# HYDROGEOLOGIC EVALUATION OF THE BEAR CANYON MINE PERMIT AND PROPOSED EXPANSION AREAS

CO-OP MINING COMPANY
Salt Lake City, Utah

Prepared By

EARTHFAX ENGINEERING, INC.
Midvale, Utah

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REGISTERED PROFESSIONAL ENGINEER
No. 7102
RICHARD B. WHITE
STATE OF UTAH

Richard B. White
11 Mar 1991

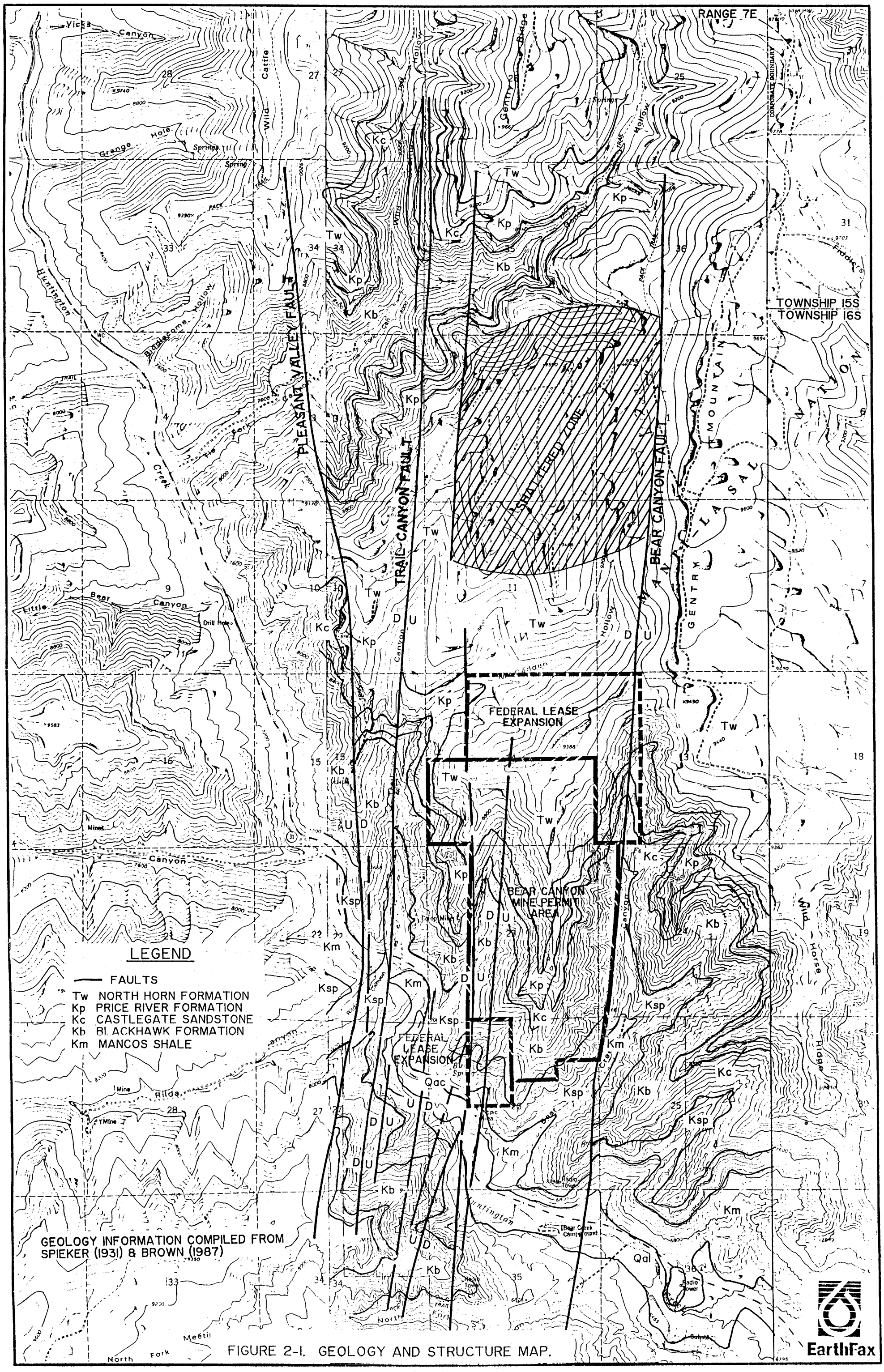


FIGURE 2-1. GEOLOGY AND STRUCTURE MAP.

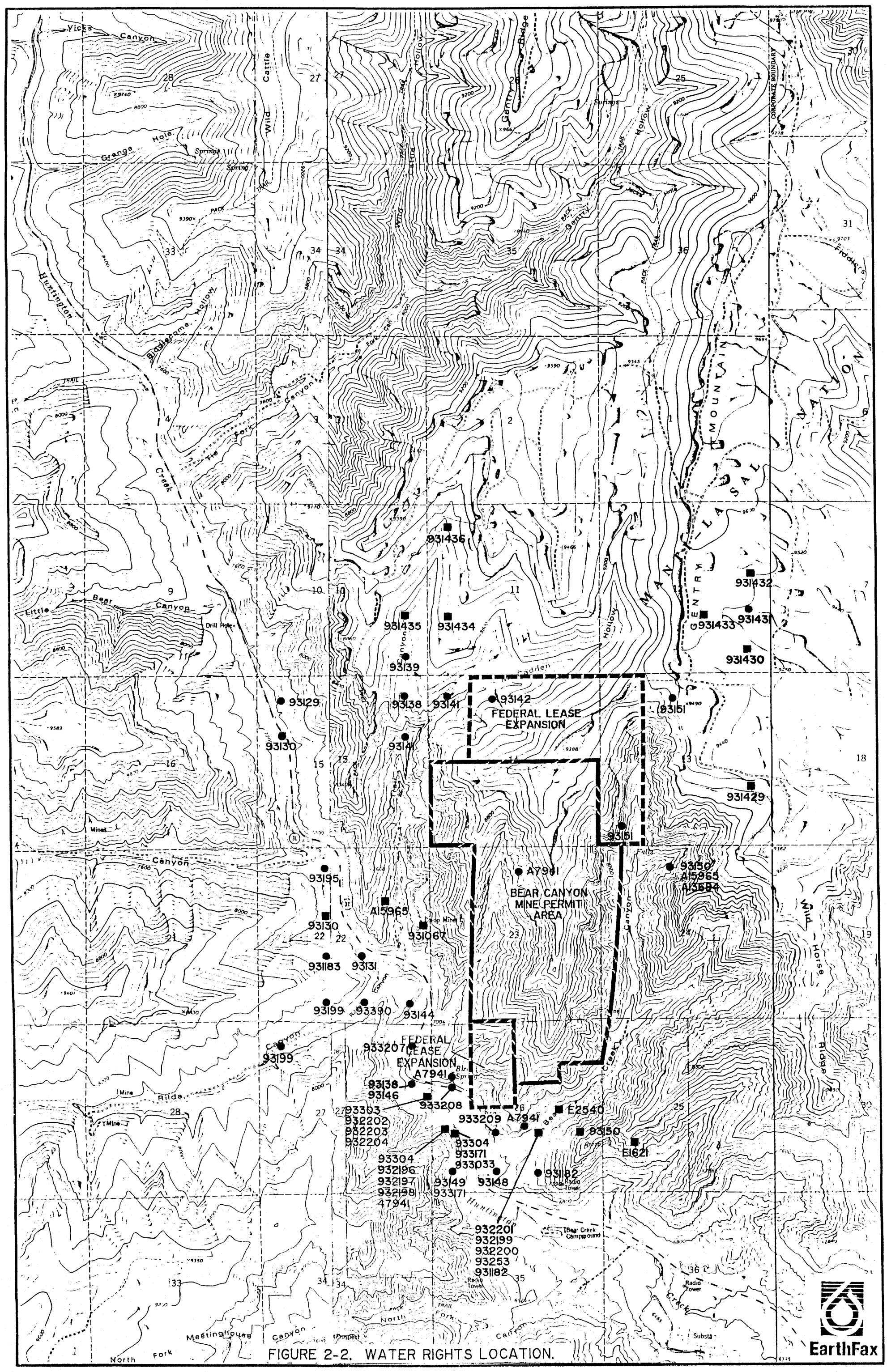


FIGURE 2-2. WATER RIGHTS LOCATION.

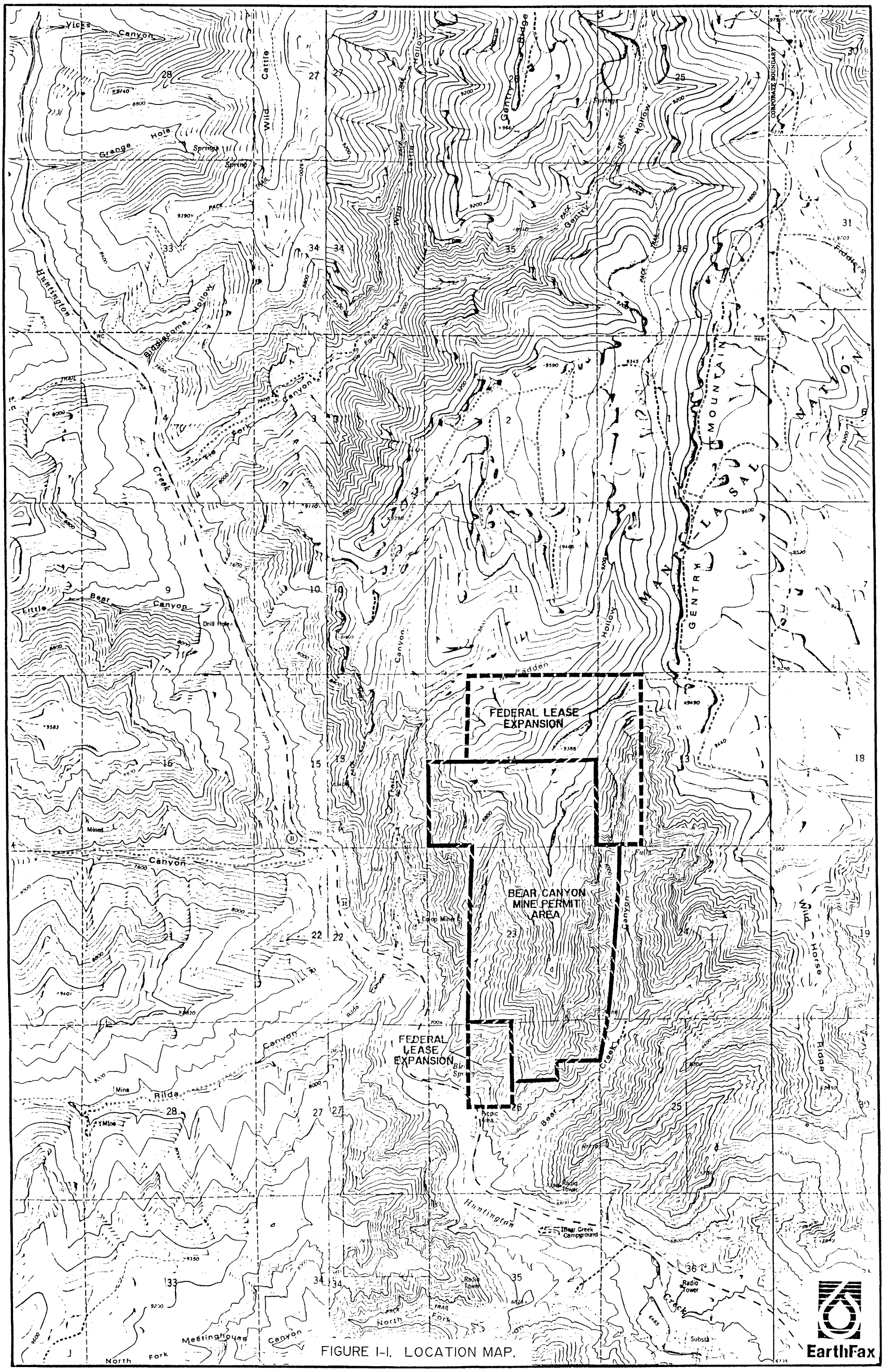


FIGURE I-I. LOCATION MAP.

