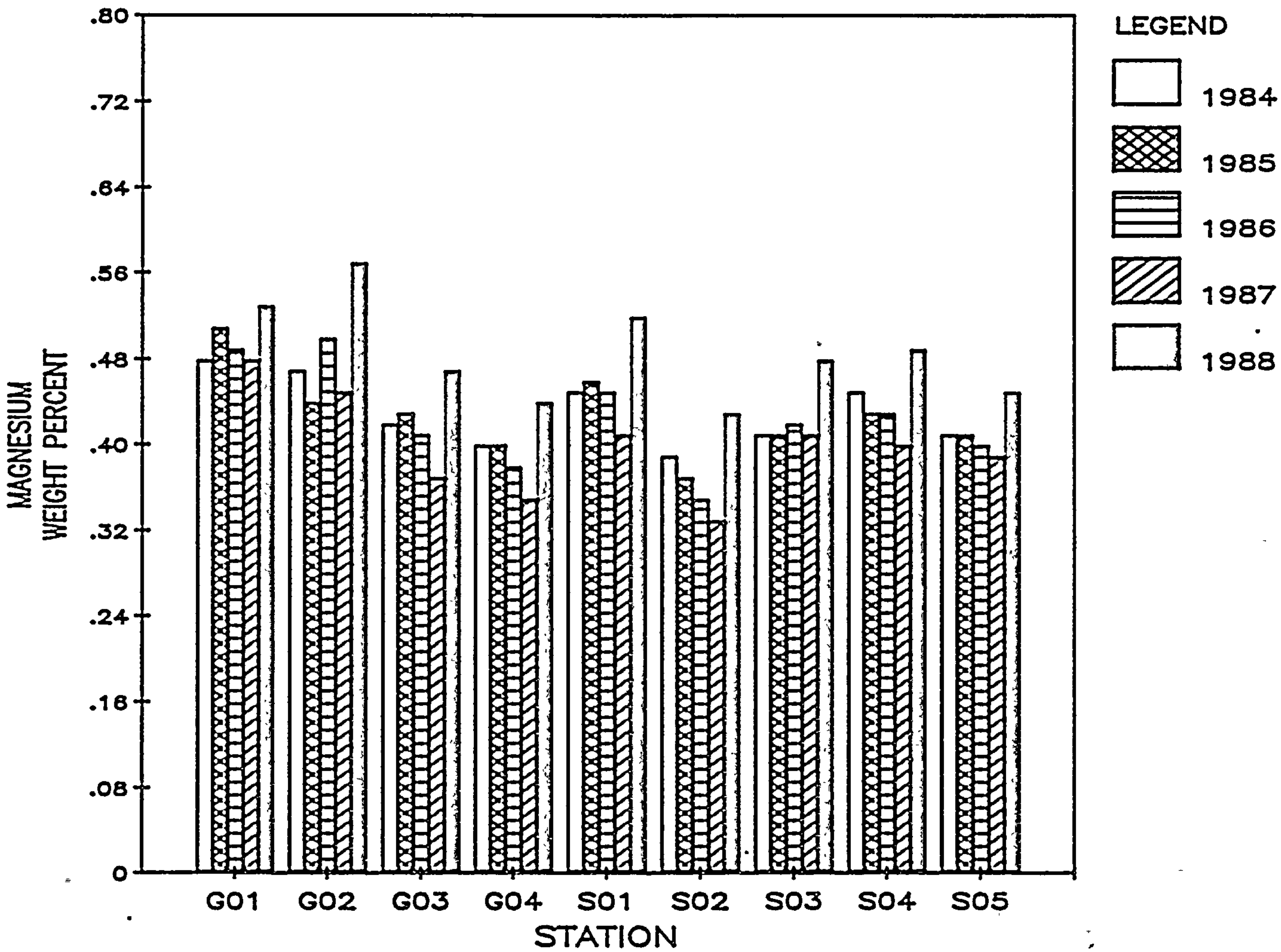


Figure 5-51. Soil Magnesium for 1984 Through 1988

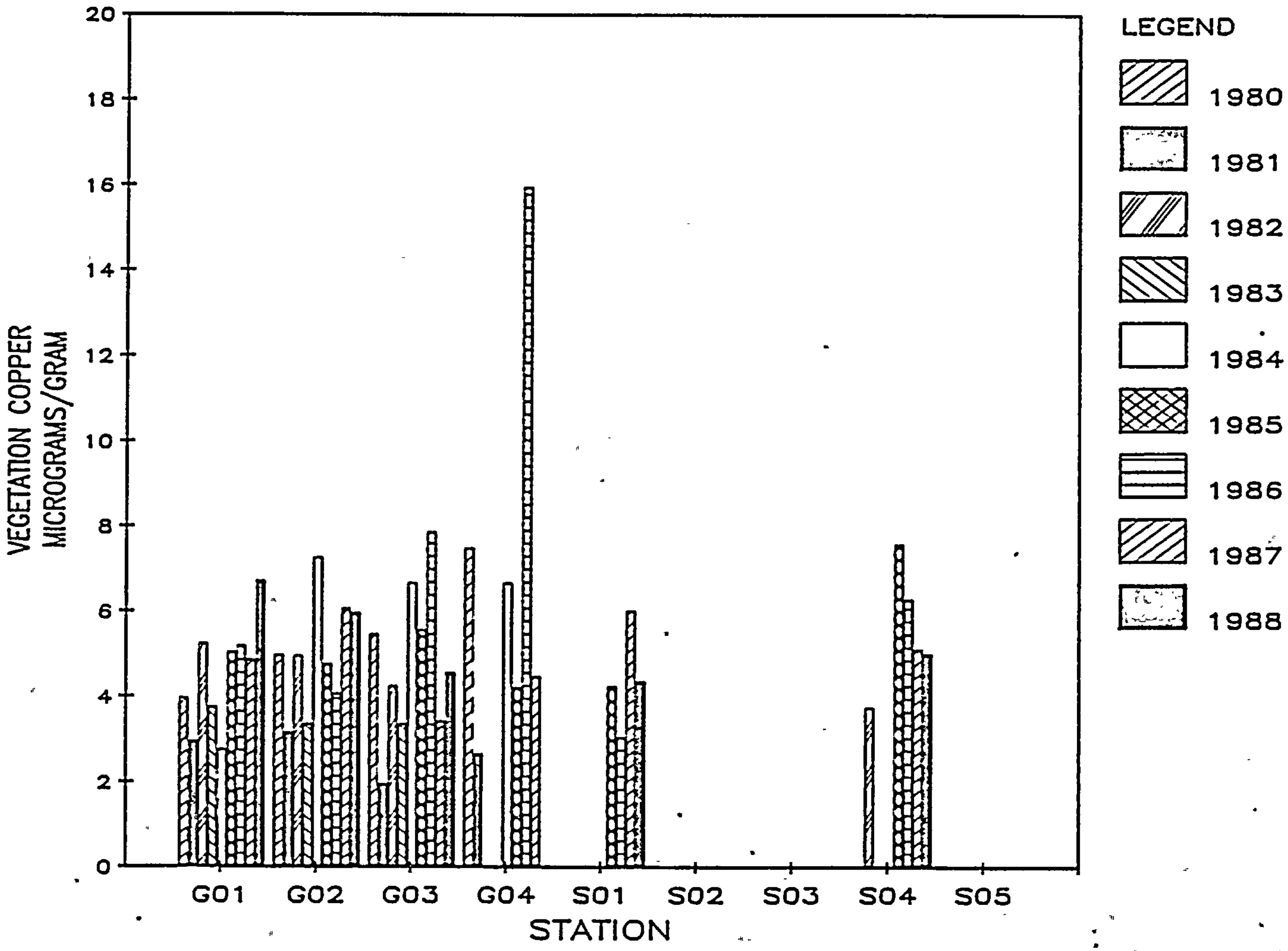


Figure 5-52. Copper Concentration (ug/g) in *Sisymbrium altissimum* by Station for 1980 Through 1988

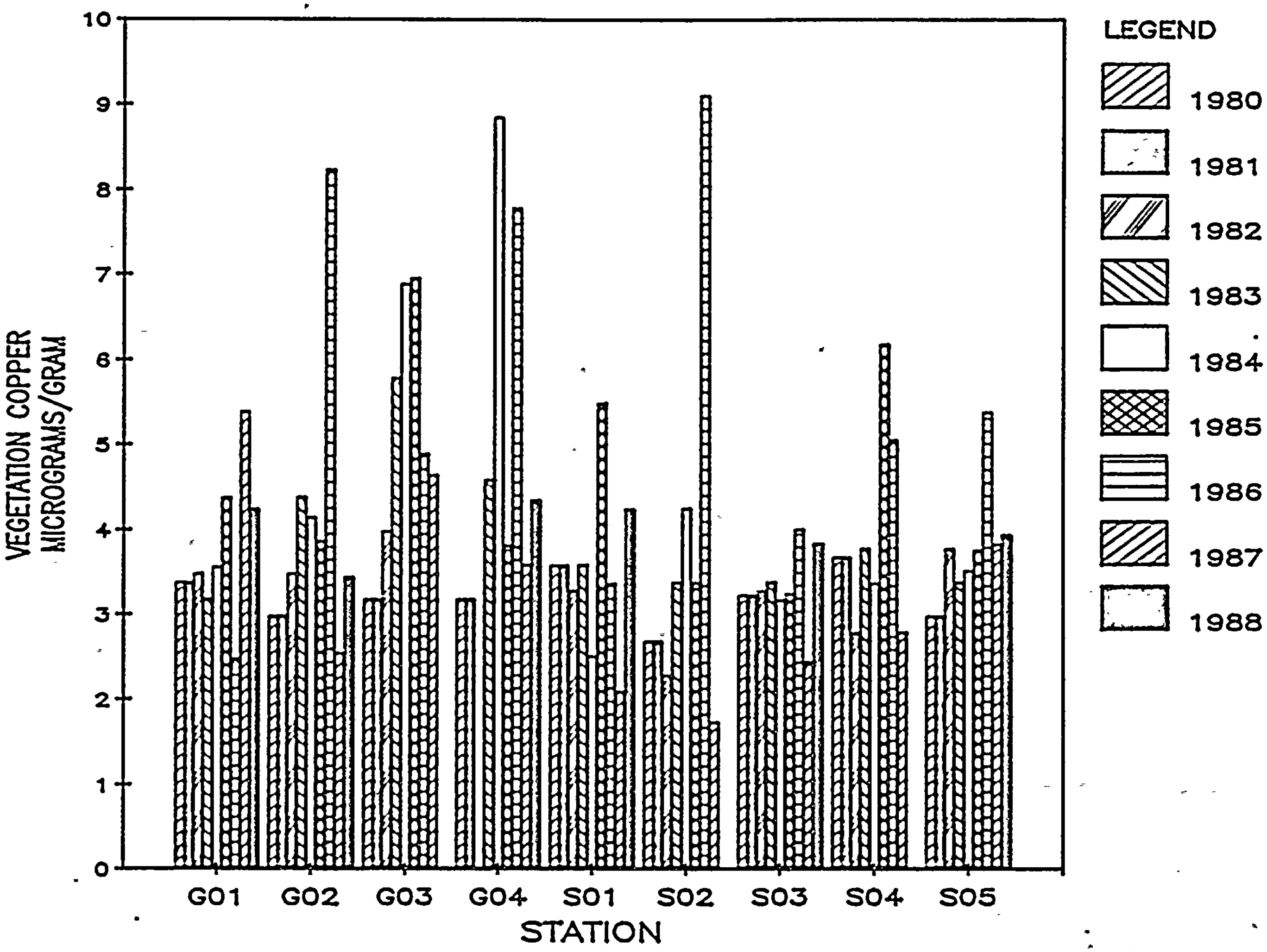


Figure 5-53. Copper Concentration (ug/g) in _Poa sandbergii_ by Station for 1980 Through 1988