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# HYDROGEOLOGIC EVALUATION OF THE BEAR CANYON MINE PERMIT AND PROPOSED EXPANSION AREAS

## 1.0 INTRODUCTION

### 1.1 Scope

This report presents an evaluation of the potential impact of the existing Bear Canyon Mine on Birch and Big Bear Springs. It also addresses revisions to the Bear Canyon permit area to allow incorporation of new Federal Coal leases (U-024316 and U-024318).

The scope of work for the spring evaluation included:

1) Conducting a review of the technical literature from the U.S.G.S., the Utah Division of Water Resources, and permits on file with the Utah Division of Oil, Gas, and Mining.

2) Conducting a field trip to the mine site to include: an evaluation of the springs; collection of historical flow data for the springs; tour of the accessible underground workings to allow evaluation of the groundwater inflows; discussions with Wendell Owen regarding the historic groundwater inflows to the mines and operations history of the mines; and a preliminary water quality assessment (pH, temperature, and conductivity) of all accessible water sources.

3) Analysis of monthly precipitation and spring flow data. The evaluation compared the flows of Birch, Big Bear, Tie Fork, and Little Bear Springs.

The report is divided into five sections. This introduction presents a brief description of the location and history of mining operations in the area. Following the introduction, a

description of the hydrogeologic setting of the area is presented. The third section is a description of the data analyses to determine the potential for impact of mining on the springs. Fourth, is the conclusions and recommendations section of the report. Last, the references section is presented. Appendices are presented following the references.

## 1.2 Background Information

The Bear Canyon Mine is located along the eastern margin of the Wasatch Plateau Coal Field in Bear Creek Canyon, which is a tributary to the Huntington Creek Canyon (see Figure 1-1). The mine is located approximately 9.5 miles west of Huntington, Utah. Within the permit area, elevations range from approximately 6,500 to over 9,000 feet.

Mining in the region of the study area has been essentially continuous since the early 1900's. Mining operations have been or are being conducted by U.S. Fuel at Hiawatha, by Plateau Resources at Wattis, and by Co-Op Mining Company in the Trail Canyon and the Bear Creek Canyon. All of these operations have intersected faults which the Big Bear and Birch Springs are associated with. The operations closest to the springs include the Trail Canyon and Bear Canyon Mines, both by the Co-Op Mining Company. The Trail Canyon Mine discontinued operations in late 1982 and has since been sealed. The Bear Canyon Mine commenced operations in 1982 and has been continuous since then.

Fig 1-1

# 2.0 HYDROGEOLOGIC SETTING

## 2.1 Climate

The Bear Canyon Mine permit and adjacent area (the study area) are located on the eastern face of the Wasatch Plateau. The elevation over the study area ranges from approximately 6,500 to over 9,000 feet. This elevation range results in a significant range in average annual precipitation depths. At the higher elevations of the Wasatch Plateau, the average annual precipitation exceeds 40 inches. In the area of Hiawatha, at an elevation of 7,280, the annual precipitation is 12.89 inches. To provide an estimate of the precipitation in the study area, data for five surrounding precipitation recording stations were averaged. The stations used in the average were the NOAA weather stations at Hiawatha and Electric Lake and the SCS SNOWTEL stations at Stuart Ranger Station, Red Pine Ridge, and Cottonwood-Mammoth. The monthly precipitation data for each of the stations, as well as the five-station monthly average are presented in Appendix A.

## 2.2 Geology

Table 2-1 presents the stratigraphic relationships of the geologic units in the study area. The depositional environments of the formations reflects an overall regressive sequence. This is seen in the sequence of marine shale (Mancos Shale) through littoral and lagoonal, interbedded silt/mudstone and sandstone (Blackhawk Formation) to fluvial (Castlegate Sandstone, Price River Formation, and North Horn Formation) and lacustrine (Flagstaff Limestone) deposits. The interbedded nature of the Blackhawk Formation is mainly due to an oscillating depositional environment within the overall regressive trend.

Figure 2-1 presents the location of the surface outcrops of the described formations and geologic structures within the study area. Regionally, the rock strata in the study area dip to the southeast at an angle of two to three degrees (Brown, et.al., 1987). As shown on Figure 2-1, the Bear Canyon and Trail Canyon Mines are located in a graben bounded by the Pleasant Valley Fault on the west and the Bear Canyon Fault on the east. Both faults are

Table 2-1

Stratigraphic relationships, thicknesses, lithologies, and water-bearing characteristics of geologic units in the upper drainages of Huntington and Cottonwood Creeks (adapted from Stokes, 1964)

| System | Series | Formations and members | Thickness (feet) | Lithology and water-bearing characteristics |
|---|---|---|---|---|
| Quaternary | Holocene and Pleistocene | | 0-100 | Alluvium and colluvium; clay, silt, sand, gravel, and boulders; yields water to springs that may cease to flow in late summer. |
| Tertiary | Eocene and Paleocene | Flagstaff Limestone | 10-300 | Light-gray, dense, cherty, lacustrine limestone with some interbedded thin gray and green-gray shale; light-red or pink calcareous siltstone at base in some places; yields water to springs in upland areas. (See table 9.) |
| | Paleocene | North Horn Formation | 800± | Variegated shale and mudstone with interbeds of tan-to-gray sandstone; all of fluvial and lacustrine origin; yields water to springs. (See table 9.) |
| Cretaceous | Upper Cretaceous | Price River Formation | 600-700 | Gray-to-brown, fine-to-coarse, and conglomeratic fluvial sandstone with thin beds of gray shale; yields water to springs locally. |
| | | Castlegate Sandstone | 150-250 | Tan-to-brown fluvial sandstone and conglomerate; forms cliffs in most exposures; yields water to springs locally. |
| | | Blackhawk Formation | 600-700 | Tan-to-gray discontinuous sandstone and gray carbonaceous shales with coal beds; all of marginal marine and paludal origin; locally scour-and-fill deposits of fluvial sandstone within less permeable sediments; yields water to springs and coal mines, mainly where fractured or jointed. |
| | | Star Point Sandstone | 350-450 | Light-gray, white, massive, and thin-bedded sandstone, grading downward from a massive cliff-forming unit at the top to thin interbedded sandstone and shale at the base; all of marginal marine and marine origin; yields water to springs and mines where fractured and jointed. |
| | | Masuk Member Mancos Shale | 600-800 | Dark-gray marine shale with thin, discontinuous layers of gray limestone and sandstone; yields water to springs locally. |

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down-dropped approximately 100-150 feet. Brown, et.al. (1987) described a shattered zone within the graben, approximately two miles to the north of the northern extent of the Bear Canyon Mine. This zone is described as being broken by many faults and fractures. Within the graben, in the permit area, only some minor faulting has been identified.

The major coal-bearing unit within the Wasatch Plateau Coal Field is the Blackhawk Formation. Mining, in the Bear Canyon and Trail Canyon mines, are conducted in two coal seams: the upper Blind Canyon Seam and the lower Hiawatha Seam (Co-Op Mining Company, 1990). Throughout the permit area, the Blind Canyon Seam is continuous, while the Hiawatha seam thins and pinches out. A local warping of the over and underlying strata results in a small dome, within the center of the east half of Section 23, Township 16 South, Range 7 East, which affects the Hiawatha Seam. This warping may have resulted from movement along the west side of the Bear Canyon Fault.

## 2.3 Surface Water

Most of the study area is drained by two main canyons, Trail Canyon to the west and Bear Canyon to the east. Several small canyons drain the remaining southeast portion of Bear Canyon permit area. The Trail Canyon and Bear Canyon drainages hold intermittent streams, while the small drainages from the southeast portion of the permit area contain ephemeral streams. These streams discharge to Huntington Creek, which is the major drainage in the area.

The streams mainly flow during the snowmelt period. According to Danielson, et.al. (1981), about 65 to 80 percent of the annual discharge at the Huntington Creek gaging station, located near Huntington, Utah at the Utah Power and Light diversion for the Deer Creek Power Plant occurs during the snowmelt period, from April through July. Flow records for the period from 1981 through 1983 and 1985 were obtained from Utah Power & Light. The water year 1984-1985 data were not available. The flow records for 1986 through 1988 were obtained from the U.S. Geological Survey, Water Resources Division. These data are presented in Appendix B.

Danielson, et.al. (1981) conducted surface water sampling of flows from selected streams in the study area. The waters sampled at the Huntington Creek gaging station were predominantly a calcium-bicarbonate water type. Waters sampled from the tributaries of Huntington Creek were predominantly a calcium-, magnesium-bicarbonate water type. During periods of low flow, the concentrations of sulfate in the tributaries were significantly higher than in Huntington Creek itself.

## 2.4 Groundwater

The groundwater system in the study area has been studied by Danielson, et.al. (1981), Co-Op Mining Company (1986), and Montgomery (1991). The recharge, movement, and discharge of water within the groundwater system is dependent on climatic and geologic conditions in the study area. Danielson, et. al. (1981) indicate that groundwater occurs in all of the geologic units listed in Table 2-1, however, none of the units are saturated everywhere.

### 2.4.1 Occurrence of Groundwater

The formations in the study area have been identified as having a combination of perched and regional water tables. Perched water tables occur where water is held up by a perching bed whose permeability is so low that water cannot readily percolate downward. In most of the study area, perched zones exist in the North Horn, Price River, Castlegate Sandstone and upper Blackhawk Formations. Danielson, et. al. (1981) indicate that a regional water table exists in the Star Point Sandstone and, in places, the lower portion of the Blackhawk Formation. This aquifer is referred to as the Star Point-Blackhawk aquifer.

A total of 16 boreholes have been drilled in the area of the Bear Canyon Mine. Co-Op Mining Company drilled twelve of the boreholes within the permit area for the purpose of evaluating coal quality and geologic conditions and four holes were drilled approximately 1.5 miles north of the present permit area for the purpose of coal exploration, by Nevada Power and Light. The deepest Co-Op borehole, located adjacent to the mine portal, was drilled to the top of the Mancos Shale. No groundwater was encountered in this hole (Co-Op Mining

Company, 1990). The remaining 11 holes, drilled by Co-Op, within and adjacent to the permit area penetrated various units below the coal seams and also did not encounter any water during the drilling activities (Co-Op Mining Company, 1990). This indicates that the Trail Canyon and Bear Canyon Mines are located above the regional water table.

The coal exploration holes, by Nevada Power and Light, to the north of the existing permit area were drilled to the top of the Star Point Sandstone (Co-Op Mining Company, 1990). These holes are thought to have encounter water during the drilling activities. However, the logs do not indicate whether the fluid level reported is a static water level or the level of drilling fluid in the hole at the time of logging. No information is available regarding how the holes were drilled, how long after drilling before holes were logged, or other information to determine the suitability of these holes for use as piezometers or the data as being representative of the actual groundwater surface. The holes were abandoned immediately following the geophysical logging activities and are not available for additional monitoring.

To assist in understanding the potential impacts of the mining operations on the surrounding water resources, a search of the Utah State Water Rights records was conducted. The computer records were scanned for all water rights, surface and groundwater, which occurred in the area of Sections 10 through 15 and 22 through 27 of Township 16 South, Range 7 East. This provides a search of an area between one half and one mile beyond the permit boundary. The water rights which were identified are located on Figure 2-2 and presented in Appendix C.

Within the permit and proposed expansion areas three surface water rights are identified. No springs with water rights were identified above the coal seams within the permit or proposed expansion areas. In the adjacent area, 30 surface water rights and 29 groundwater rights were identified. Fifteen of the groundwater rights were associated with the flow from Big Bear and Birch Springs. The remaining rights were associated with either the mines or small stockwatering springs to the north of the permit area.

### 2.4.2 Recharge

Snow at the higher elevations provides the greatest source of groundwater recharge. Danielson, et.al. (1981) showed by radio-isotope sampling that most, if not all, groundwater is derived from snow. The percentage of water derived from snow which recharges the groundwater system versus that which runs off to stream flow is controlled by the surface relief, permeability of overlying strata, depth of the snowpack, and the rate of snowmelt. The highest recharge occurs in areas of low surface relief and on formations which have high permeability from fractures and/or solution openings.

In the study area, the criteria which encourage recharge from snowmelt are typical of the areas of exposed North Horn and upper Price River Formations. The main recharge area to the groundwater system in the area of the Bear Canyon Mine is expected to be the shattered zone identified by Brown, et. al. (1987) in Section 1, 2, and the north half of 11, in Township 16 South, Range 7 East (see Figure 2-1). An additional area of recharge could also be expected in the southern half of Section 11 and the northern half of Section 14, due to the surface exposure of North Horn Formation (see Figure 2-1). However, this area is not as fractured as the area to the north.

Most of the exposed outcrops within the permit area are Price River, Castlegate Sandstone, Blackhawk, and Star Point Formations. Danielson, et. al. (1981) indicated that recharge to the Star Point-Blackhawk aquifer from direct infiltration of snowmelt on areas of the formations which outcrop below the North Horn Formation is small in comparison to recharge through the low relief surfaces of the North Horn Formation. In the study area, the exposure of formations below the North Horn Formation and above the coal outcrops is limited due to the steep canyons. Therefore, the potential for recharge through these formations to the regional groundwater system within the permit area is limited.

This limited recharge is reflected in the number of springs and seeps which occur within the permit area. Co-Op Mining Company has conducted spring and seep surveys of the permit and adjacent area and has identified three springs and two seeps which occur

above the coal seam. These water sources are located in the northern part of the permit and adjacent area. As shown on the water rights map, Figure 2-2, no groundwater rights are found on the ridge overlying the Bear Canyon Mine. The only groundwater sources identified in the southern portion of the permit and adjacent area are the Big Bear and Birch Springs. These springs are located below the mine and coal seam elevation. The limited number of springs which occur from the area overlying the mine area indicate that only limited recharge occurs in the Bear Canyon permit area.

### 2.4.3 Movement

The movement of groundwater in the study area is strongly controlled by the geologic structure, such as faulting and the dip of bedding in the strata. Most of the water movement in the study area is through fractures, faults, and openings between the beds (Danielson, et. al., 1981). According to Danielson, et.al. (1981), a portion of the snowmelt recharge water is discharged close to the original recharge source, where the downward movement of water is impeded by impermeable beds of shale or mudstone. If lateral movement occurs close to the canyon edge, this movement continues until the land surface is encountered and discharge occurs as a perched spring. If the movement occurs on the interior of the mountain, the lateral movement continues until other vertically permeable lithologies or zones of fracturing are encountered that allow further vertical flow.

In areas of fracturing, due to increased rock permeability, water is able to pass vertically through strata which would normally impede such flows. Depending on the degree of interconnection in the fractures, the groundwater flow can be limited to a small area or it can reach the regional water table (see Figure 2-3). Lines (1985) indicated that for the hydrogeologically similar area of Trail Mountain, located to the south of the study area, even with the large quantity of rock with negligible permeability, some hydraulic connection exists between the perched aquifers and the regional aquifer. Most of the exchange of water occurs as downward unsaturated flow from perching beds to the regional aquifer along the fractures and faults.

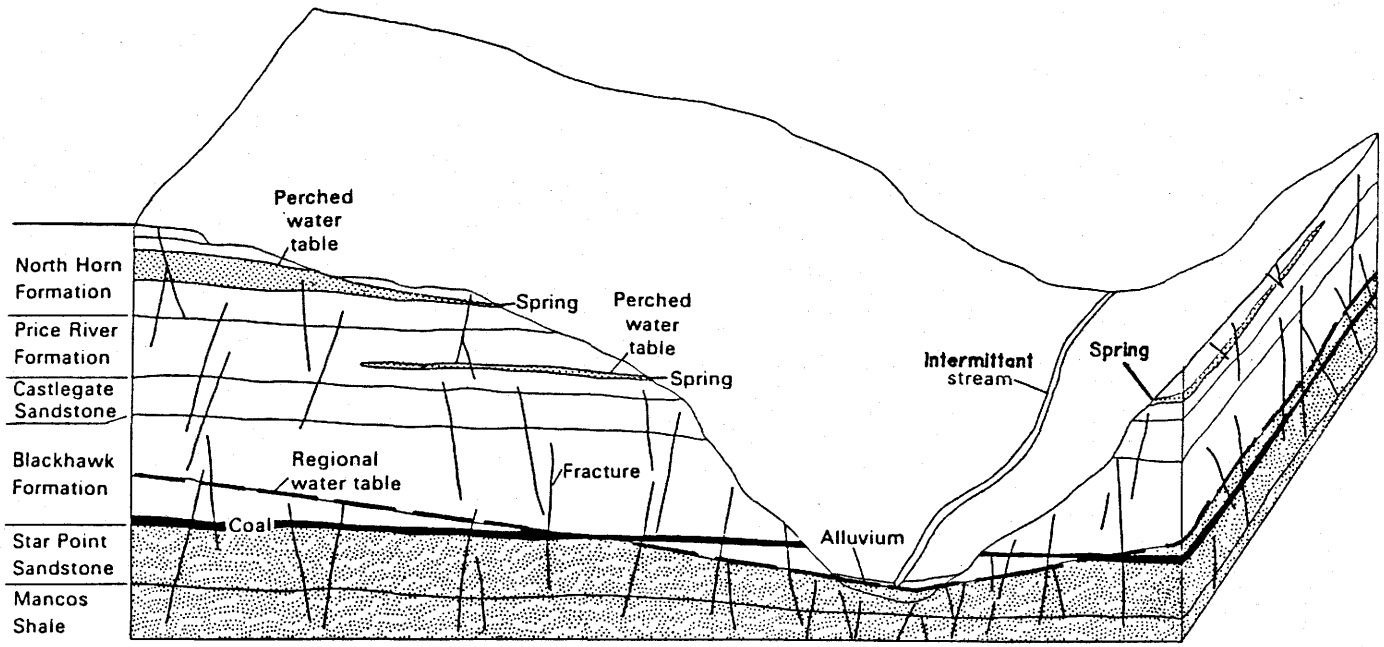


FIGURE 2-3. GENERALIZED BLOCK DIAGRAM SHOWING OCCURRENCE OF GROUND WATER.

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### 2.4.4 Discharge

Groundwater naturally discharges through springs, seeps, and by evapotranspiration. Some discharge from the groundwater system in the mine area may occur either by flow in the faults and fractures out of the Huntington Creek drainage or as subsurface flow to the alluvial fills of the canyons. These flows can not be quantified. The major source of water discharge which can be quantified is from springs. Within the area of the mine, two major springs have been identified, the Big Bear Spring and the Birch Spring. In the adjacent area, outside the effect of the Bear Canyon Mine, two additional springs are identified. These are Tie Fork and Little Bear Springs.

Big Bear Spring, maintained by the Castle Valley Special Services District, discharges from three prominent joints. Birch Spring, maintained by the North Emery Water Users Association, discharges from a normal fault having approximately 20 feet of displacement. Both springs occur in the lower sandstone unit of the Star Point Sandstone, where the Mancos Shale serves as a barrier to downward movement of groundwater (Montgomery, 1991). Tie Fork is really not a spring, but two flowing geophysical boreholes which have been developed by Castle Valley Special Services District. Little Bear Spring is a spring from faults which is also maintained by Castle Valley Special Services District. Flow records for these springs have been collected from the water companies and are presented in Appendix D. Big Bear Spring has a 9 year period of record, from 1981 to present. Birch Spring has only a 2 year period of record, from 1989 to present. Tie Fork has a 6 year period of record, 1984 to the present. Little Bear Spring has a 8 year period of record, 1982 to the present.

# 3.0 DATA ANALYSIS

This section presents a discussion of the data analysis and field work conducted for this study. First, a discussion of the field investigation is presented. This is followed by a comparison of the spring flows, monthly precipitation, and stream flows. Third, an evaluation of the potentiometric surface for the study area is discussed. Last, a discussion of the comments made by North Emery and Castle Valley is presented.

## 3.1 Field Investigation

On February 18 and 19, 1991, a field investigation was conducted to:

- evaluate the geology and water inflows to the Bear Canyon Mine;
- evaluate the geology and water flow of Big Bear and Birch Springs and the surrounding areas;
- obtain spring flow records for Big Bear and Birch Springs and surrounding springs; and
- obtain descriptions of spring development from the water companies.

### 3.1.1 Bear Canyon Mine

According to Wendell Owen, the Bear Canyon Mine had an initial mine water inflow in the old abandoned workings prior to the start of operations by Co-Op Mining Company. During the development of the East Bleeders, water was encountered in two small step faults to the Bear Canyon Fault. This flow was essentially the same volume as flowed to the abandoned workings. Within a short period of this interception, the inflow to the abandoned workings dried up.