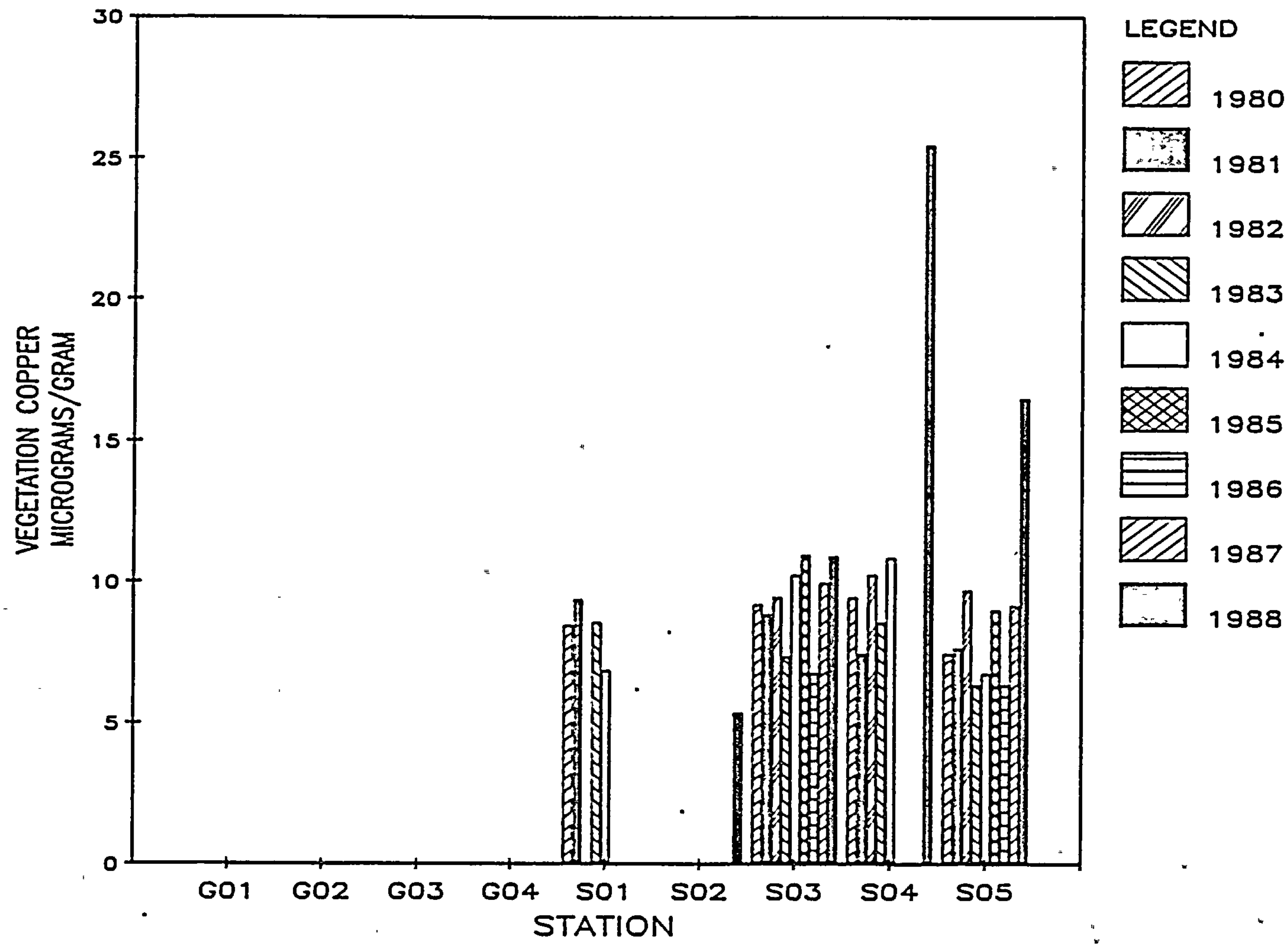


Figure 5-54. Copper Concentration (ug/g) in <u>Artemisia tridentata</u> by Station for 1980 Through 1988

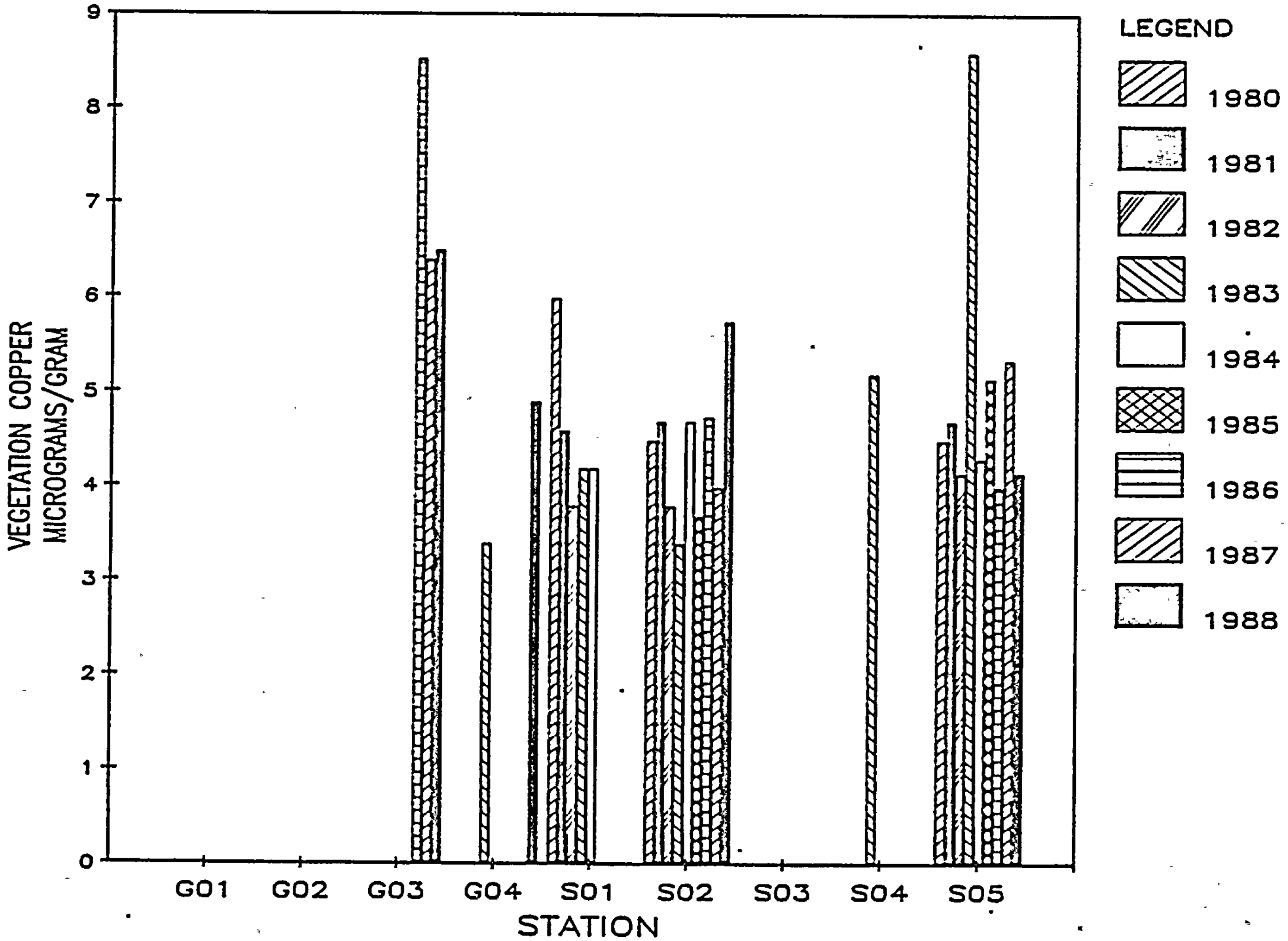


Figure 5-55. Copper Concentration (ug/g) in <u>Purshia tridentata</u> by Station for 1980 Through 1988

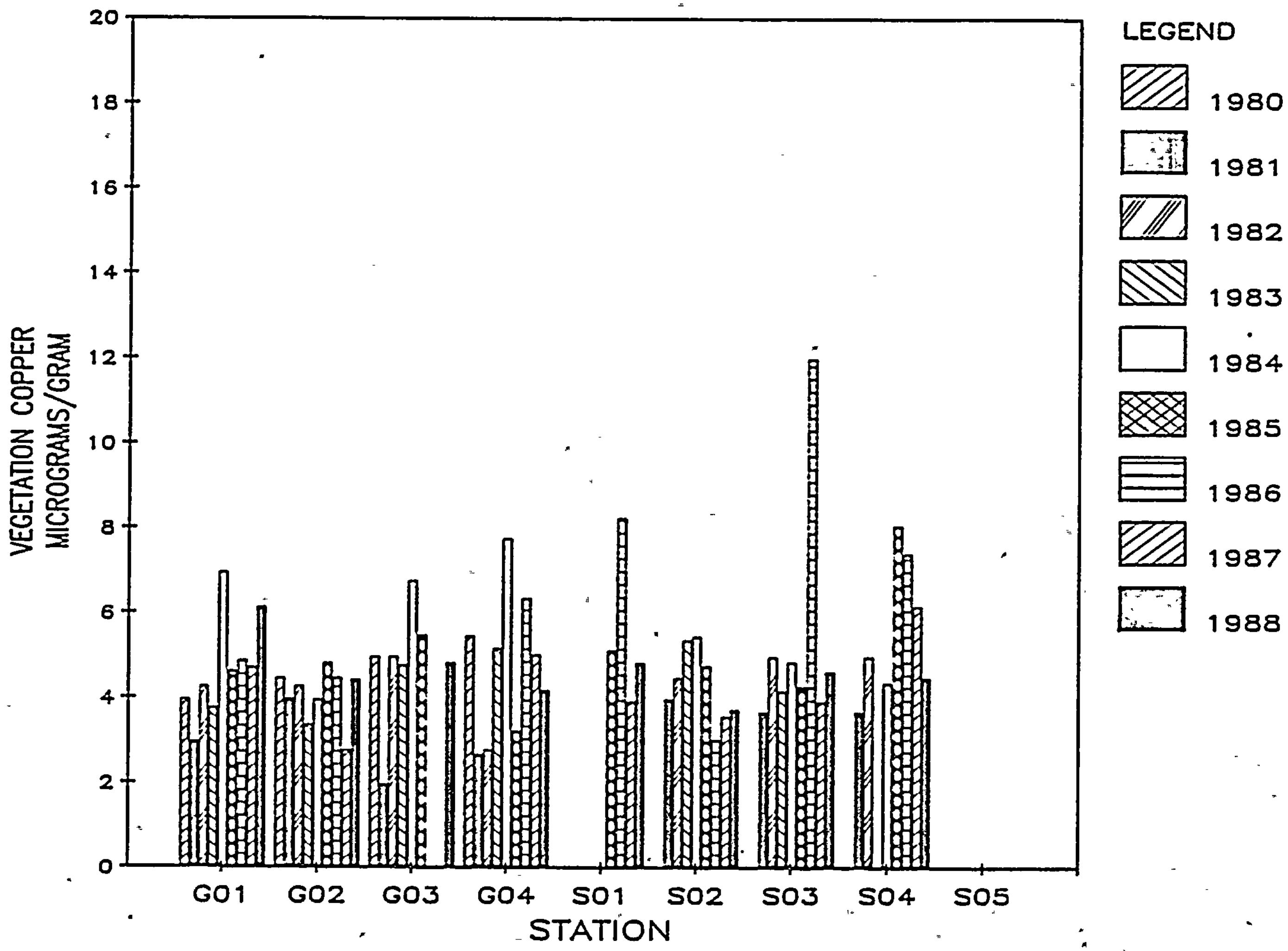


Figure 5-56. Copper Concentration (ug/g) in Phlox longifolia by Station for 1980 Through 1988

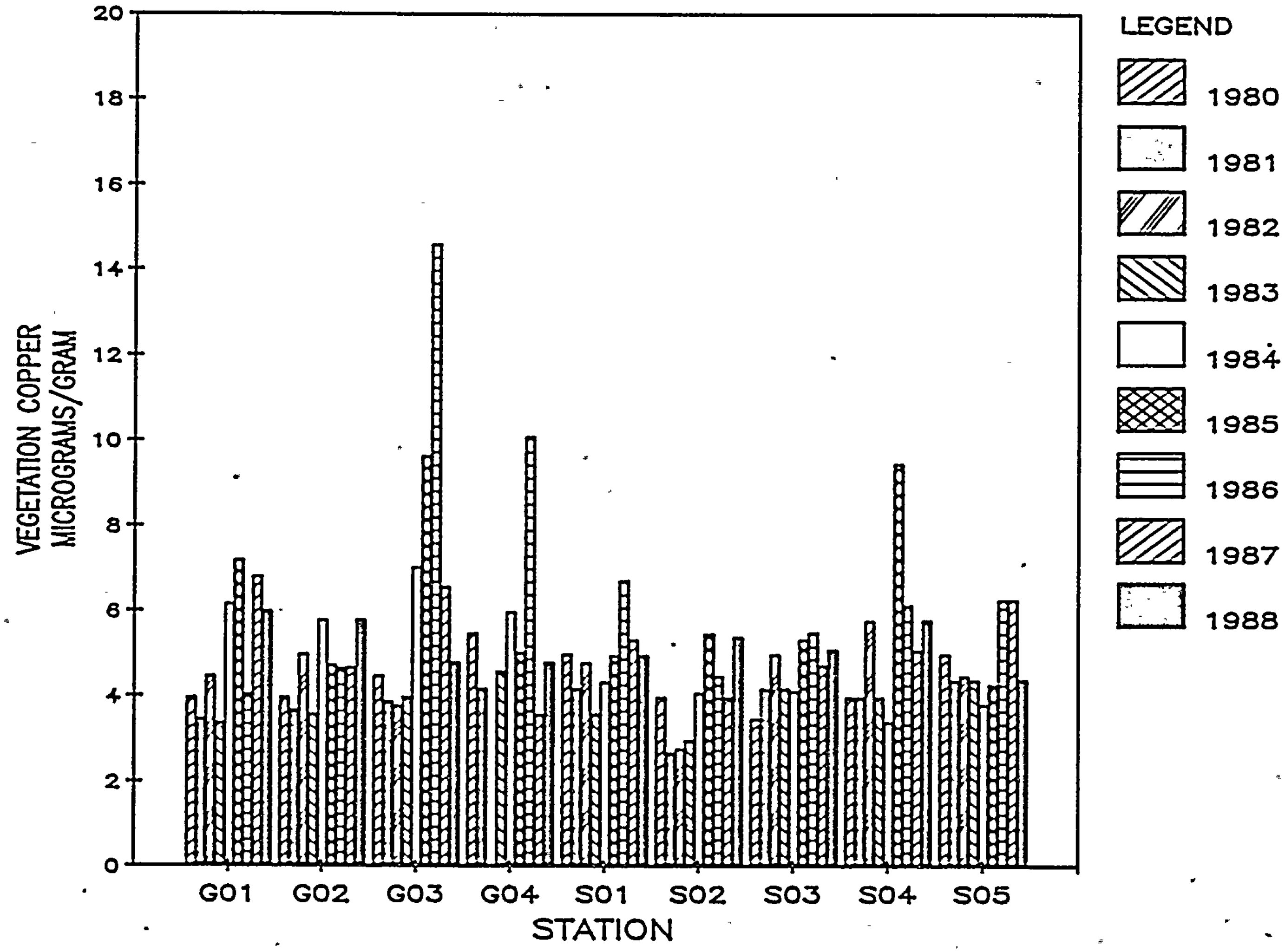


Figure 5-57. Copper Concentration (ug/g) in <u>Bromus tectorum</u> by Station for 1980 Through 1988