The East Bleeder inflow remained constant until the summer of 1989, when water was encountered at the northern end of the North Main entries. According to Wendell Owen, the mine intercepted a flow of about 110 gpm. This flow occurred mainly from fractures and roof

bolt holes in the roof and has essentially remained constant since it was first encountered. The coordination of inflows being intercepted and stopping between these three areas indicates a high degree of hydraulic connection between these areas. It also indicates that this fracture system directs flows, within either the coal seam or the overlying strata, to the southeast along the dip of the beds.

The underground tour and survey indicated a limited number of continuous flow sources. The major water source in the mine was located at the north end of the North Main entries. The North Main entries in the area of the inflow are acting as a sump for this water. The water is being pumped to the East Bleeder sumps where some of the water is used for in-mine use. The remainder of the water is pumped to the surface and used for culinary supplies or discharged to Bear Creek.

The remaining water inflows to the mine are small inflows from diffuse sources. Only one small roof dripper was found during the underground tour with sufficient flow (0.1 gallon per minute) to be sampled. The results of the pH, temperature, and conductivity readings taken are presented in Table 3-1. Most other inflows occurred as isolated dripping over a wide area. Wendell Owen indicated that several of the areas surveyed had previously been much wetter; however, only limited water inflows were found during the survey.

This condition, of mine inflows drying up in short periods, is similar to the inflow patterns found in other mines (i.e., Deer Creek, Plateau, and others) in the Wasatch Plateau Danielson, et.al., 1981). In areas which do not intersect faults upon initial mining, a moderate water inflow occurs from diffuse sources, mainly from roof bolts. These sources are generally limited in flow rate to less than one to two gallons per minute. After a short period, generally one to two months, the rate of inflow decreases and eventually dries up.

This is caused by the draining of the localized areas of more permeable strata. Typically, the roof bolt intersects and provides a drain for a localized perched aquifer, often consisting of a sandstone lense, which stores a limited amount of water. Once the stored

**TABLE 3-1**

**Field Parameter Results**

| Sample I.D. | pH (Units) | Temperature (°C) | Conductivity (μmhos/cm) |
|---|---|---|---|
| Big Bear Spring Overflow | 6.9 | 10.9 | 460 |
| Seepage Above Big Bear Spring | 8.1 | 12.4 | 2000 |
| Roof dripper in 3rd West Entries | 7.7 | 14.2 | 510 |

water is drained, the recharge to the perched zone is not sufficient to maintain the previous flow and the inflow drys up or is reduced.

### 3.1.2 Springs

Big Bear and Birch Springs were visited during the site survey to evaluate the geology of the spring locations and to collect a sample of discharge water, if available. No surface flow was occurring at the Birch Spring and the collection system was locked. At Big Bear Spring, a sample was taken from the spring overflow from the northern most joint. The flow from the overflow was less than 1 gallon per minute.

A second sample was taken of seepage flow which occurs from the slope above the Big Bear Spring. The seepage originates from the cliffs at the contact between the Star Point Sandstone and Blackhawk Formation. The flow occurs in two areas approximately 100 yards apart. The seepage in each area appears to be occurring along the bedding planes of the formation contact. Seepage in each area occurs along approximately 100 to 150 feet of the outcrop. The flow is difficult to quantify at this point, but it is concentrated at several bedrock ledges. The combined flow was estimated to be approximately 10 gallons per minute. The eastern-most seep occurs at a location that is in shade most of the day at the base of the cliffs. Considerable accumulations of ice where found at this seep, due to the discharge continually freezing. This may have been the flow and ice accumulations which were observed by Montgomery (1991). The pH, temperature, and conductivity values for these samples are presented in Table 3-1.

As indicated in Table 3-1, the water made within the mine is similar in conductivity to the water found in the Big Bear Spring. The flow from the cliff seepage above the spring is considerably different, with a conductivity approximately four times that which occurs in the other samples. Due to the quality differences of the inflow to the mine and seepage from the cliff face, these two sources do not appear to be the same water.

## 3.2 Spring Flow Analysis

The monthly flows from the Big Bear, Birch, Little Bear, and Tie Fork springs were analyzed. Little Bear and Tie Fork springs were included in the analysis be cause of their period of record and their proximity to the area. The spring flows were compared to five-station average monthly precipitation (see Appendix A) and stream flow for Huntington Creek gauging station above the Deer Creek Diversion (see Appendix B) plotted against time. These three plots were superimposed on a single graph to allow a direct comparison. For readability, the graph durations were limited to one year per sheet for each spring analyzed. An example graph is presented in Figure 3-1. All graphs are presented in Appendix E.

### 3.2.1 Little Bear Spring

Flows from Little Bear Spring for the period of 1982 through 1985 show that spring flows peak one month behind the stream flow in Huntington Creek. In 1986 the peaks occur in the same month, possibly indicating an early snowmelt. In 1987, the peak from Little Bear Spring was delayed by two months.

In the period from 1988 through 1990, no significant spring peak flow is identified. There is a gradual rise in the spring flow in the fall of 1988 and a gradual decline in early 1989. This is not characteristic of the prior flow of the spring.

### 3.2.2 Tie Fork Wells

The flows from Tie Fork wells show no seasonal variation, except for a period starting in July through November of 1988. By December, the flow had returned to approximately the previous level and flows through 1989 and 1990 have been essentially constant. This flow fluctuation corresponds, time wise, to the flow increase in the Little Bear Spring, though the fluctuation of Little Bear was over a longer period.

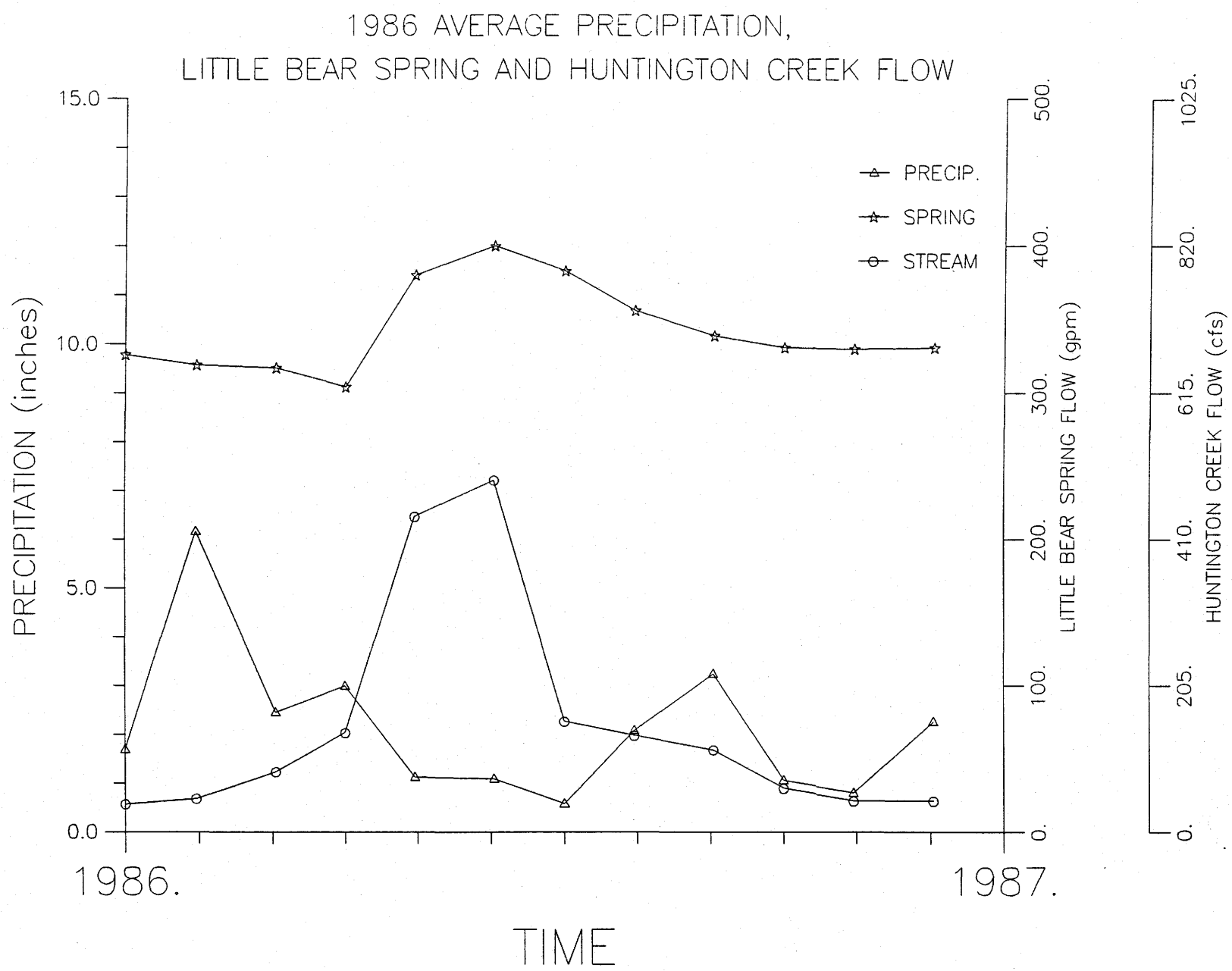


FIGURE 3-I. SAMPLE SPRING FLOW GRAPH.

### 3.2.3 Big Bear Spring

The plots show that the spring flow during the period of 1980 through 1986 peaks about one month later than the stream peak flow at the Huntington gauging station above the Deer Creek Mine access road. In the 1987-1988 water year, the lag period between peaks in the stream and spring discharge is approximately two months. This increase in lag time is due to a combination of lower precipitation accumulations (28.4 inches average annual precipitation 1980-1986 versus 19.75 inches 1987-1990, see Appendix A) and shorter melt period.

Comparison of the flow recessions for the spring for the years of 1980 through 1986 show very similar patterns. The slope line of the spring flow decline and the base flow level for the spring are generally the same from year to year. This indicates that the snowmelt recharge is greater than the volume required to recharge the groundwater system storage and the excess water is being discharged from the system at the spring. It also indicates that no outside influences (i.e., mining) are affecting or changing the groundwater system.

For the period from 1988 to 1990, no snowmelt peak could be identified for the spring flow. Also, a comparison of spring flow from years 1987 through 1990 indicates a general decline in flow. This is also felt to be due to the lower precipitation which occurred during this period. The snowmelt recharge is not sufficient to either:

- o completely fill the depleted storage in the system, as in the periods where subsequent years base flow is lower than the previous year, or
- o the system storage is filled by the recharge, but there is no excess water to provide a spring flush.

Under the first condition, the groundwater system is being drained and a new base flow condition will eventually be established provided precipitation inputs are stabilized. Once the groundwater system stabilizes, the second condition will operate until the precipitation

increases to fill the excess storage capacity in the groundwater system. It appears that the first condition is what occurred at the Big Bear Spring during the period of 1987 to 1990.

During the period of 1984 through 1989, the Bear Canyon Mine intercepted inflows at the abandoned workings, the East Bleeders, and the North Main entries. No significant flow reductions at the Big Bear Spring were reported for this period. Therefore, the water intercepted within the mine did not contribute to the Big Bear Spring flow.

### 3.2.4 Birch Spring

Birch Spring has a very limited period of record. The published stream flow data for Huntington Creek do not include the period of record for Birch Spring; therefore no comparison to stream flow can be made.

The flows from Birch Spring show some seasonal fluctuation; however, two years of data do not provide sufficient information to identify the general flow characteristics. The data in Appendix E indicate that the flow of the spring gradually diminished in 1990, a situation that was noted in verbal communication by North Emery Water User Association.

The declining flow at Birch Spring is considered a result of the reduced precipitation which the area has experienced in the last four to five years. The Big Bear and Little Bear Springs, which are located in the local area, are also experiencing similar flow reductions. As discussed for Big Bear Spring, when the recharge to the groundwater system is reduced below the amount required to fill the storage volume depleted by the prior years base flow discharge, the discharge from the system at the various discharge locations is adjusted to balance the change in storage of the system.

## 3.3 Potentiometric Surface

An attempt was made to develop a potentiometric surface for the mine area, however insufficient data were available to allow development of the surface. The data reviewed

included the geophysical boreholes by Savage Energy Services for Nevada Power and Light, boreholes drilled by Co-Op Mining Company described in Section 2.4.1 of this report, and Birch and Big Bear spring occurrence elevations.

The geophysical hole data were discounted as not being representative. As indicated in Section 2.4.1, it is unknown if the fluid levels reported by Savage Energy Services for the geophysical holes were water levels or drilling fluid levels. Additionally, no other information regarding the drilling of the holes was available.

A question of extrapolating the surface through the mine area and across McCadden Hollow without any verification was also raised. The distance between the boreholes and the springs is over two and a half miles. This distance is too great to extend a water surface across a major drainage structure without intervening data. The only data that are currently available in this area are the data from the dry monitoring well at the mine portal and the dry geologic holes drilled within the permit area. The monitoring well is located on the other side of the Bear Canyon Fault from the existing mine workings, and therefore is not considered representative of groundwater information beneath the mine.

Based on these concerns it was determined that no currently available data should be used to develop a potentiometric surface.

## 3.4 Water Company Comments

Comments were submitted to the Division regarding the Co-Op Mining company permit application. These comments addressed:

- The groundwater monitoring program and water quality impacts;
- A complete water rights survey;
- Probable Hydrologic Consequences and potential flow impacts; and
- Water supply fluctuations.

### 3.4.1 Water Monitoring and Water Quality Impacts

Both Big Bear and Birch Springs are included in the monitoring program. The program, described in section 7.1.7 of the MRP, indicates that both springs will be sampled quarterly. The Big Bear spring sample can be taken from the spring overflow. No easy sampling point is available for the Birch Spring. Therefore, samples are currently taken only when surface flow occurs. Co-Op should consider a sampling arrangement with North Emery Water Users Association to allow access to a sampling port.

The potential water-quality impacts resulting from an underground coal mine are elevated concentrations of inorganic constituents and acid-mine drainage. However, no such impacts have been documented in the mine water discharge from the Co-Op mines (Co-Op Mining Company, 1990).

### 3.4.2 Water Rights

A complete search of the Utah Division of Water Rights records for the area within one-half mile of the existing and proposed permit area of the Co-Op Mining operations was conducted. The data are presented in Appendix C.

### 3.4.3 Probable Hydrologic Consequences

The information collected and reviewed for this study, supports the Co-Op PHC and DOGM CHIA descriptions regarding the occurrence of springs and seeps in the groundwater system of the permit area. As described in section 2.4.1, the mining operations are being conducted above the regional water table, which is the source for water to the water supply springs. The potential for recharge within the permit area and proposed expansion areas is relatively low compared to the recharge potential to the north of these areas. Therefore, it is felt that minimal impact to the flow to the springs has occurred as a result of the mining operations. Even though the exact nature of the potentiometric surface is not known, it is assumed that its elevation does rise to the north from approximately the elevation of Birch and

Big Bear Springs. Thus, an impact may occur to the north; however, it is not possible to predict where or if it will occur.

Where the mining operations on both sides of the faults associated with the springs occur above the regional water table, the potential to affect the spring flow is rather minimal. As indicated in section 2.4, for a contribution to be of long term importance to the water supply, it needs to have an extensive and continuous water source. To date, no such inflow has been identified in the mine, except for the flows which occurred over time in the abandoned mine workings, the East Bleeders, and the North Mains. If such a source were present, in the area above the mine workings, it would be expected that springs and seeps would be exhibited in the area. As indicated in Section 2.4.1, no springs are found above the coal seams in the southern area of the permit area. ?

Some very minor impact could occur as a result of dewatering of small isolated sandstone lenses which could contribute small flows, like what is intercepted from roof bolting (1-2 gpm). However, these areas do not have sufficient long term recharge capacity to be of significant concern for a water supply. ?

what about 110 gpm from North Mains?

### 3.4.4 Spring Flow Fluctuations

The Birch Spring flow increased by almost 300 percent for a three month period and a reduction in water quality in the fall of 1989 (North Emery Water Users Association, 1991). The reason for this fluctuation is unknown. This is shortly after the Bear Canyon mine intercepted an inflow of about 110 gpm in the North Mains, though the response of the spring if this were a mine related impact would be a reduction in flow rather than an increase. Montgomery (1991) attributed this flow rise to a release of collected water in the abandoned Trail Canyon Mine. This is highly unlikely as both the Trail Canyon and Bear Canyon Mines are above the regional water table, as discussed in Section 2.4.1. Additionally, a sustained discharge of 230 gallons per minute for 90 days would result in a cumulative flow volume of approximately 30 million gallons (92 ac-ft) of water. This would require a significant storage volume. Assuming that four entries each 12 foot wide and 8 foot high were filled with water,



Not necessarily. create a hydraulic gradient forcing water into the fault hence > flow @ the spring

they would need to be 2 miles long to be able to store the required volume of water to sustain this flow during a low flow period of the year. Given the contention that the area is extensively faulted and the faults and fractures are interconnected, the possibility of storing this volume of water as a perched water table above a large extent of the mine, without discharge occurring in other locations, is very unlikely.

An alternative source of the surge in flow could be the opening or connection of saturated fractures which previously did not convey water to Birch Spring. These fractures could have contained a significant volume of water which had built up over a long period of time. As these fractures drained, the flow contributed to the Birch Spring was sufficient to raise the water level in the fractures to a level which previously had not conveyed water. This would result in a flush of sediment and dissolved constituents, as reported by North Emery Water User Association, which had accumulated over time. Once the excess water in the fractures had drained the flow in the spring and the water quality returned to normal levels.

# 4.0 CONCLUSIONS AND RECOMMENDATIONS

## 4.1 Conclusions

Based on this study the following conclusions are made:

- The groundwater system in the area of the Trail Canyon and Bear Canyon mines in mainly controlled by geologic structures (faults and fractures) and lithology.

- In the area of present development, the regional water table is located below both the Blind Canyon and Hiawatha seams in both the Trail Canyon and Bear Canyon mines as indicated by downhole drilling. ?

- Water intercepted within the mine workings of the Bear Canyon mine have not had any identifiable impact on the spring flows of Big Bear or Birch Springs.

- No evidence is available to show a mine-related impact on the spring flows of the Big Bear or Birch Springs. The recent reduction in spring flows appear to be caused by the significant reduction of precipitation over the last four to five years.

- Insufficient data are available to determine if further development of the mine to the north will impact the regional water table.

## 4.2 Recommendations

The following recommendations are presented to assist in addressing some of the concerns of the water companies and the Utah Division of Oil, Gas, and Mining:

- Co-Op should arrange with the water companies to allow coordinated monitoring of the springs for flow and water quality. This will ensure an acceptable data base for future investigation of potential impacts to the spring flows.

- Co-Op should install a minimum of four monitoring wells within the Bear Canyon Mine to allow determination of a defendable potentiometric surface of the regional water surface within the present permit area. This information can then be projected into the new lease area.

  - The wells should be located in areas which will have long term access for the life of the mine.

  - Construction of the monitoring wells should include a 2-inch PVC casing and slotted screen in a 4-inch borehole, with a sand pack and bentonite seal. This will allow the wells to be sampled and hydraulically tested. The wells should be completed with a flush grade cap, be located close to the coal rib within the entry, and the location should be indicated with paint on the rib adjacent to the well or a marker hung from the roof.

  - Figure 4-1 presents proposed locations for monitoring wells which may be considered.

  - Wells will need to be permitted with the Utah Division of Water Resources and the Utah Division of Oil, Gas, and Mining.

- Co-Op Mining Company should revise the PHC associated with the mining operation based on the data collected from the new monitoring wells.

## 5.0 REFERENCES

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# Appendix A
# Precipitation Data

# TABLE A-1

## MONTHLY PRECIPITATION DATA SUMMARY

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1980 | March | 3.34 | 1.88 | 2.31 | 5.42 | 3.20 | 3.23 |
| 1980 | April | 1.27 | 0.76 | 3.15 | 3.26 | 2.10 | 2.11 |
| 1980 | May | 3.09 | 2.78 | 2.72 | 3.15 | 4.00 | 3.15 |
| 1980 | June | 0.12 | 0 | 0.52 | 0 | 0.10 | 0.15 |
| 1980 | July | 0.37 | 0.30 | 0 | 0 | 0.30 | 0.19 |
| 1980 | August | 0.38 | 0.82 | 0 | 0 | 0.70 | 0.38 |
| 1980 | September | 1.80 | 2.53 | 3.35 | 3.40 | 2.30 | 2.68 |
| 1980 | October | 1.45 | 2.07 | 0 | 0 | 2.10 | 1.12 |
| 1980 | November | 0.98 | 0.36 | 0 | 0 | 1.70 | 0.61 |
| 1980 | December | 0.32 | 0 | 2.35 | 4.45 | 0.30 | 1.48 |
| | TOTAL | 13.12 | 18.68 | 25.39 | 34.21 | 28.90 | 24.06 |

# TABLE A-1

## MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1981 | January | 1.30 | 0.29 | 0.25 | 0.72 | 1.00 | 0.71 |
| 1981 | February | 1.04 | 0.30 | 1.45 | 3.54 | 2.10 | 1.67 |
| 1981 | March | 3.20 | 2.82 | 3.15 | 4.90 | 3.50 | 3.51 |
| 1981 | April | 1.45 | 0.84 | 1.84 | 3.45 | 1.20 | 1.76 |
| 1981 | May | 3.06 | 2.40 | 3.04 | 3.80 | 3.70 | 3.20 |
| 1981 | June | 0.39 | 0.20 | 0 | 1.27 | 1.00 | 0.57 |
| 1981 | July | 1.61 | 1.49 | 0 | 0 | 0 | 0.62 |
| 1981 | August | 2.73 | 2.64 | 0 | 0 | 1.90 | 1.45 |
| 1981 | September | 1.44 | 2.29 | 6.81 | 5.65 | 2.80 | 3.80 |
| 1981 | October | 4.18 | 3.71 | 0 | 0 | 0 | 1.58 |
| 1981 | November | 1.44 | 0.43 | 0 | 0 | 0 | 0.37 |
| 1981 | December | 4.79 | 1.21 | 0 | 17.10 | 9.40 | 6.50 |
| | TOTAL | 26.63 | 18.62 | 16.54 | 40.43 | 26.60 | 25.76 |