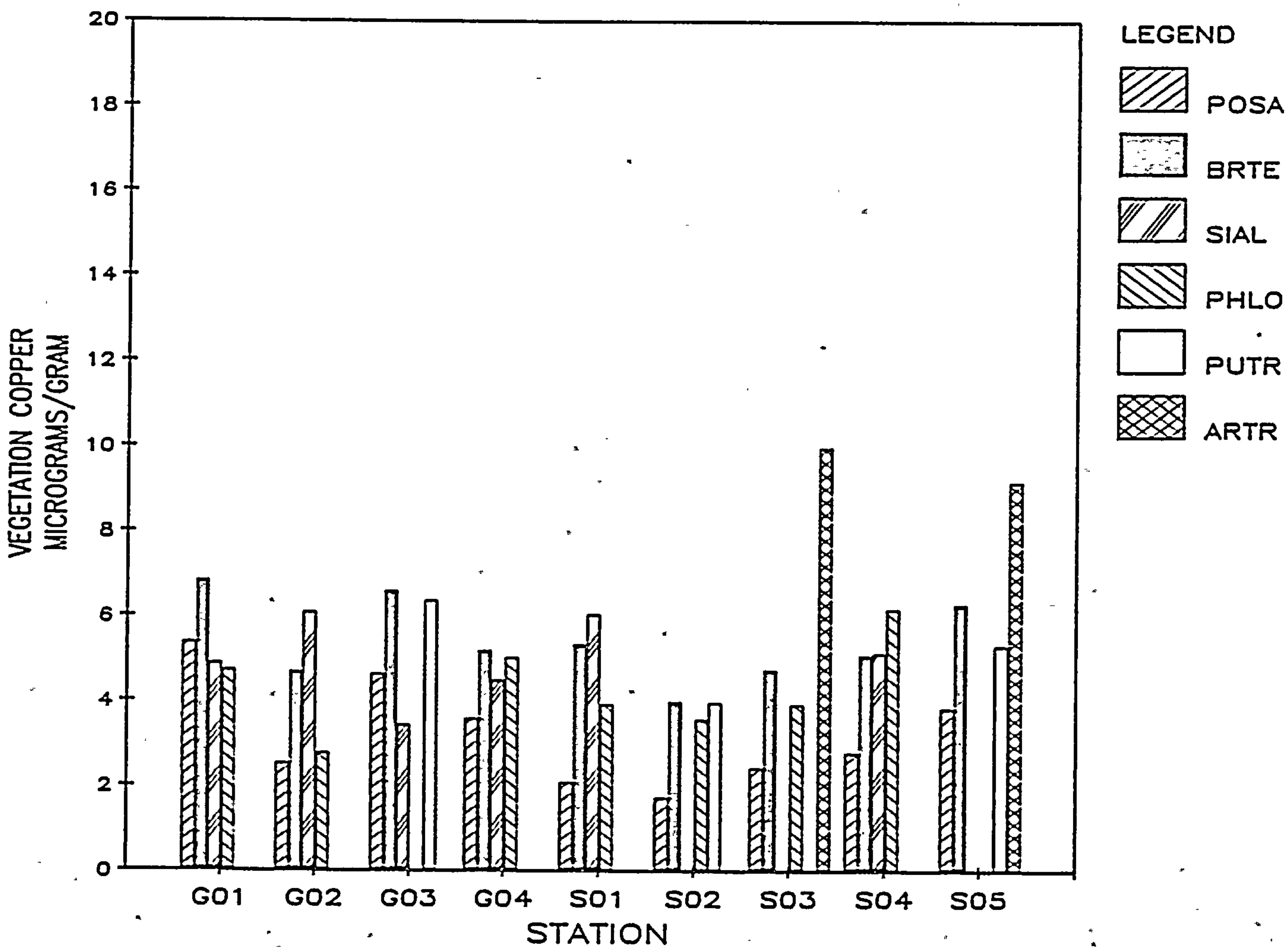


Figure 5-58. Total Vegetation Copper for May 1988

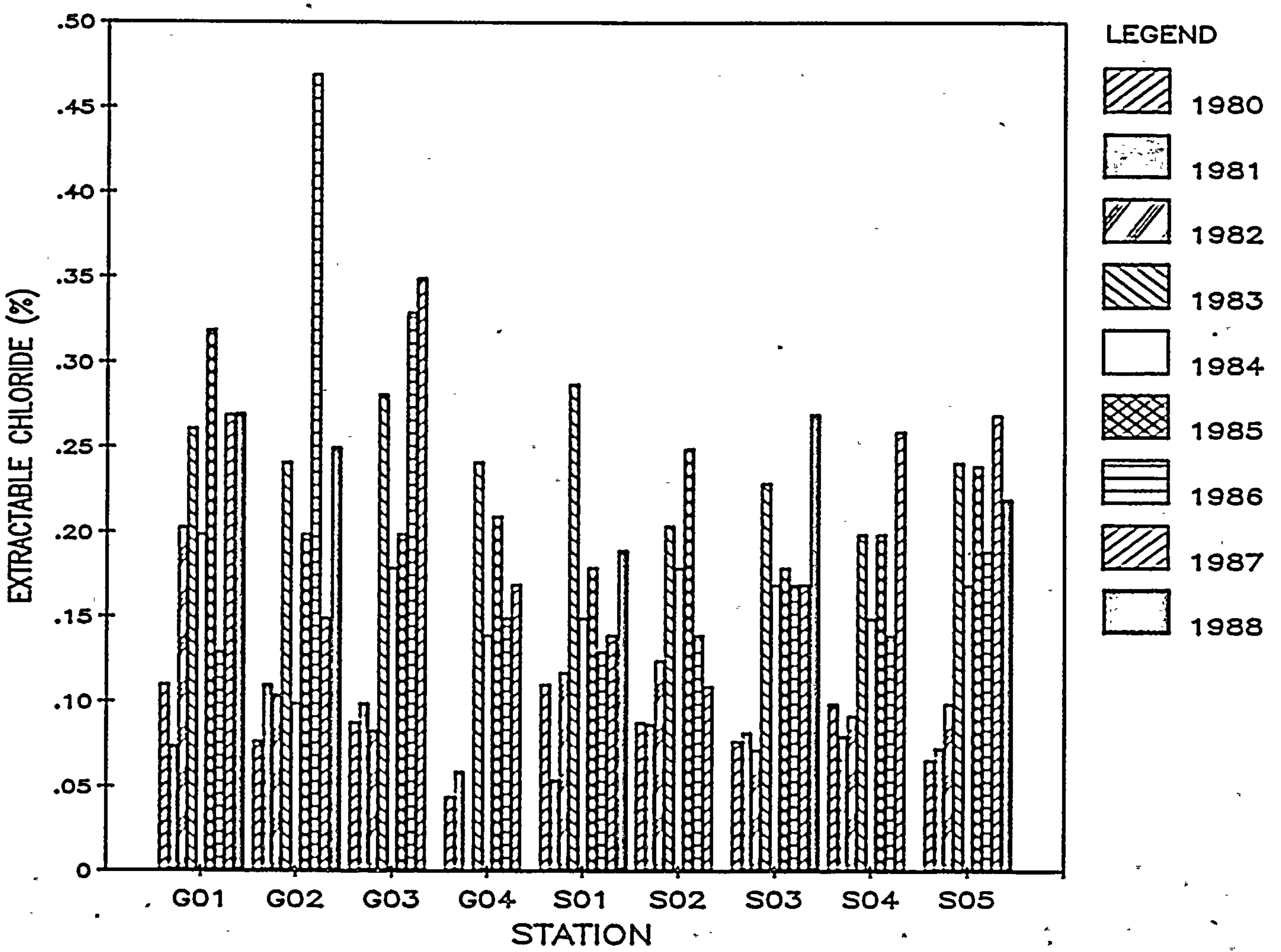


Figure 5-59. Chloride Concentration (%) in _Poa sandbergii_ by Station for 1980 Through 1988

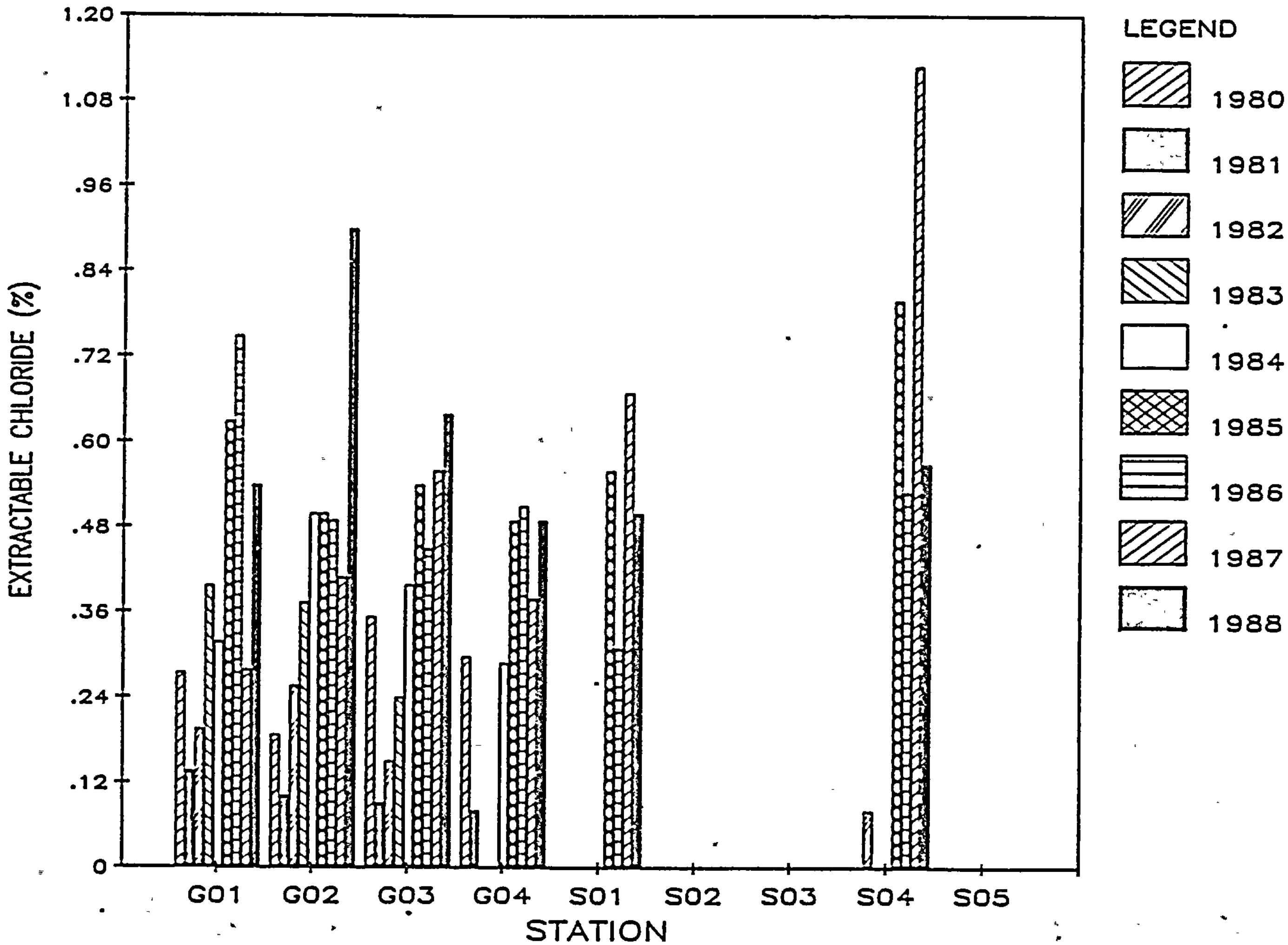


Figure 5-60. Chloride Concentration (%) in *Sisymbrium altissimum* by Station for 1980 Through 1988

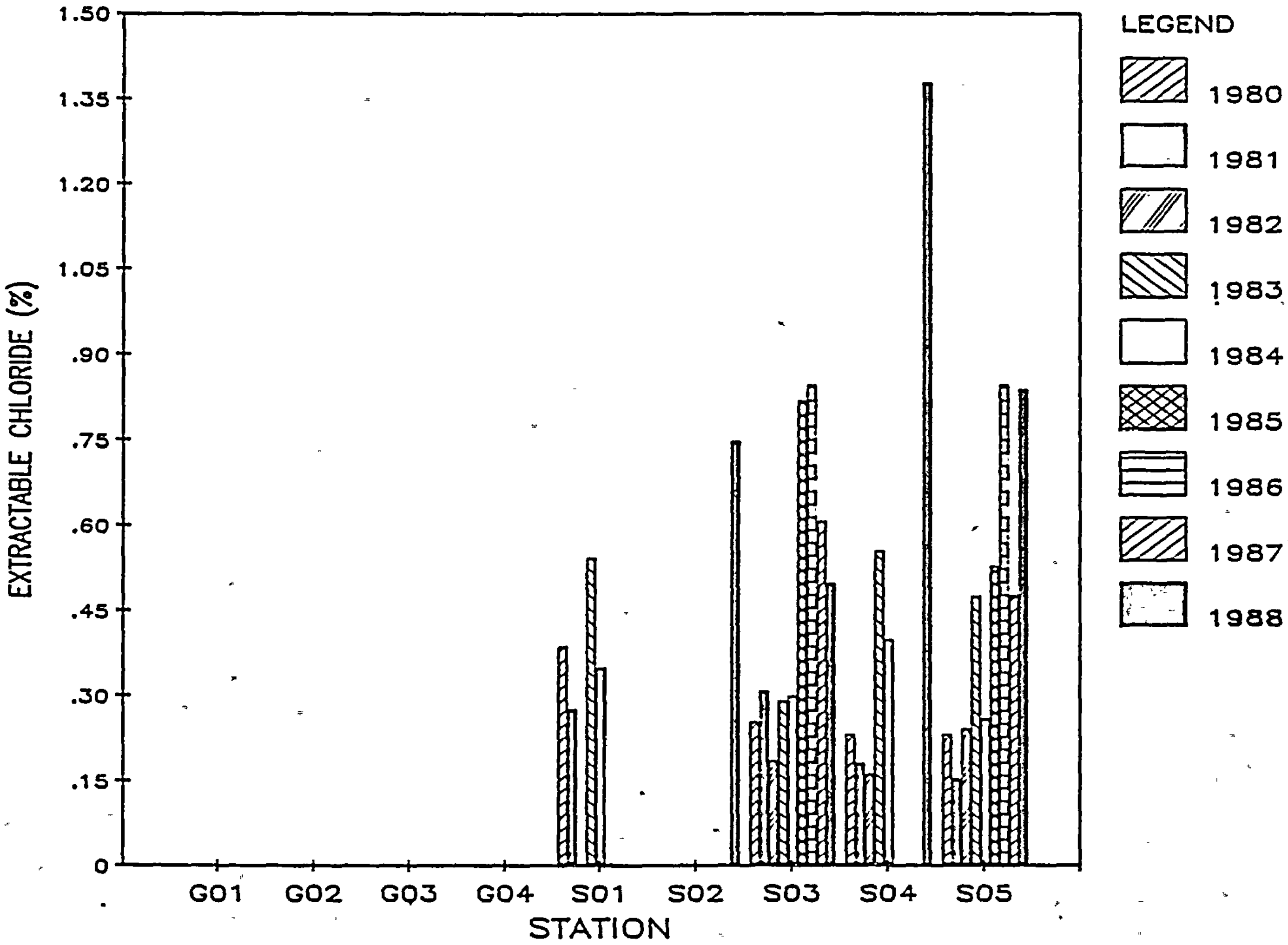


Figure 5-61. Chloride Concentration (%) in *Artemisia tridentata* by Station for 1980 Through 1988

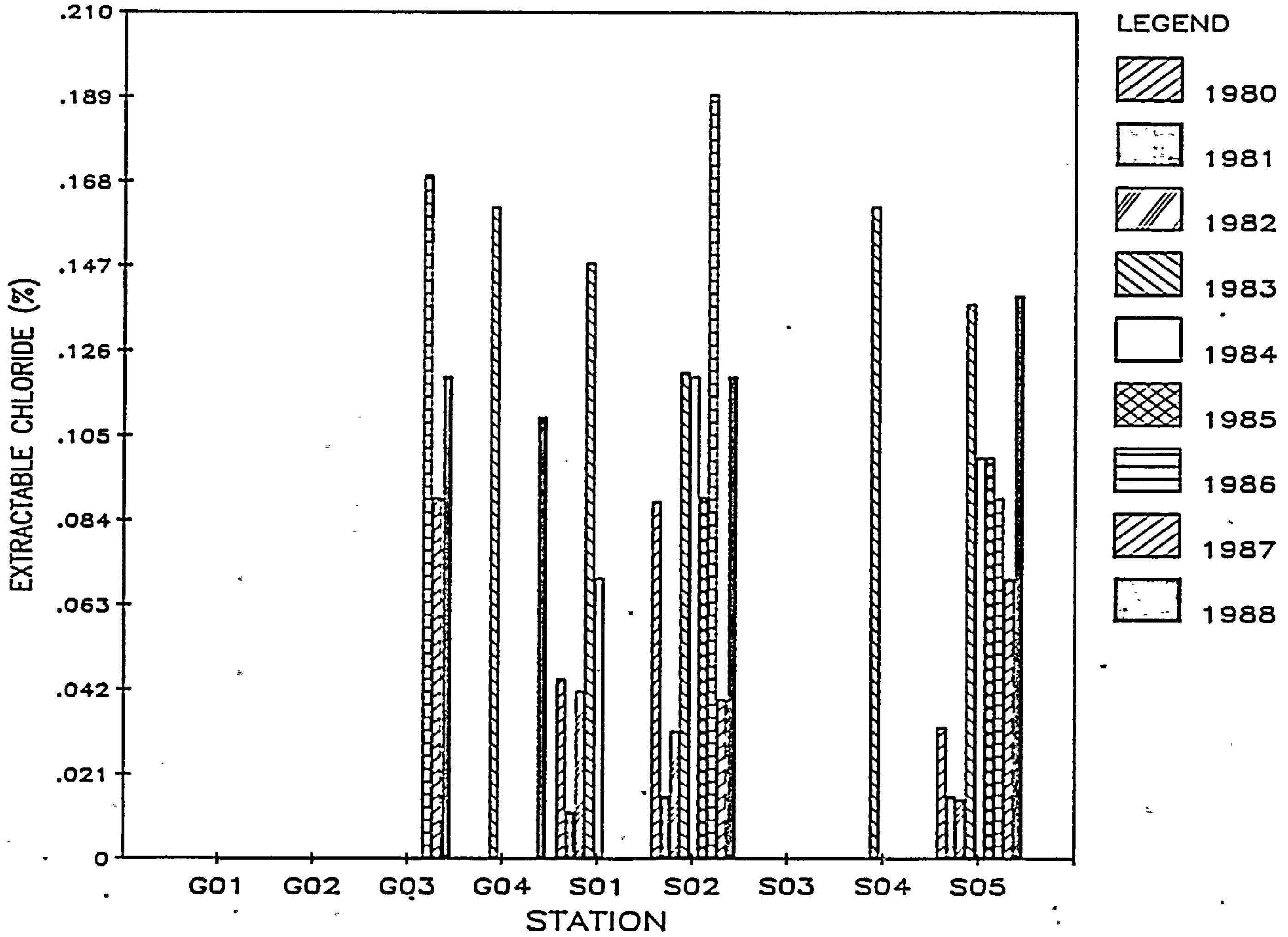


Figure 5-62. Chloride Concentration (%) in <u>Purshia tridentata</u> by Station for 1980 Through 1988

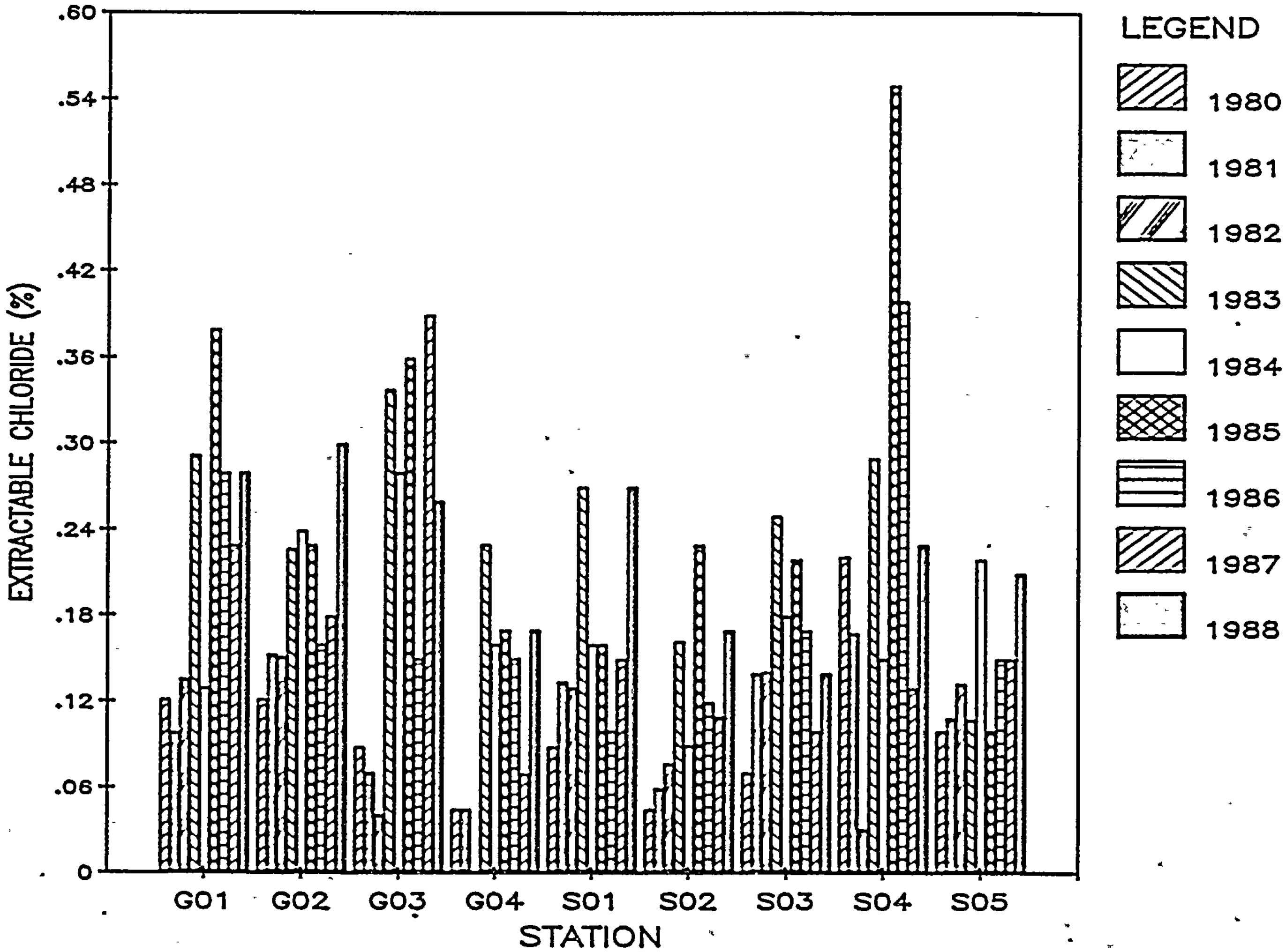


Figure 5-63. Chloride Concentration (%) in Bromus tectorum by Station for 1980 Through 1988

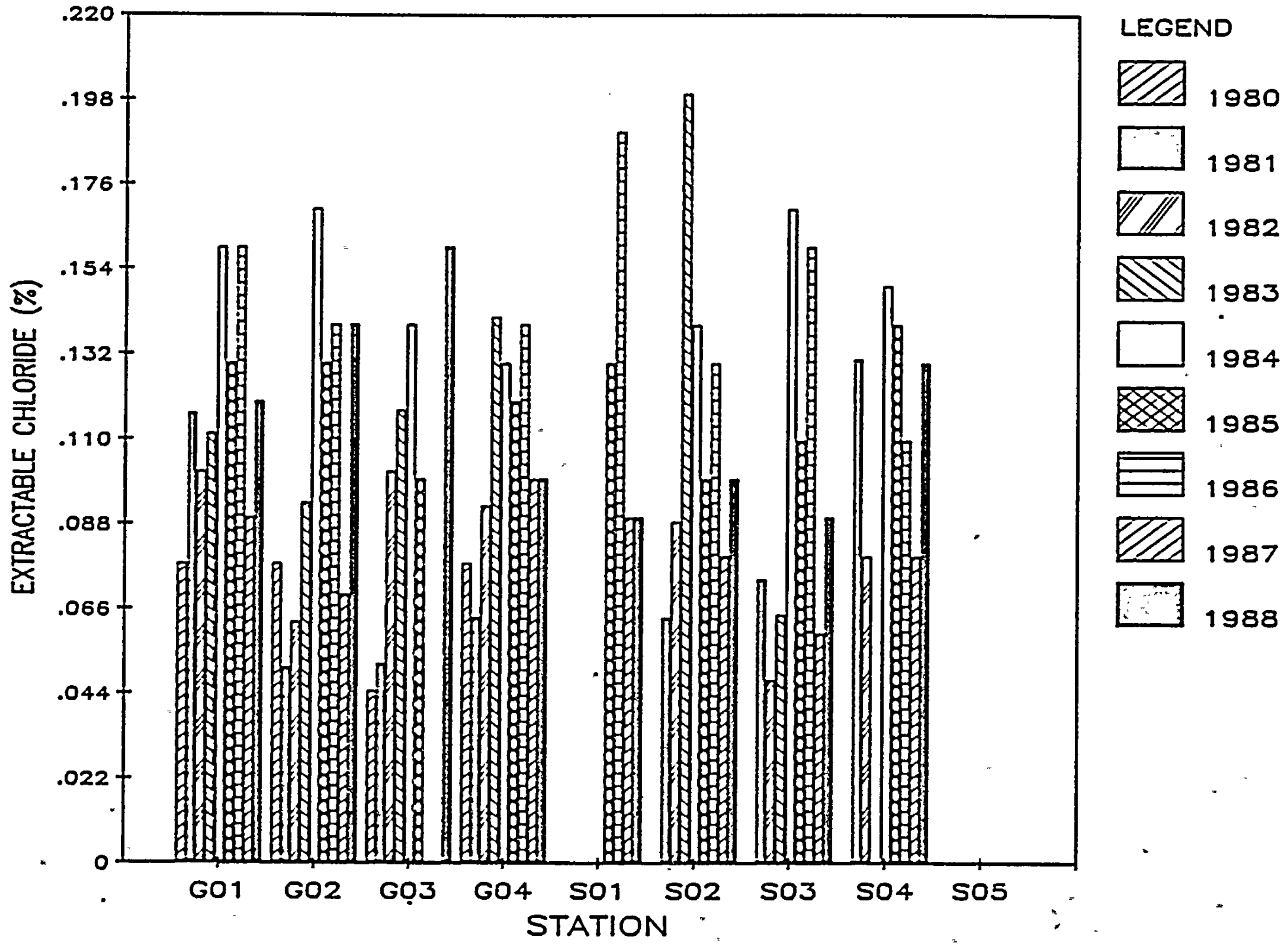


Figure 5-64. Chloride Concentration (%) in _Phlox longifolia_ by Station for 1980 Through 1988