TABLE A-1

MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1982 | January | 5.26 | 3.08 | 11.82 | 4.32 | 4.80 | 5.86 |
| 1982 | February | 1.66 | 0.36 | 1.36 | 3.34 | 2.30 | 1.80 |
| 1982 | March | 5.06 | 1.56 | 3.48 | 4.91 | 4.20 | 3.84 |
| 1982 | April | 1.11 | 1.11 | 0.45 | 1.52 | 2.50 | 1.34 |
| 1982 | May | 1.40 | 1.40 | 1.07 | 1.63 | 1.80 | 1.46 |
| 1982 | June | 0.59 | 0.59 | 0.26 | 0.81 | 1.00 | 0.65 |
| 1982 | July | 1.26 | 1.26 | 0 | 0 | 0 | 0.50 |
| 1982 | August | 2.29 | 2.29 | 0 | 0 | 0 | 0.92 |
| 1982 | September | 4.49 | 4.49 | 8.40 | 9.80 | 9.40 | 7.32 |
| 1982 | October | 1.88 | 1.88 | 0 | 0 | 0 | 0.75 |
| 1982 | November | 3.68 | 3.68 | 0 | 0 | 0 | 1.47 |
| 1982 | December | 2.76 | 2.76 | 5.58 | 12.1 | 10.50 | 6.74 |
| | TOTAL | 31.44 | 24.46 | 32.42 | 38.43 | 36.50 | 32.65 |

TABLE A-1

MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1983 | January | 2.41 | 0.96 | 1.12 | 2.30 | 1.80 | 1.72 |
| 1983 | February | 4.00 | 1.23 | 2.29 | 3.60 | 4.60 | 3.14 |
| 1983 | March | 4.30 | 2.04 | 4.94 | 6.18 | 4.30 | 4.35 |
| 1983 | April | 2.35 | 1.66 | 1.59 | 2.58 | 2.80 | 2.20 |
| 1983 | May | 2.81 | 1.04 | 2.50 | 2.70 | 3.60 | 2.53 |
| 1983 | June | 1.35 | 1.25 | 0 | 0.18 | 1.80 | 0.92 |
| 1983 | July | 1.34 | 2.74 | 0 | 0 | 0 | 0.82 |
| 1983 | August | 1.5 | 1.67 | 0 | 0 | 0 | 0.63 |
| 1983 | September | 2.88 | 2.15 | 7.26 | 7.02 | 8.10 | 5.48 |
| 1983 | October | 2.15 | 1.57 | 0 | 0 | 0 | 0.74 |
| 1983 | November | 4.81 | 2.98 | 0 | 0 | 5.00 | 2.56 |
| 1983 | December | 7.43 | 2.55 | 14.23 | 21 | 7.10 | 10.46 |
| | TOTAL | 37.33 | 21.84 | 33.93 | 45.56 | 39.10 | 35.55 |

# TABLE A-1

## MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1984 | January | 1.27 | 0.22 | 0.40 | 0.80 | 0.90 | 0.72 |
| 1984 | February | 1.56 | 0.50 | 2.60 | 0.93 | 1.80 | 1.48 |
| 1984 | March | 2.77 | 0.69 | 1.06 | 2.73 | 2.70 | 1.99 |
| 1984 | April | 3.23 | 1.37 | 2.81 | 5.00 | 3.50 | 3.18 |
| 1984 | May | 1.73 | 0.66 | 2.37 | 3.38 | 1.30 | 1.89 |
| 1984 | June | 3.41 | 1.50 | 4.53 | 4.50 | 4.50 | 3.69 |
| 1984 | July | 2.55 | 2.56 | 0 | 0 | 2.40 | 1.50 |
| 1984 | August | 2.26 | 3.27 | 0 | 0 | 1.50 | 1.41 |
| 1984 | September | 1.47 | 0.76 | 6 | 5.90 | 2.70 | 3.37 |
| 1984 | October | 2.92 | 3.80 | 0 | 5.51 | 0 | 2.45 |
| 1984 | November | 2.63 | 0.79 | 0 | 0 | 5.40 | 1.76 |
| 1984 | December | 3.24 | 1.70 | 9.12 | 9.45 | 2.60 | 5.22 |
| | TOTAL | 29.04 | 17.82 | 28.89 | 38.20 | 29.30 | 28.65 |

TABLE A-1

MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1985 | January | 1.54 | 0.41 | 0.63 | 1.15 | 2.10 | 1.17 |
| 1985 | February | 1.09 | 0.55 | 1.54 | 2.67 | 1.90 | 1.55 |
| 1985 | March | 3.54 | 1.13 | 2.60 | 4.16 | 2.40 | 2.77 |
| 1985 | April | 1.95 | 1.59 | 2.56 | 3.40 | 2.70 | 2.44 |
| 1985 | May | 1.19 | 2.18 | 1.51 | 3.16 | 1.90 | 2.00 |
| 1985 | June | 0.89 | 0.68 | 1.04 | 1.59 | 1.60 | 1.16 |
| 1985 | July | 3.04 | 4.02 | 0 | 4.11 | 3.00 | 2.83 |
| 1985 | August | 0.03 | 0 | 0 | 0 | 0.50 | 0.11 |
| 1985 | September | 2.24 | 2.79 | 5.70 | 2.74 | 2.40 | 3.17 |
| 1985 | October | 0 | 1.28 | 0 | 5.51 | 2.70 | 1.90 |
| 1985 | November | 6.62 | 2.05 | 0 | 0 | 6.30 | 2.99 |
| 1985 | December | 1.99 | 0.30 | 7.64 | 11.74 | 2.30 | 4.79 |
| | TOTAL | 24.12 | 16.98 | 23.22 | 40.23 | 29.80 | 26.87 |

TABLE A-1

MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1986 | January | 1.81 | 0.13 | 2.02 | 3.10 | 1.40 | 1.69 |
| 1986 | February | 8.54 | 2.39 | 7.43 | 5.86 | 6.60 | 6.16 |
| 1986 | March | 2.48 | 1.36 | 1.88 | 3.41 | 3.10 | 2.45 |
| 1986 | April | 3.79 | 1.27 | 2.11 | 3.89 | 3.90 | 2.99 |
| 1986 | May | 1.62 | 0.38 | 0 | 1.90 | 1.70 | 1.12 |
| 1986 | June | 0.26 | 0.33 | 2.47 | 2.37 | 0 | 1.09 |
| 1986 | July | 1.01 | 1.28 | 0 | 0 | 0.60 | 0.58 |
| 1986 | August | 1.68 | 1.66 | 4.15 | 0 | 2.90 | 2.08 |
| 1986 | September | 2.73 | 2.22 | 1.75 | 6.10 | 3.40 | 3.24 |
| 1986 | October | 1.86 | 1.64 | 0 | 0 | 1.80 | 1.06 |
| 1986 | November | 1.98 | 0.22 | 0 | 0 | 1.80 | 0.80 |
| 1986 | December | 0.55 | 0.07 | 4.19 | 5.68 | 0.80 | 2.26 |
| | TOTAL | 28.31 | 12.95 | 26.00 | 32.31 | 28.00 | 25.51 |

TABLE A-1

MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1987 | January | 2.14 | 1.1 | 0 | 0 | 1.70 | 0.99 |
| 1987 | February | 2.07 | 0.97 | 3.97 | 6.80 | 2.50 | 3.26 |
| 1987 | March | 2.47 | 1.57 | 2.03 | 3.01 | 2.20 | 2.26 |
| 1987 | April | 1.03 | 1.31 | 1.40 | 2.41 | 1.60 | 1.55 |
| 1987 | May | 2.93 | 2.59 | 0 | 2.90 | 3.40 | 2.36 |
| 1987 | June | 0.79 | 0.52 | 4.73 | 4.37 | 1.90 | 2.46 |
| 1987 | July | 2.12 | 2.9 | 0 | 0 | 1.90 | 1.38 |
| 1987 | August | 1.22 | 1.54 | 0 | 0 | 1.40 | 0.83 |
| 1987 | September | 0.49 | 0.09 | 5.80 | 6.10 | 1.30 | 2.76 |
| 1987 | October | 1.39 | 2.34 | 2.00 | 3.02 | 0.90 | 1.93 |
| 1987 | November | 1.68 | 1.59 | 1.66 | 2.52 | 2.80 | 2.05 |
| 1987 | December | 3.50 | 0.92 | 1.99 | 3.03 | 2.50 | 2.39 |
| | TOTAL | 21.83 | 17.44 | 23.58 | 34.16 | 24.10 | 24.22 |

TABLE A-1

MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1988 | January | 3.06 | 2.60 | 2.21 | 2.92 | 3.10 | 2.78 |
| 1988 | February | 0.72 | 0.06 | 2.08 | 3.40 | 0.60 | 1.37 |
| 1988 | March | 3.32 | 0.99 | 3.29 | 4.45 | 3.70 | 3.15 |
| 1988 | April | 2.14 | 1.73 | 2.79 | 4.15 | 2.00 | 2.56 |
| 1988 | May | 1.60 | 0.68 | 1.24 | 1.28 | 2.30 | 1.42 |
| 1988 | June | 0.86 | 1.38 | 0.77 | 1.33 | 0.60 | 0.99 |
| 1988 | July | 1.04 | 0.65 | 1.15 | 0.94 | 0.70 | 0.90 |
| 1988 | August | 2.23 | 1.08 | 1.50 | 2.08 | 1.50 | 1.68 |
| 1988 | September | 1.16 | 1.10 | 1.55 | 2.17 | 0.90 | 1.38 |
| 1988 | October | 1.20 | 0.84 | 1.78 | 1.20 | 1.00 | 1.20 |
| 1988 | November | 2.68 | 0.34 | 1.48 | 4.30 | 3.40 | 2.44 |
| 1988 | December | 1.91 | 1.44 | 1.77 | 3.70 | 2.70 | 2.30 |
| | TOTAL | 21.92 | 12.89 | 21.61 | 31.92 | 22.50 | 22.17 |