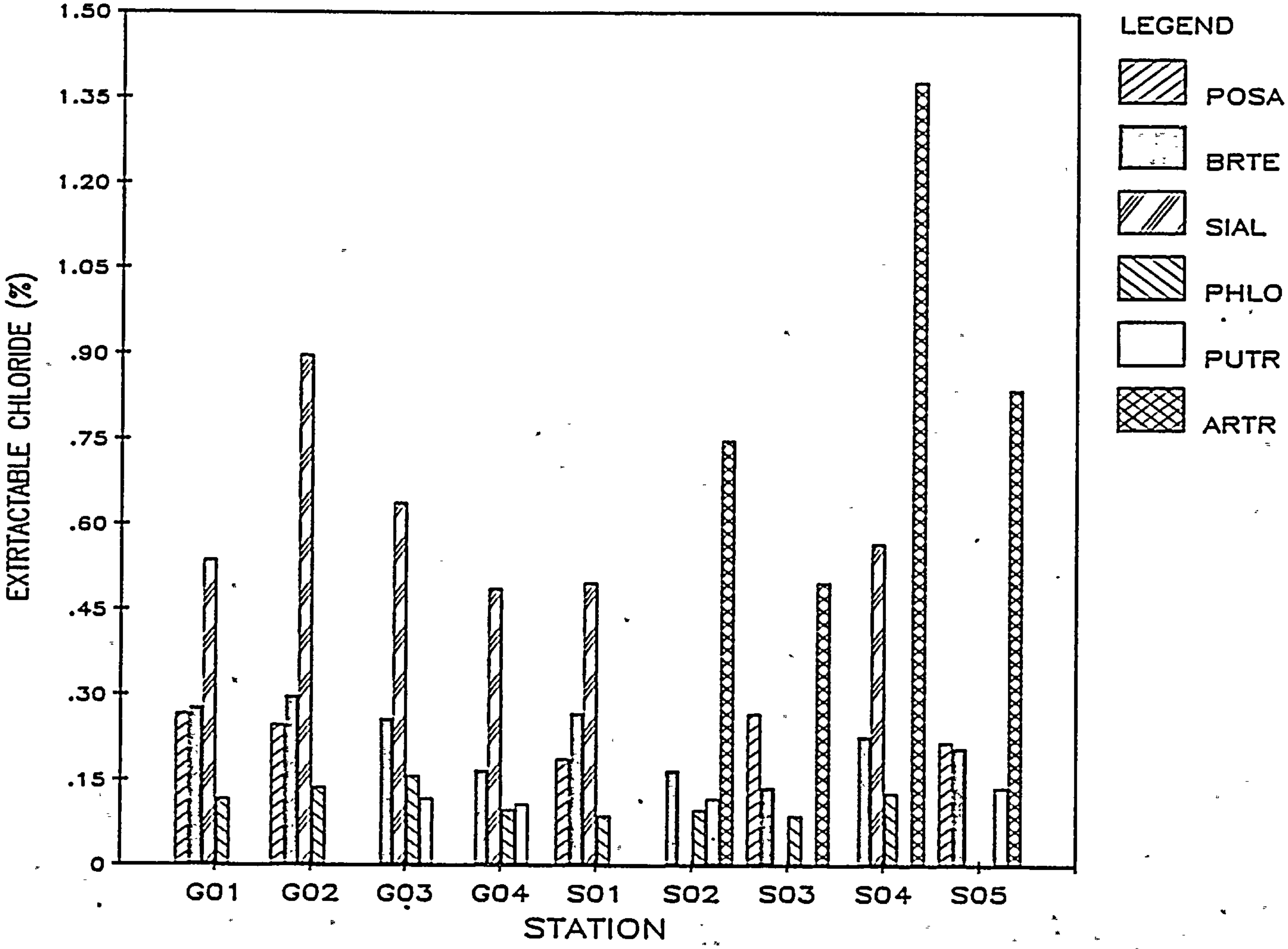


Figure 5-65. Total Vegetation Chloride for May 1988

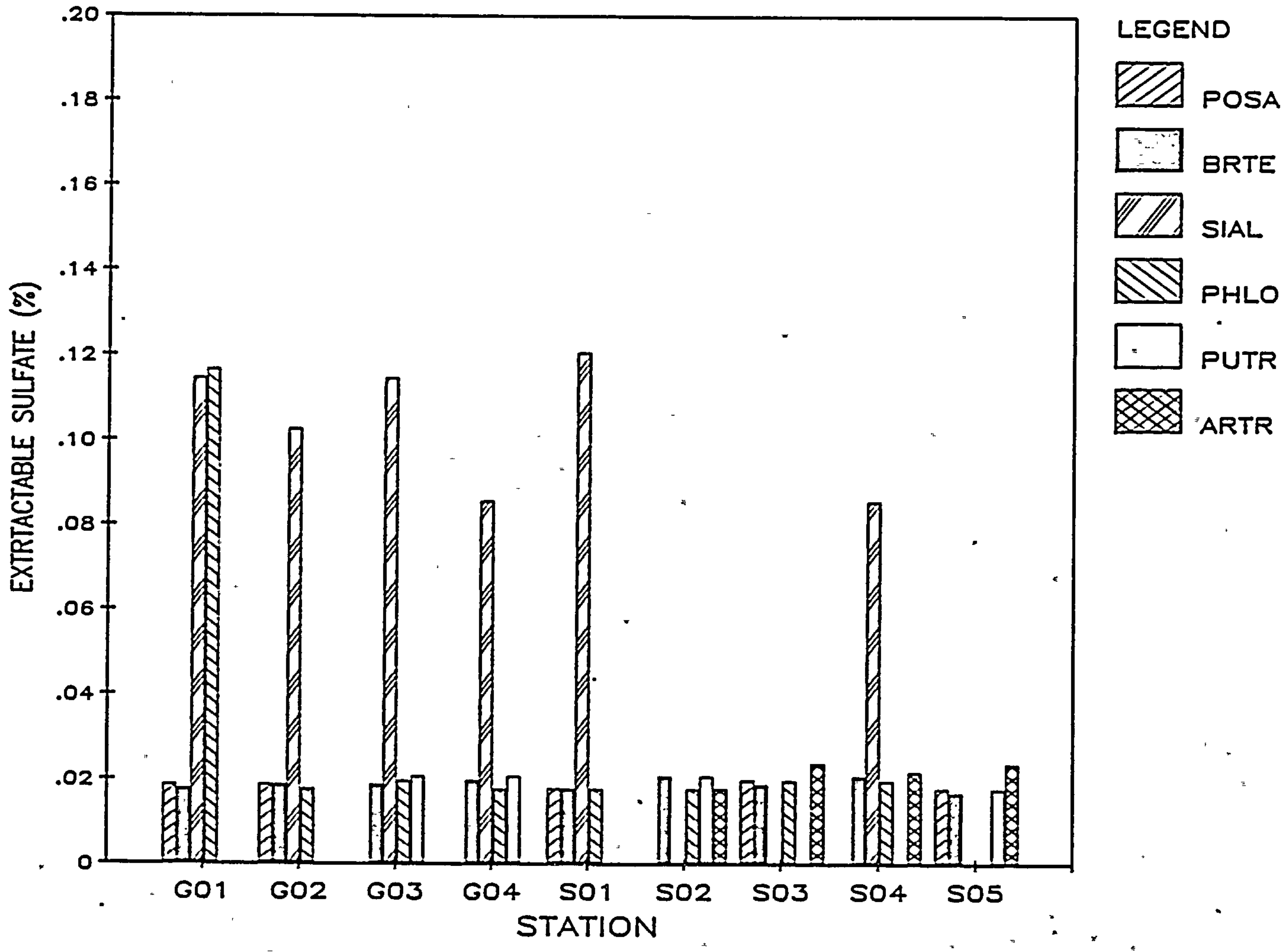


Figure 5-66. Total Vegetation Sulfate for May 1988

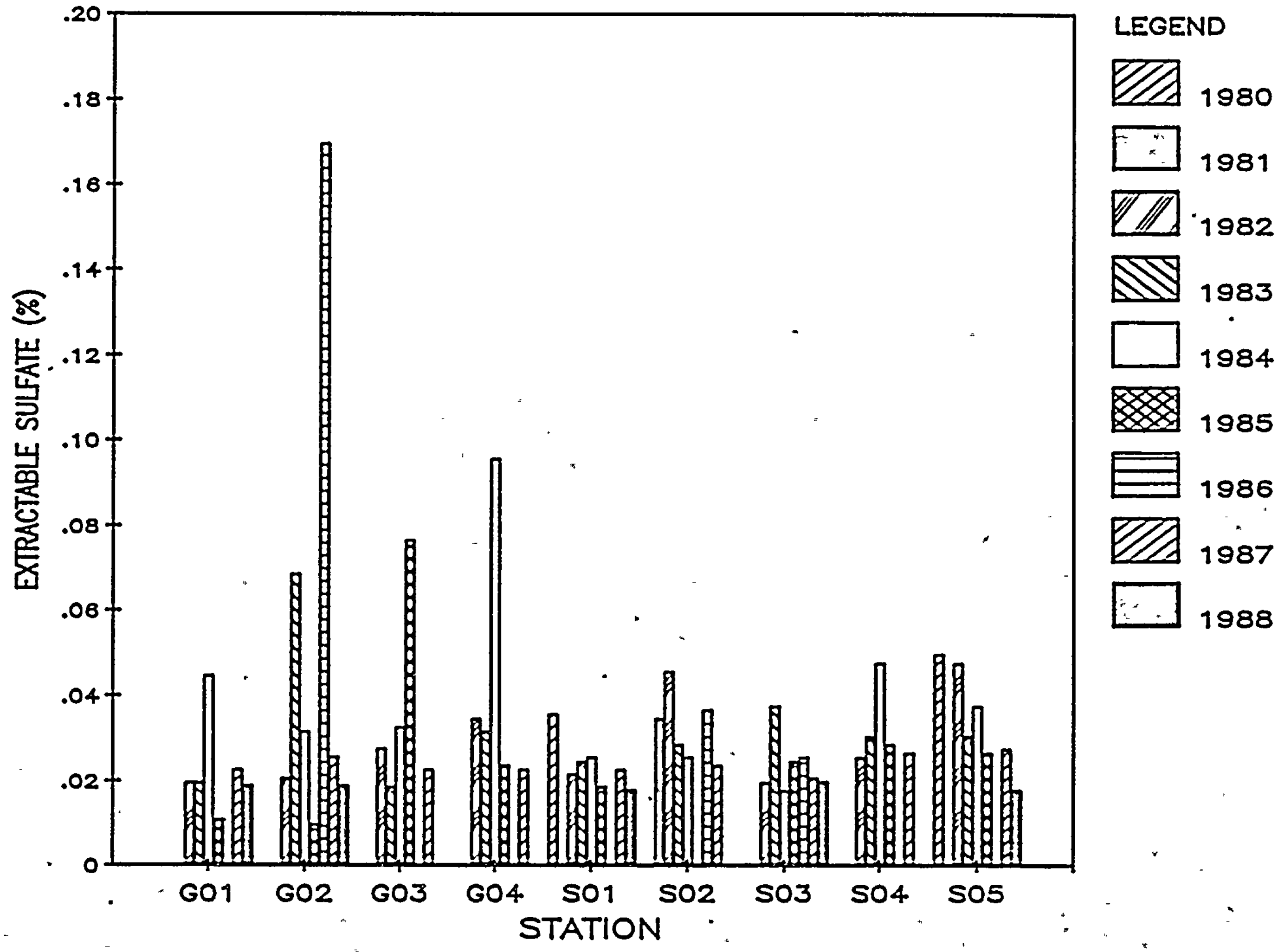


Figure 5-67. Sulfate Concentrations (%) in *Poa sandbergii* by Station for 1980 Through 1988

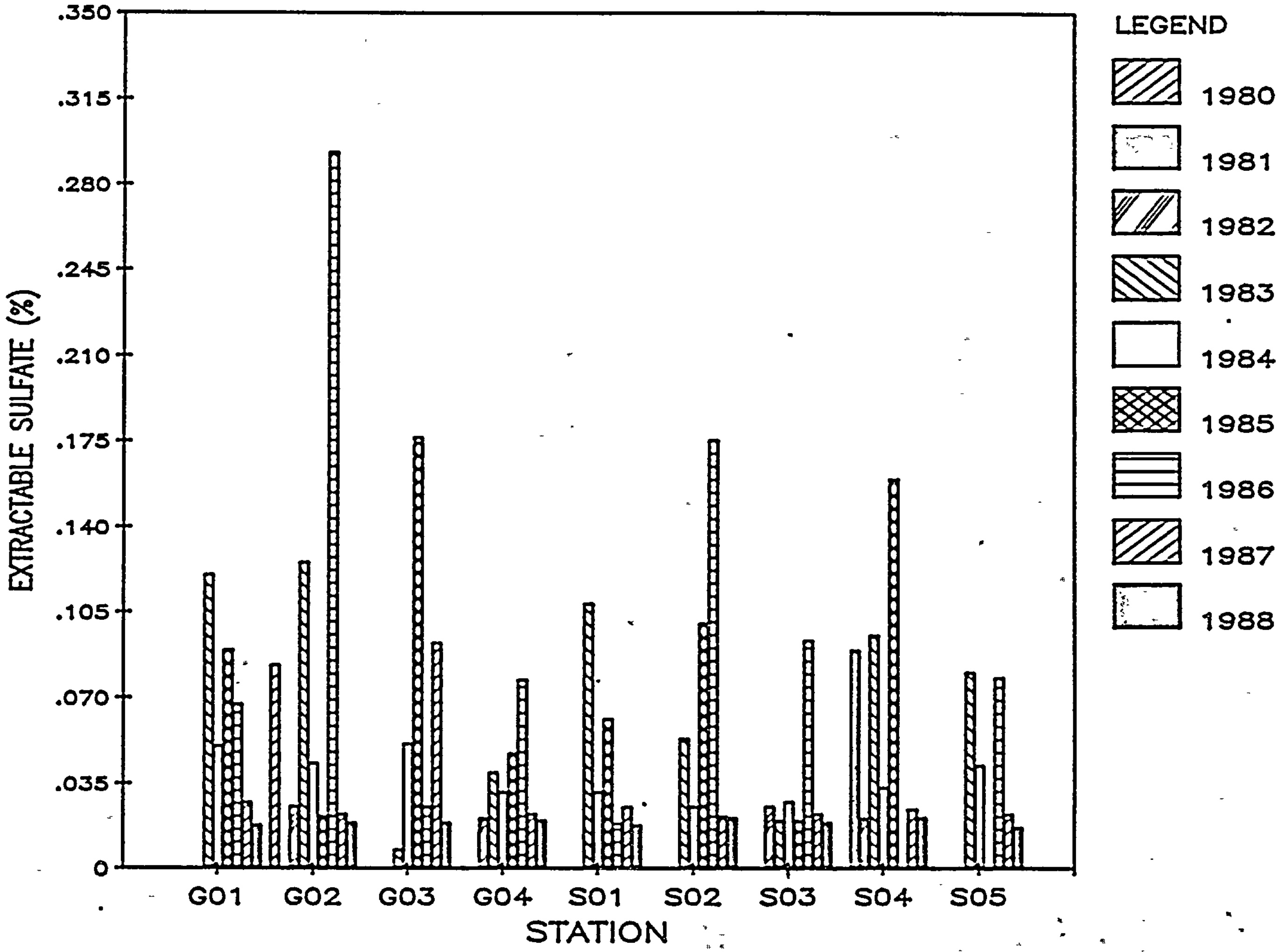


Figure 5-68. Sulfate Concentration (%) in <u>Bromus tectorum</u> by Stationfor 1980 Through 1988

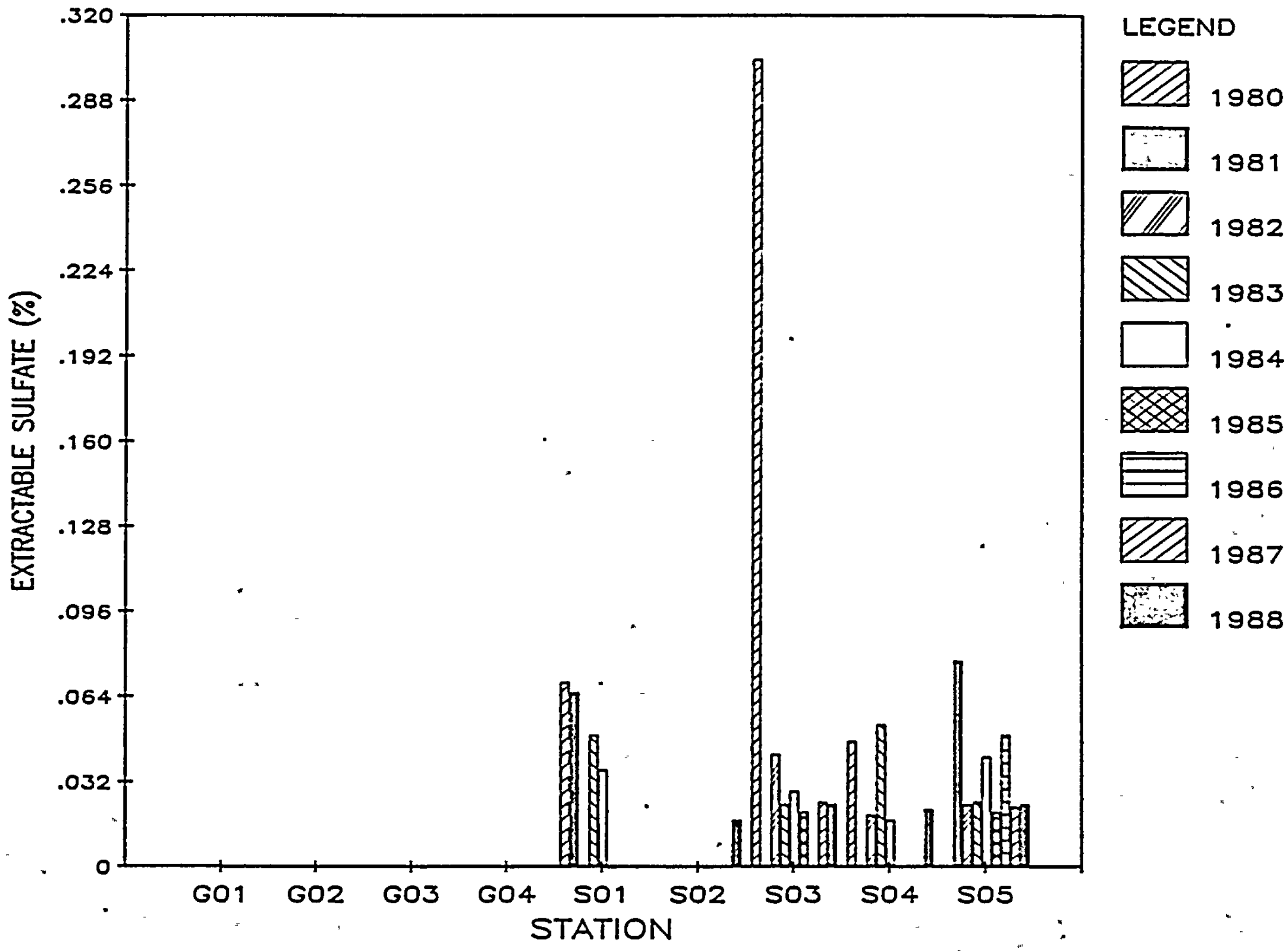


Figure 5-69. Sulfate Concentration (%) in *Artemisia tridentata* by Station for 1980 Through 1988

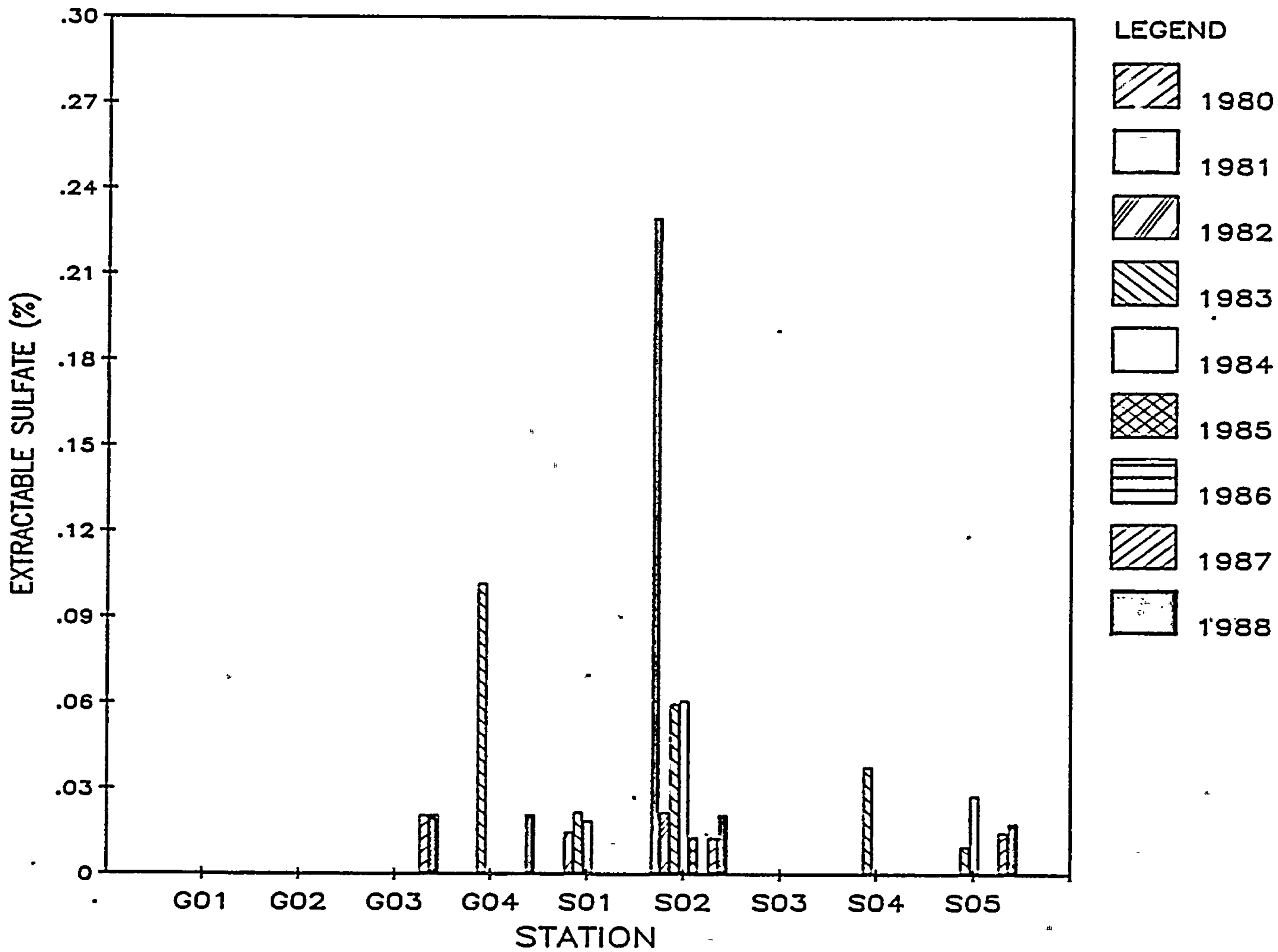


Figure 5-70. Sulfate Concentration (%) in <u>Purshia tridentata</u> by Station for 1980 Through 1988