# TABLE A-1

## MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1989 | January | 1.52 | 0.55 | 1.57 | 2.30 | 1.7 | 1.53 |
| 1989 | February | 1.99 | 0.44 | 1.48 | 1.90 | 2 | 1.56 |
| 1989 | March | 3.55 | 0.96 | 2.96 | 4.00 | 3.7 | 3.03 |
| 1989 | April | 0.35 | 0.40 | 1.18 | 1.70 | 1 | 0.93 |
| 1989 | May | 0.06 | 0.71 | 0.38 | 0.90 | 1 | 0.61 |
| 1989 | June | 1.54 | 0.78 | 0.24 | 1.20 | 1.8 | 1.11 |
| 1989 | July | 1.43 | 1.11 | 1.40 | 1.50 | 1.2 | 1.33 |
| 1989 | August | 1.37 | 2.21 | 1.28 | 1.60 | 3 | 1.89 |
| 1989 | September | 1.19 | 1.17 | 1.33 | 2.20 | 2.7 | 1.72 |
| 1989 | October | 1.21 | 0.32 | 0 | 1.80 | 2.1 | 1.09 |
| 1989 | November | 1.88 | 0.44 | 0 | 2.30 | 2.2 | 1.36 |
| 1989 | December | 0.70 | 0.07 | 0 | 1.90 | 1.2 | 0.77 |
| | TOTAL | 16.79 | 9.16 | 11.82 | 23.30 | 23.6 | 16.93 |

# TABLE A-1

## MONTHLY PRECIPITATION DATA SUMMARY (CONTINUED)

| YEAR | MONTH | ELECTRIC LAKE PRECIP. | HIAWATHA PRECIP. | STUART RANGER STATION PRECIP. | RED PINE RIDGE PRECIP. | MAMMOTH-COTTONWOOD PRECIP. | AVERAGE PRECIP. |
|---|---|---|---|---|---|---|---|
| 1990 | January | 2.00 | 0.55 | * | 2.00 | 1.70 | 1.25 |
| 1990 | February | 4.06 | 1.80 | * | 4.00 | 3.90 | 2.75 |
| 1990 | March | 2.30 | 1.36 | * | 3.00 | 1.70 | 1.67 |
| 1990 | April | 2.00 | 0.92 | * | 3.10 | 2.30 | 1.66 |
| 1990 | May | 0.81 | 0.57 | * | 0.50 | 0.40 | 0.46 |
| 1990 | June | 1.87 | 0.81 | * | 2.00 | 2.60 | 1.46 |
| 1990 | July | 1.08 | 0.61 | * | 2.00 | 0.90 | 0.92 |
| 1990 | August | 0.62 | 1.06 | * | 0.70 | 1.50 | 0.78 |
| 1990 | September | 1.87 | 2.20 | * | 2.90 | 1.80 | 1.75 |
| 1990 | October | 1.32 | 0.57 | * | 0 | 0 | 0.38 |
| 1990 | November | 0 | 0 | * | 0 | 0 | 0 |
| 1990 | December | 0 | 0 | * | 0 | 0 | 0 |
| | TOTAL | 17.93 | 10.45 | * | 20.20 | 16.80 | 16.34 |

* No Data Reported

# Appendix B

# Streamflow Data

TABLE B-1

HUNTINGTON CREEK AVERAGE MONTHLY FLOW (cfs)

| YEAR | JAN AVG FLOW | FEB AVG FLOW | MAR AVG FLOW | APR AVG FLOW | MAY AVG FLOW | JUNE AVG FLOW | JULY AVG FLOW | AUG AVG FLOW | SEPT AVG FLOW | OCT AVG FLOW | NOV AVG FLOW | DEC AVG FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1981 | 26.9 | 28.9 | 28.1 | 61.9 | 100.0 | 85.5 | 135.0 | 87.8 | 56.8 | 34.5 | 19.3 | 0.0 |
| 1982 | 20.5 | 21.4 | 27.7 | 42.9 | 270.0 | 374.0 | 173.0 | 97.5 | 92.8 | 95.1 | 70.9 | 0.0 |
| 1983 | 45.5 | 26.3 | 39.4 | 55.0 | 315.0 | 1003.0 | 324.0 | 138.0 | 105.0 | 85.7 | 72.7 | 52.2 |
| 1984 | 54.0 | 60.5 | 65.0 | 143.0 | 853.0 | 823.0 | 292.0 | 173.0 | 175.0 | * | * | * |
| 1985 | * | * | * | * | * | * | * | * | * | 61.1 | 36.0 | 35.3 |
| 1986 | 39.1 | 46.6 | 84.2 | 139.0 | 442.0 | 493.0 | 155.0 | 135.0 | 115.0 | 61.1 | 43.3 | 43.4 |
| 1987 | 43.4 | 48.6 | 45.8 | 97.2 | 171.0 | 125.0 | 85.6 | 73.6 | 82.5 | 69.4 | 46.3 | 40.4 |
| 1988 | 29.9 | 28.3 | 26.1 | 47.5 | 157.0 | 149.0 | 98.2 | 73.1 | 62.4 | * | * | * |

* Data not available.

# Appendix C

# Water Rights Data

## Table C-1

## Summary of Water Rights

| Water Right Number | User Name | Source Name | Quantity (cfs) | Water Use | Priority Date |
|---|---|---|---|---|---|
| 93 1435 | USA Forest Service | Left Fork Trail Canyon Spring | .0110 | Stockwatering | 1875 |
| 93 139 | USA Forest Service | Trail Canyon Creek | .0000 | Stockwatering | 1875 |
| 93 1436 | USA Forest Service | Surface Runoff Spring | .0110 | Stockwatering | 1875 |
| 93 1434 | USA Forest Service | McCadden Ridge Spring | .0110 | Stockwatering | 1875 |
| 93 1432 | USA Forest Service | Unnamed Spring | .0110 | Stockwatering | 1875 |
| 93 1433 | USA Forest Service | Tuttle Spring | .0110 | Stockwatering | 1875 |
| 93 1431 | USA Forest Service | Unnamed Stream | .0110 | Stockwatering | 1875 |
| 93 1430 | USA Forest Service | Boundary Spring | .0110 | Stockwatering | 1875 |
| 93 151 | USA Forest Service | Bear Creek | .0000 | Stockwatering | 1875 |
| 93 1429 | USA Forest Service | Wild Horse Flat Spring | .0110 | Stockwatering | 1875 |
| 93 142 | USA Forest Service | McCadden Hollow | .0000 | Stockwatering | 1875 |
| 93 141 | Nevada Electric Investment Co. | McCadden Hollow Stream | .0000 | Stockwatering | 1875 |
| 93 129 | Nevada Electric Investment Co. | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 138 | Nevada Electric Investment Co. | Trail Canyon Creek | .0000 | Domestic Stockwatering | 1875 |

Table C-1 (Cont.)

Summary of Water Rights

| Water Right Number | User Name | Source Name | Quantity (cfs) | Water Use | Priority Date |
|---|---|---|---|---|---|
| 93 130 | USA Forest Service | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 195 | USA Forest Service | Mill Fork Huntington Creek | .0000 | Stockwatering | 1875 |
| a15965 | Co-op Mining Company | 1) Spring 2) Mine Portal | .0000 | Irrigation Domestic Mining | 1991 |
| 93 1067 | Charles W. Kingston | Underground Water Tunnel | .2500 | Irrigation Mining | 1964 |
| 93 1183 | Utah Power & Light Co. | Huntington Creek | .0000 | Stockwatering | 1902 |
| 93 131 | Peabody Coal Company Nevada Electric Investment Co. | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 144 | USA Forest Service | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 390 | Nevada Electric Investment Co. | Rilda Canyon | .0000 | Stockwatering | 1902 |
| 93 199 | Utah Power & Light Co. | Rilda Canyon Creek | .0000 | Stockwatering | 1902 |
| a7941 | Huntington-Cleveland Irrigation Company | Huntington Creek and Tributaries | 392.2500 | Irrigation Domestic Stockwatering Power Other | 1974 |
| 93 150 | Nevada Electric Investment Co. | Bear Creek | .0000 | Stockwatering | 1875 |
| a13694 | Mrs. Charles W. Kingston (Lavenda) | Bear Canyon Tunnel | .2500 | Irrigation Domestic Mining Other | 1985 |

Table C-1 (Cont.)

Summary of Water Rights

| Water Right Number | User Name | Source Name | Quantity (cfs) | Water Use | Priority Date |
|---|---|---|---|---|---|
| E1621 | Utah Power & Light Co. | Well | .1100 | Other | 1979 |
| 93 3208 | USA Bureau of Land Management | Huntington Creek | .0000 | Stockwatering | 1860 |
| E2504 | Castle Valley Special Service District | Bear Spring | .0000 | Municipal | 1987 |
| 93 2196 | Huntington Cleveland Irrigation Company | Birch Spring | 45.0000 | Irrigation Domestic Stockwatering Power Other | 1879 |
| 93 2198 | Huntington Cleveland Irrigation Company | Birch Spring | 80.0000 | Irrigation Domestic Stockwatering Power Other | 1888 |
| 93 304 | Huntington Cleveland Irrigation Company | Birch Spring | 150.0000 | Irrigation Domestic Stockwatering Power Other | 1876 |
| 93 2197 | Huntington Cleveland Irrigation Company | Birch Spring | 77.2500 | Irrigation Domestic Stockwatering Power Other | 1884 |

Table C-1 (Cont.)

Summary of Water Rights

| Water Right Number | User Name | Source Name | Quantity (cfs) | Water Use | Priority Date |
|---|---|---|---|---|---|
| 93 2200 | Huntington Cleveland Irrigation Company | Bear Canyon Spring | .0000 | Irrigation Domestic Stockwatering Power Other | 1884 |
| 93 253 | Huntington Cleveland Irrigation Company | Bear Canyon Spring | 150.0000 | Irrigation Domestic Stockwatering Power Other | 1876 |
| 93 1182 | Peabody Coal Company | Bear Creek | .0000 | Stockwatering | 1902 |
| 93 2201 | Huntington Cleveland Irrigation Company | Bear Canyon Spring | 80.0000 | Irrigation Domestic Stockwatering Power Other | 1888 |
| 93 2199 | Huntington Cleveland Irrigation Company | Bear Canyon Spring | 45.0000 | Irrigation Domestic Stockwatering Power Other | 1879 |
| 93 3171 | Northwest Carbon Corporation | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 3033 | Northwest Carbon Corporation | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 143 | Nevada Electric Investment Company | Birch Spring | .0110 | Stockwatering | 1875 |
| 93 3209 | USA Bureau of Land Management | Huntington Creek | .0000 | Stockwatering | 1860 |

Table C-1 (Cont.)