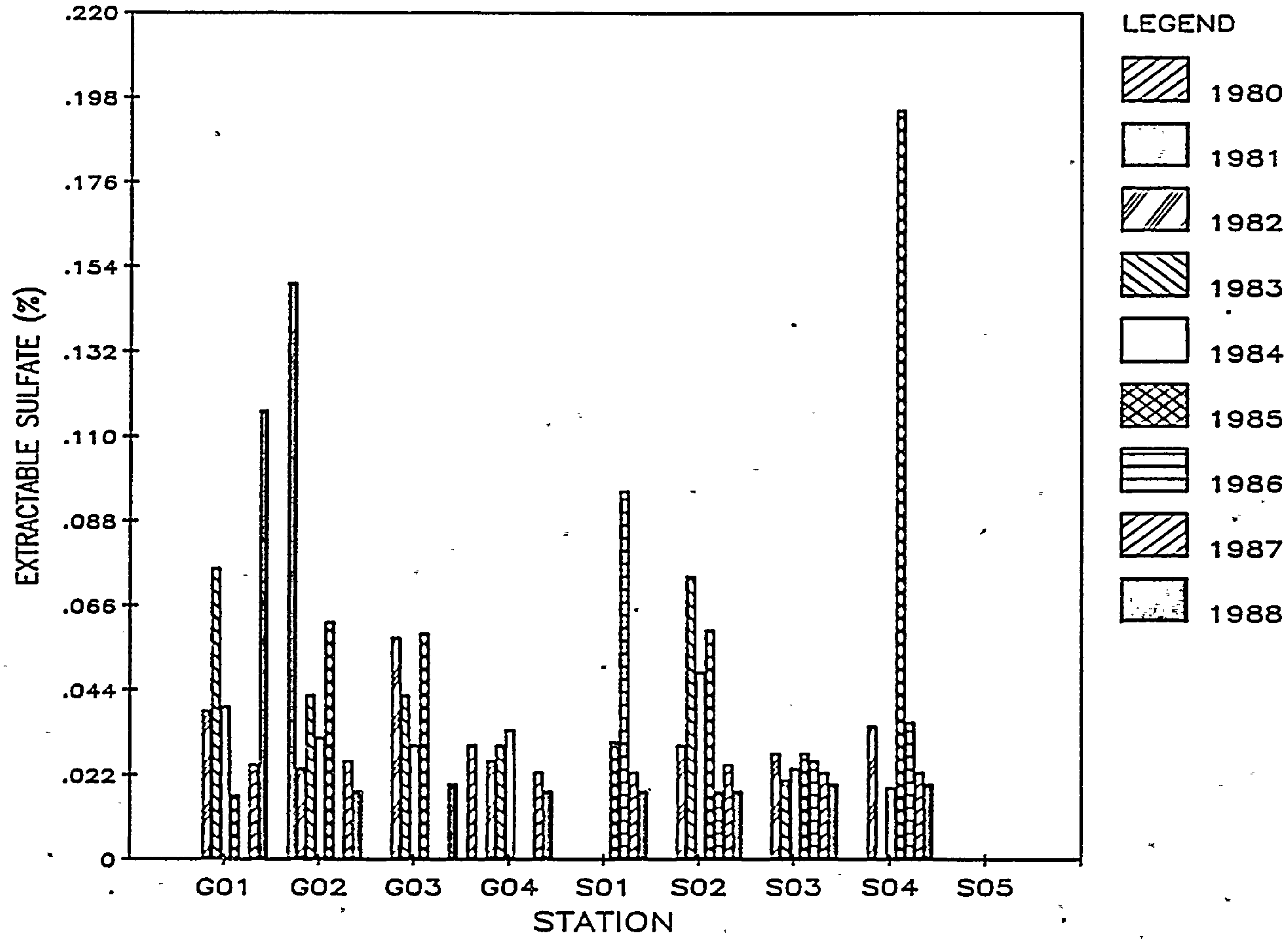


Figure 5-71. Sulfate Concentration in <u>Phlox longifolia</u> by Station for 1980 Through 1988

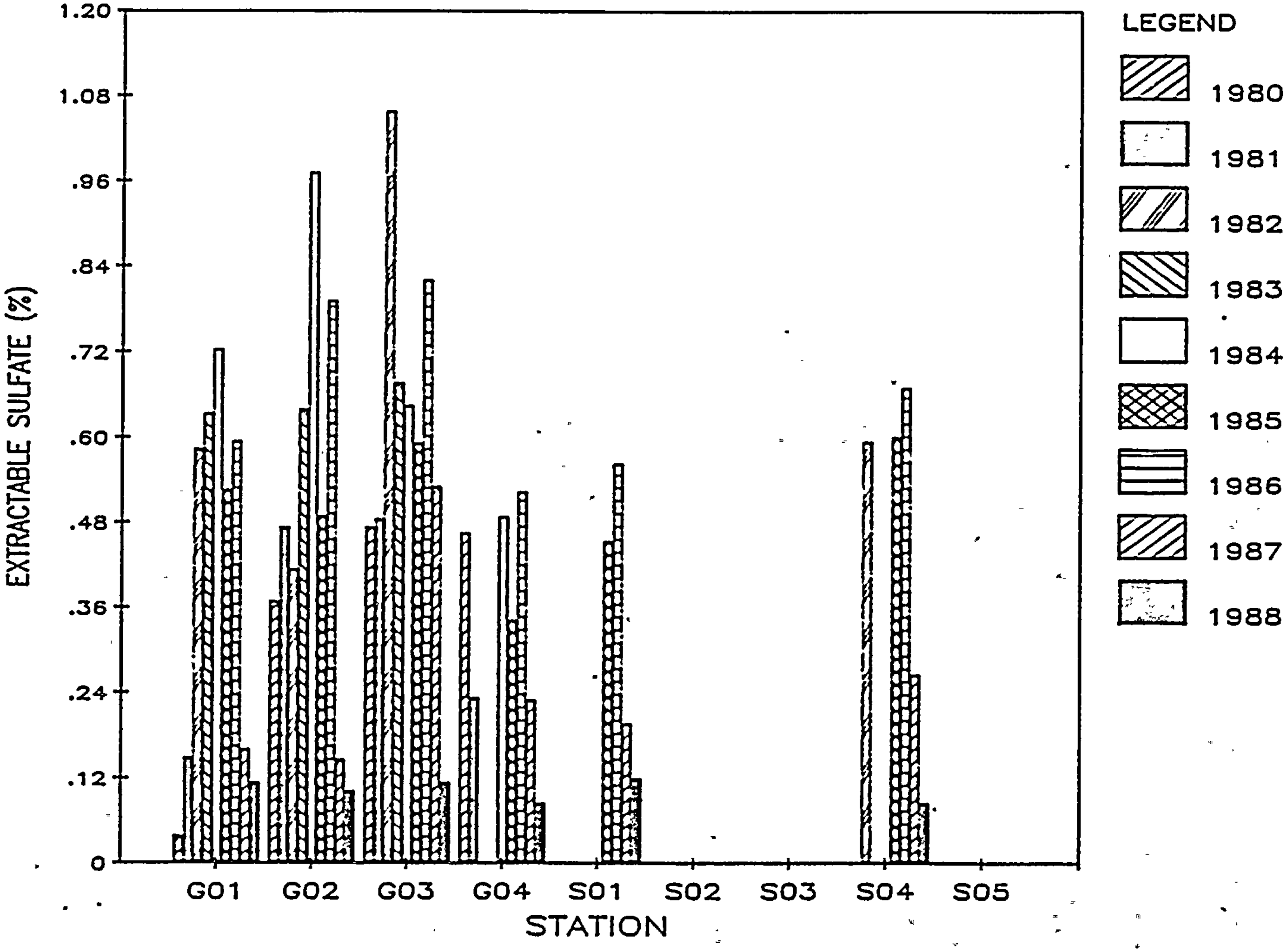


Figure 5-72. Sulfate Concentrations (%) in *Sisymbrium altissimum* by Station for 1980 Through 1988

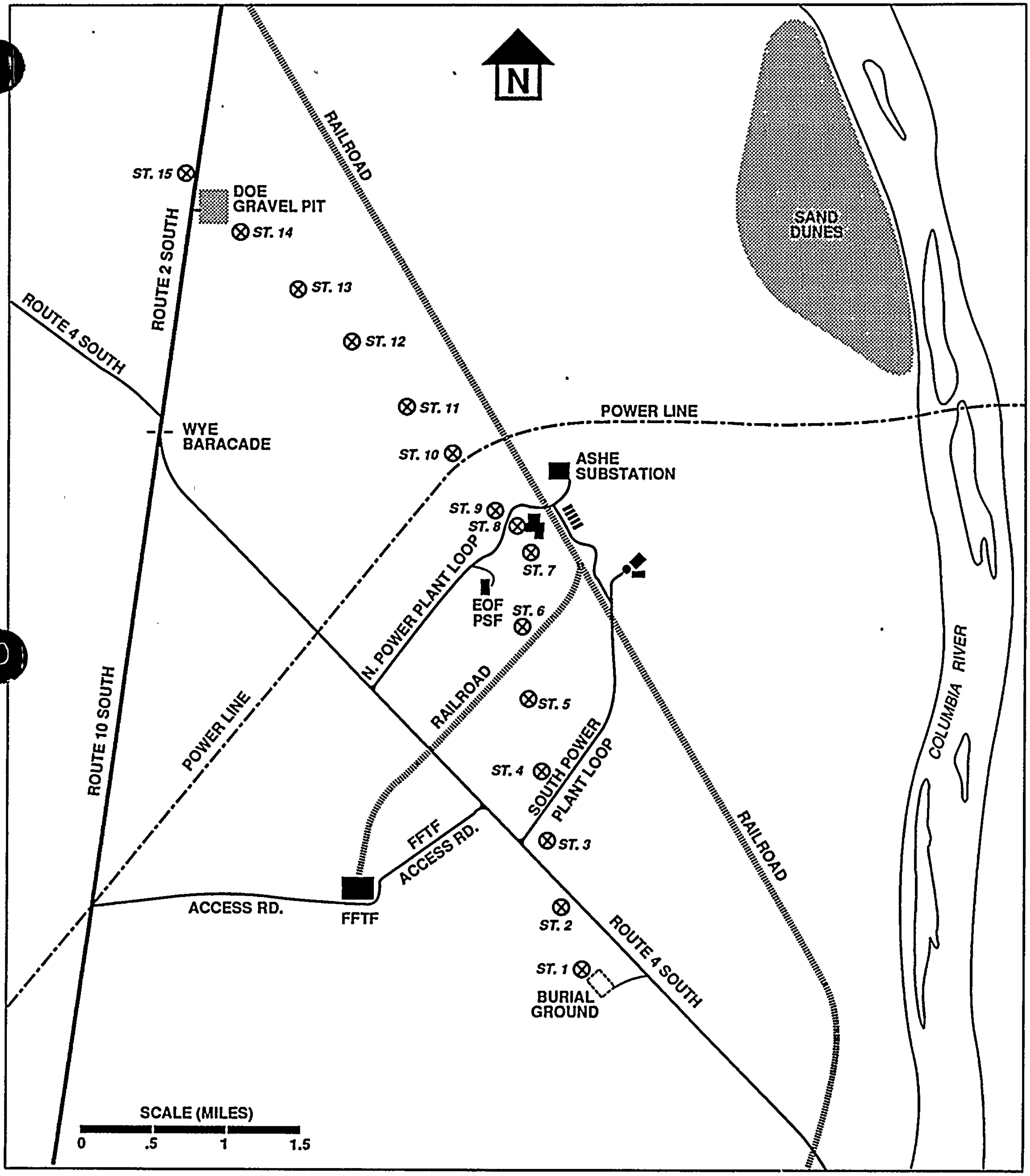


Figure 5-73. Location Map of Cooling Tower Drift Monitoring Sites

880851
MARCH 1989

⊗ SAMPLE LOCATIONS WITH REPLICATE SAMPLES

ST. 16 CONTROL SAMPLE LOCATION AT OLD HANFORD TOWNSITE

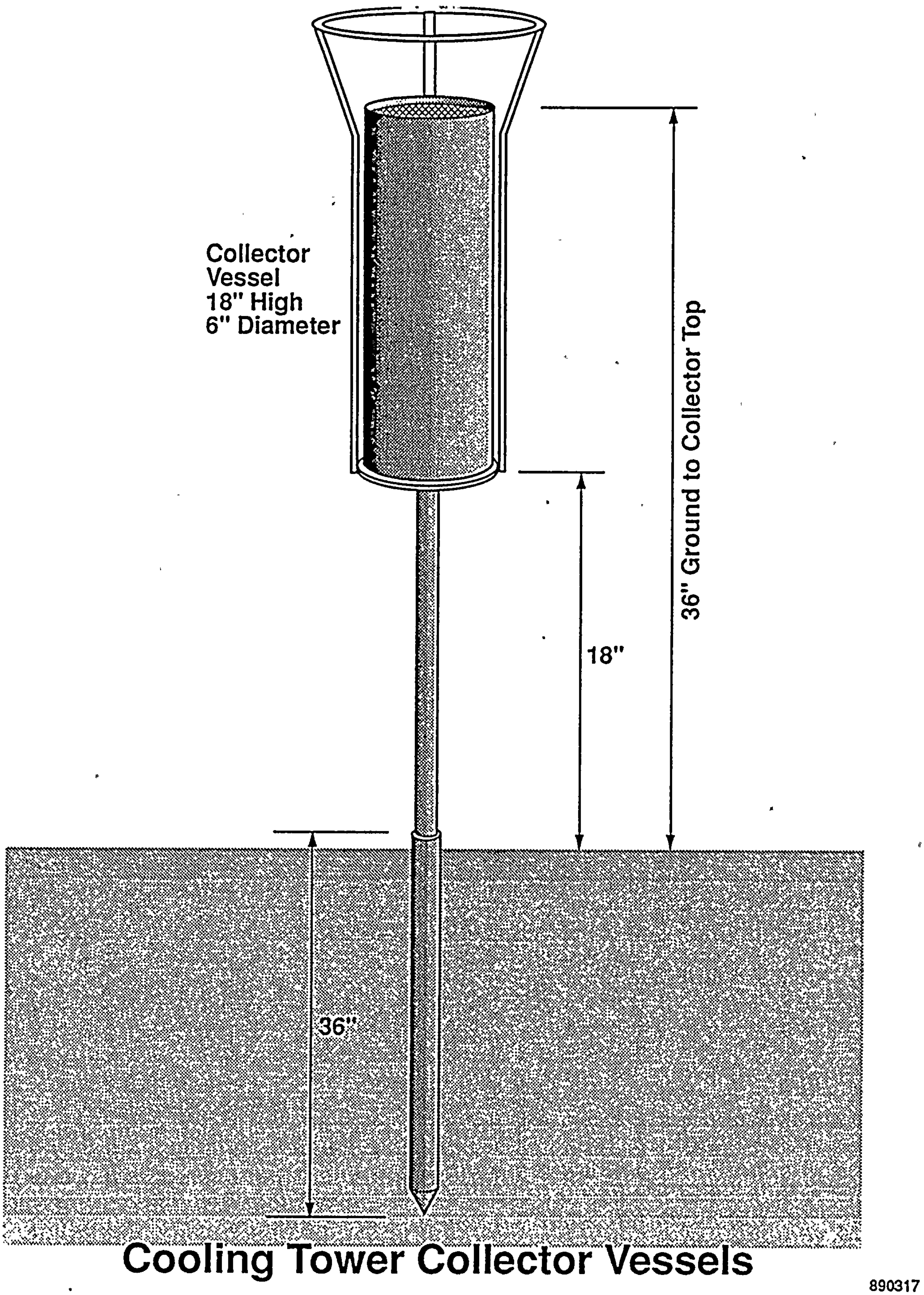


Figure 5-74. Cooling Tower Drift Collection Vessel

6.0 INTAKE STRUCTURE FOULING SURVEYS

6.1 INTRODUCTION

Columbia River water is removed through two perforated stainless steel intake structures and pumped to WNP-2 where it is primarily used to replace cooling water lost to evaporation and drift. Each intake structure is 107 cm (42 in) in diameter and approximately 6 m (20 ft) in length. Water is removed through four perforated pipe sections (2 each per intake structure) each 2 m (6.5 ft) in length with 0.95 cm (3.8 in) circular holes. A 91 cm (36 in) diameter perforated internal sleeve is used to equalized flow. Abnormal flow conditions may result in 47,300 to 94,600 liters per minute (lpm) (12,500 to 25,000 gpm) being removed from an intake structure, with the respective modeled (Washington Public Power Supply System, 1977) entrance velocities of 0.20 to 0.34 mps (0.50 and 1.1 fps). Under normal operating conditions 47,300 lpm (12,500 gpm) is removed through both intake structures (24,000 lpm or 6,250 gpm per structure) with an estimated entrance velocity of 0.05 mps. (0.15 fps). River velocities measured near the perforated pipes ranged between 1.22 and 1.53 mps (4 to 5 fps).

6.2 MATERIALS AND METHODS

Historical studies were conducted between 1978 and 1979 (Beak Consultants, 1980; Mudge et. al., 1981) using SCUBA divers. Routinely, divers inspect and report any fish impingement on or interaction with the intake structure, the need for maintenance, unusual conditions such as accumulation of submerged debris and plugging of water entrance orifices by periphyton. Video tape record logs of intake fouling may be made in the fall at four stations (two per intake), each measuring approximately 400 cm^2 (64 in^2) in size. In 1986, the monthly (March through November) survey period was reduced to a semiannual inspection of the screen fouling and riverbed stability.

6.3 RESULTS AND DISCUSSION

The intake inspections took place in July and in October. No fish were found impinged on the intake screens and algal growth was moderate. Fouling of the intake screens were comparable to past years. No unusual movement of the riverbed was noted.

6.4 BIBLIOGRAPHY

Beak Consultants, Inc. 1980. Aquatic ecological studies near WNP-1, 2, and 4, August 1978 through March 1980. Supply System Columbia River Ecology Studies Vol. 7. Portland, OR.

Mudge, J.E., G.S. Jeane II, K.P. Campbell, B.R. Eddy and L.E. Foster. 1981. Evaluation of a perforated pipe intake structure for fish protection. In: Advanced Intake Technology For Power Plant Cooling Water Systems.

Washington Public Power Supply System. 1977. WNP-2 Environmental Report Operating License Stage. Richland, WA.

7.0 CORBICULA CLAM SURVEYS

7.1 INTRODUCTION

The Asiatic clam (Corbicula fluminea) is an introduced species which has caused problems at electrical generating plants. Extensive fouling by relic shells have reduced cooling water flow rates in safety-related systems necessitating plant shutdowns in the southeast. Because of these problems, the Nuclear Regulatory Commission issued Inspection and Enforcement Bulletin 81-03 in April, 1981. This bulletin requires holders of operating licenses to inspect these systems for the presence of the bivalve.

7.2 MATERIALS AND METHODS

Surveys of the tower make-up (TMU) pump pit, the circulating water pumphouse and the main condenser water boxes are conducted at least once a year. The inspections of the TMU and circulating water pumphouse is done with SCUBA when the pump pits are filled.

7.3 RESULTS AND DISCUSSION

An extensive inspection of the main condenser water boxes was conducted during the annual refueling outage. No living Corbicula or relic shells were found. The circulating water pumphouse pit was not drained during the outage, however, no evidence of Corbicula was found during maintenance dives there. The December, 1987 inspection dive in the TMU pit revealed that the population of clams there continued to be small.

8.0 AERIAL PHOTOGRAPHY PROGAM

8.1 INTRODUCTION

The aerial photography program began in June of 1988 to monitor the vegetation surrounding WNP-2 for impact due to cooling tower operation. Aerial photographs taken with color infrared (CIR) film, allow large areas to be monitored and to detect signs of possible stress before it becomes visible to the human eye. In addition to examination for stress, the photographs will be compared with those taken in following years to look for changes in vegetation patterns and evidence of cumulative damage. This program is performed to comply with Washington State Energy Facility Site Evaluation Council (EFSEC) Resolution No. 239 dated September 14, 1987.

8.2 MATERIALS AND METHODS

This program was planned using guidelines published in NUREG/CR-1231 (NRC, 1980). This report outlined the basic requirements for an aerial monitoring program and suggested types of film, photograph scales, frequency of photograph acquisition and the size of prints.

Five flightlines (Figure 8.1) were planned to cover the areas of greatest deposition according to the drift model constructed by Battelle Pacific Northwest Laboratories (PNL, 1976). Two flightlines, approximately 7 miles (11.2 Km.) in length, run in a general north-south direction. These flightlines run between the two areas of greatest deposition according to the model. The other three flightlines of approximately 5 miles (8.1 Km.) in length, run in an east-west direction and were placed to cross gradients of deposition. The five flightlines were flown at an altitude of 1,550 feet (477m.) above mean sea level. The flightline coordinates are stored in the long-range navigation (LORAN) system in the contractors airplane. This allows the same lines to be photographed in following years.

The photographs were taken with Kodak Aerochrome 2443 color infrared film in a Hasselblad ELM 70mm camera. A Planar lens with a 80mm focal length was used with a number 12 Wratten filter attached. The scale is 1:6,000 in a 70mm x 70mm format. The relatively large scale of 1:6,000 was chosen as being large enough to differentiate the types of brush in the areas surrounding WNP-2. The 70mm size was chosen over the larger nine inch by nine inch format for ease of handling and the storage of the nearly 500 photographs.

Color infrared (CIR) film was chosen over natural color or black and white film because the symptoms of stress on vegetation may show in the infrared wavelengths before it becomes apparent in the visible wavelengths. CIR film is easier to interpret than black and white infrared because the shades of color are easier to differentiate than the subtler shades of gray in the monochromatic infrared. Healthy vegetation will show as a dark red or magenta color. Stressed vegetation will show lighter shades of red to white. Interpretation of the photographs is done on a light table and viewed with magnifying glass or stereo microscope. A plastic sheet is put over the photographs to protect the film and to allow areas of interest to be marked with a grease pencil. Each photograph is examined and signs of stress are noted by flightline number and frame number. The photographs are taken with an overlap of 50% to make it possible to view them in stereo if desired. The 50% overlap was maintained during the acquisition by controlling the shutter with an intervelometer.

The photographs were used in the placing of the samplers for the cooling tower drift study. The samplers were placed on portions of the two north-south flightlines. In future overflights, the stations may be used to ground truth the photographs. Markers will be put out next to the samplers to make the stations easier to find on the photographs. The ground truthing will consist of a survey of an area or areas on a flightline and examination of the vegetation for other signs of stress.

8.3 RESULTS AND DISCUSSION

The overflight was done on June 14 by the contractor, Photography Plus of Umatilla, Oregon. This first overflight was done a month later than originally planned and missed the time of peak photosynthesis, which is when the vegetation would show signs of stress best on CIR film. The delay was caused by some initial planning problems. However, it was felt that the overflight should be performed. This would allow the contractor the opportunity to set the flightline coordinates in the LORAN system. It would also allow Supply System personnel to become familiar with the photographs and practice methods of interpretation.

No attempts were made to examine the photographs for signs of stress. The lateness of the acquisition meant that the vegetation was beginning to be stressed by the onset of the hot summer temperature in addition to the drought condition that was prevalent in the area. The photographs were examined only for quality, which was found to be good, and to familiarize the interpreter with working with the strips of photographs. The 1988 photographs will be compared with those of following years to check vegetation density and patterns.

8.4 BIBLIOGRAPHY

Shipley, B.L., S.B. Pahwa, M.D. Thompson and R.B. Lantz. 1980. NUREG/CR-1231. Remote sensing for detection and monitoring of salt stress on vegetation: Evaluation and guidelines. Final report, September 1976-March 1979. Nuclear Regulatory Commission, Washington, D.C.

Droppo, J.G., C.E. Hane and R.K. Woodruff. 1976. Atmospheric effects of circular mechanical draft cooling towers at Washington Public Power Supply System Nuclear Power Plant Number Two. Battelle Pacific Northwest Laboratories, Richland, WA.

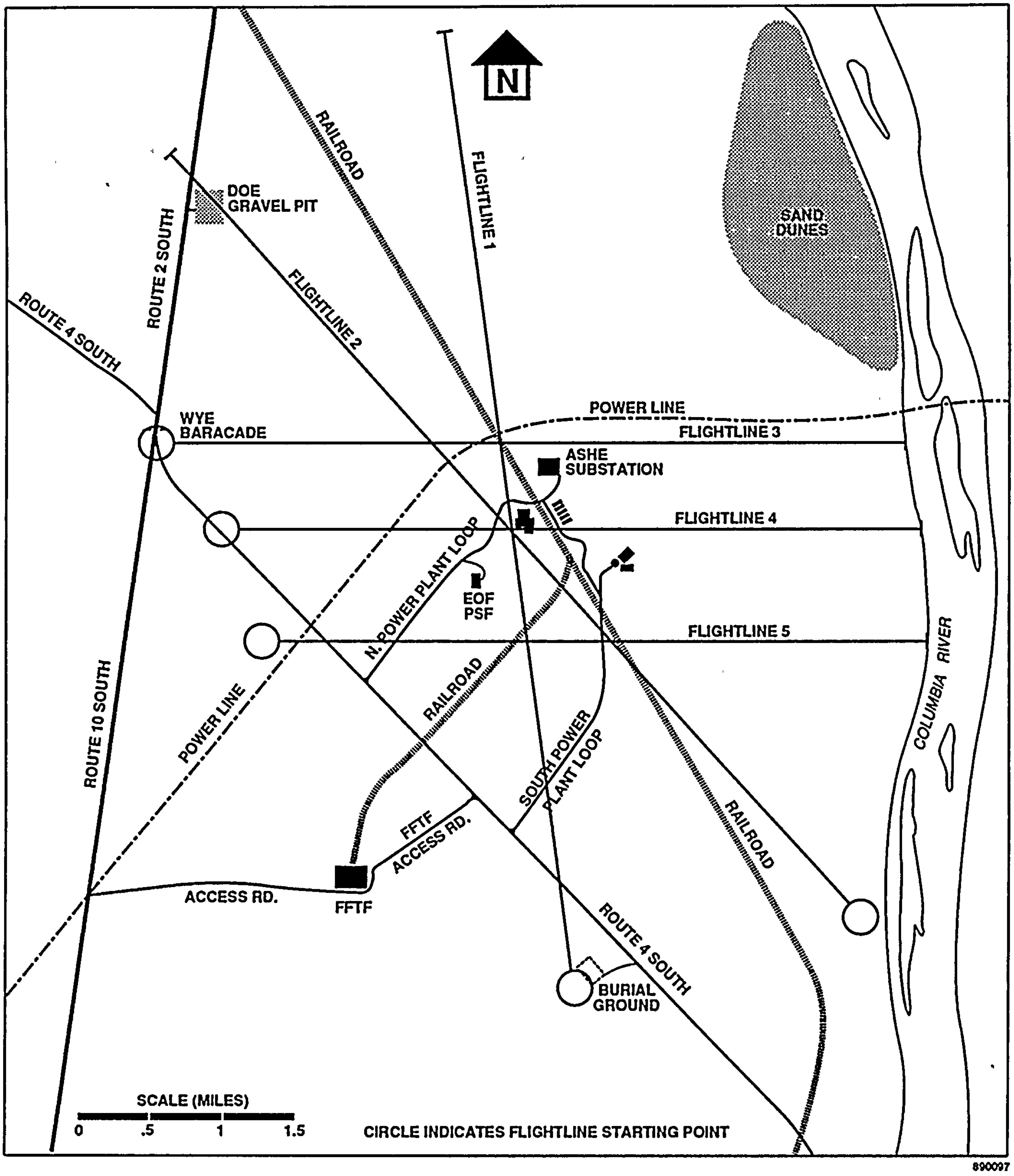


FIGURE 8-1 AERIAL PHOTOGRAPHY FLIGHTLINES