Summary of Water Rights

| Water Right Number | User Name | Source Name | Quantity (cfs) | Water Use | Priority Date |
|---|---|---|---|---|---|
| 93 149 | Nevada Electric Investment Company | Bear Creek | .0000 | Stockwatering | 1875 |
| 93 148 | USA Bureau of Land Management | Bear Creek | .0000 | Stockwatering | 1902 |
| 93 3207 | USA Bureau of Land Management | Huntington Creek | .0000 | Stockwatering | 1860 |
| 93 146 | Nevada Electric Investment Company | Huntington Creek | .0000 | Stockwatering | 1875 |
| 93 303 | Huntington Cleveland Irrigation Company | Spring | 150.0000 | Irrigation Domestic Stockwatering Power Other | 1875 |
| 93 2202 | Huntington Cleveland Irrigation Company | Unnamed Spring | 45.0000 | Irrigation Domestic Stockwatering Power Other | 1879 |
| 93 2204 | Huntington Cleveland Irrigation Company | Unnamed Spring | 80.0000 | Irrigation Domestic Stockwatering Power Other | 1888 |
| 93 2203 | Huntington Cleveland Irrigation Company | Unnamed Spring | 77.2500 | Irrigation Domestic Stockwatering Power Other | 1884 |

# Appendix D

# Spring Flow Data

# TABLE D-1

## BIG BEAR SPRING AVERAGE MONTHLY FLOW (gpm)

| YEAR | JAN AVG FLOW | FEB AVG FLOW | MAR AVG FLOW | APR AVG FLOW | MAY AVG FLOW | JUNE AVG FLOW | JULY AVG FLOW | AUG AVG FLOW | SEPT AVG FLOW | OCT AVG FLOW | NOV AVG FLOW | DEC AVG FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1980 | 223.0 | 228.0 | 226.0 | 225.0 | 228.0 | 340.0 | 365.0 | 304.0 | 245.0 | 230.0 | 239.0 | 233.0 |
| 1981 | 225.0 | 198.0 | 175.0 | 228.0 | 224.0 | 220.0 | 226.0 | 0.0 | 155.0 | 152.0 | 156.0 | 0.0 |
| 1982 | 161.0 | 159.0 | 155.0 | 152.0 | 154.0 | 213.0 | 243.0 | 198.0 | 174.0 | 168.0 | 167.0 | 0.0 |
| 1983 | 167.0 | 167.0 | 167.0 | 166.0 | 166.0 | 310.0 | 378.0 | 319.0 | 258.0 | 214.0 | 195.0 | 189.0 |
| 1984 | 189.0 | 191.0 | 187.0 | 187.0 | 198.0 | 335.0 | 321.0 | 299.0 | 245.0 | 209.0 | 203.0 | 202.0 |
| 1985 | 198.0 | 193.0 | 189.0 | 186.0 | 233.0 | 329.0 | 312.0 | 247.0 | 215.0 | 206.0 | 204.0 | 222.0 |
| 1986 | 171.0 | 190.0 | 186.0 | 182.0 | 208.0 | 304.0 | 305.0 | 249.0 | 211.0 | 198.0 | 197.0 | 193.0 |
| 1987 | 186.0 | 181.0 | 176.0 | 171.0 | 170.0 | 171.0 | 188.0 | 181.0 | 170.0 | 181.0 | 170.0 | 160.0 |
| 1988 | 153.0 | 151.0 | 147.0 | 143.0 | 147.0 | 151.0 | 157.0 | 152.0 | 151.0 | 155.0 | 151.0 | 146.0 |
| 1989 | 142.0 | 139.0 | 134.0 | 133.0 | 131.0 | 127.0 | 128.0 | 120.0 | 119.0 | 114.0 | 111.0 | 111.0 |
| 1990 | 110.0 | 110.0 | 112.0 | 109.0 | 104.0 | 104.0 | 104.0 | 105.0 | 107.0 | 110.0 | 108.0 | 125.0 |

# TABLE D-2

## LITTLE BEAR SPRING AVERAGE MONTHLY FLOW (gpm)

| YEAR | JAN AVG FLOW | FEB AVG FLOW | MAR AVG FLOW | APR AVG FLOW | MAY AVG FLOW | JUNE AVG FLOW | JULY AVG FLOW | AUG AVG FLOW | SEPT AVG FLOW | OCT AVG FLOW | NOV AVG FLOW | DEC AVG FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1982 | 296.0 | 291.0 | 286.0 | 283.0 | 321.0 | 435.0 | 438.0 | 409.0 | 356.0 | 337.0 | 330.0 | 325.0 |
| 1983 | 320.0 | 316.0 | 316.0 | 311.0 | 325.0 | 424.0 | 430.0 | 395.0 | 358.0 | 339.0 | 330.0 | 326.0 |
| 1984 | 325.0 | 326.0 | 322.0 | 324.0 | 368.0 | 423.0 | 409.0 | 377.0 | 352.0 | 340.0 | 335.0 | 332.0 |
| 1985 | 332.0 | 329.0 | 324.0 | 227.0 | 379.0 | 379.0 | 357.0 | 341.0 | 341.0 | 331.0 | 327.0 | 322.0 |
| 1986 | 326.0 | 319.0 | 317.0 | 304.0 | 380.0 | 400.0 | 383.0 | 356.0 | 339.0 | 331.0 | 330.0 | 331.0 |
| 1987 | 326.0 | 322.0 | 321.0 | 315.0 | 320.0 | 380.0 | 388.0 | 364.0 | 345.0 | 345.0 | 328.0 | 321.0 |
| 1988 | 313.0 | 311.0 | 309.0 | 314.0 | 318.0 | 327.0 | 340.0 | 327.0 | 345.0 | 366.0 | 366.0 | 285.0 |
| 1989 | 256.0 | 356.0 | 363.0 | 363.0 | 341.0 | 333.0 | 332.0 | 330.0 | 340.0 | 334.0 | 326.0 | 319.0 |
| 1990 | 308.0 | 302.0 | 295.0 | 282.0 | 278.0 | 271.0 | 270.0 | 275.0 | 280.0 | 277.0 | 272.0 | 265.0 |

# TABLE D-3

## TIE FORK SPRING AVERAGE MONTHLY FLOW (gpm)

| YEAR | JAN AVG FLOW | FEB AVG FLOW | MAR AVG FLOW | APR AVG FLOW | MAY AVG FLOW | JUNE AVG FLOW | JULY AVG FLOW | AUG AVG FLOW | SEPT AVG FLOW | OCT AVG FLOW | NOV AVG FLOW | DEC AVG FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1984 | 84.0 | 84.0 | 83.0 | 84.0 | 84.0 | 84.0 | 85.0 | 85.0 | 86.0 | 86.0 | 86.0 | 85.0 |
| 1985 | 85.0 | 85.0 | 84.0 | 85.0 | 85.0 | 85.0 | 85.0 | 85.0 | 86.0 | 87.0 | 86.0 | 85.0 |
| 1986 | 85.0 | 85.0 | 84.0 | 84.0 | 84.0 | 85.0 | 86.0 | 86.0 | 85.0 | 84.0 | 85.0 | 87.0 |
| 1987 | 85.0 | 85.0 | 86.0 | 85.0 | 86.0 | 86.0 | 86.0 | 85.0 | 84.0 | 89.0 | 85.0 | 83.0 |
| 1988 | 81.0 | 81.0 | 82.0 | 81.0 | 82.0 | 81.0 | 81.0 | 105.0 | 133.0 | 130.0 | 130.0 | 84.0 |
| 1989 | 104.0 | 106.0 | 104.0 | 102.0 | 101.0 | 101.0 | 99.0 | 98.0 | 98.0 | 97.0 | 96.0 | 96.0 |
| 1990 | 94.0 | 94.0 | 94.0 | 93.0 | 94.0 | 93.0 | 91.0 | 90.0 | 89.0 | 86.0 | 88.0 | 89.0 |

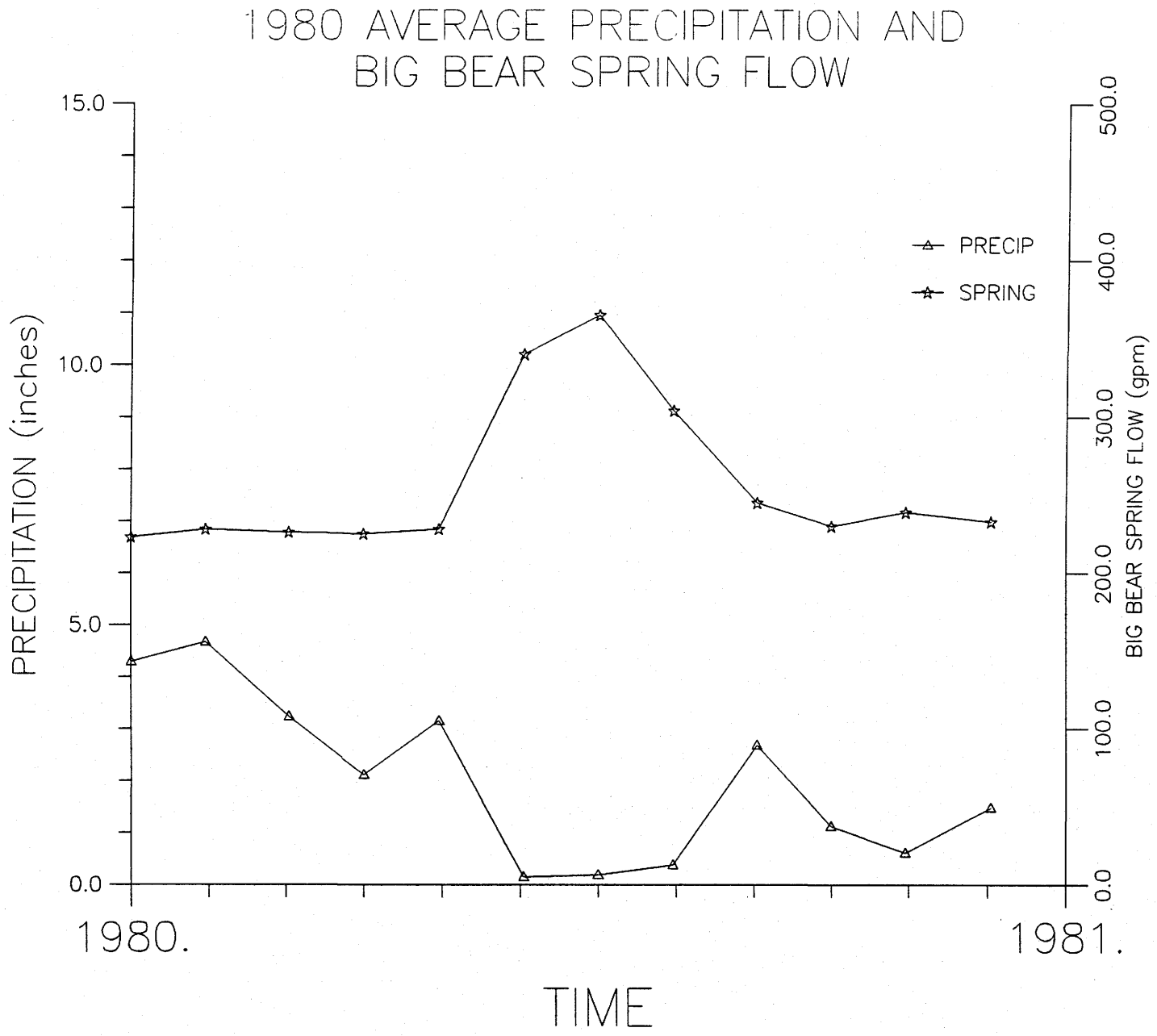
# TABLE D-4

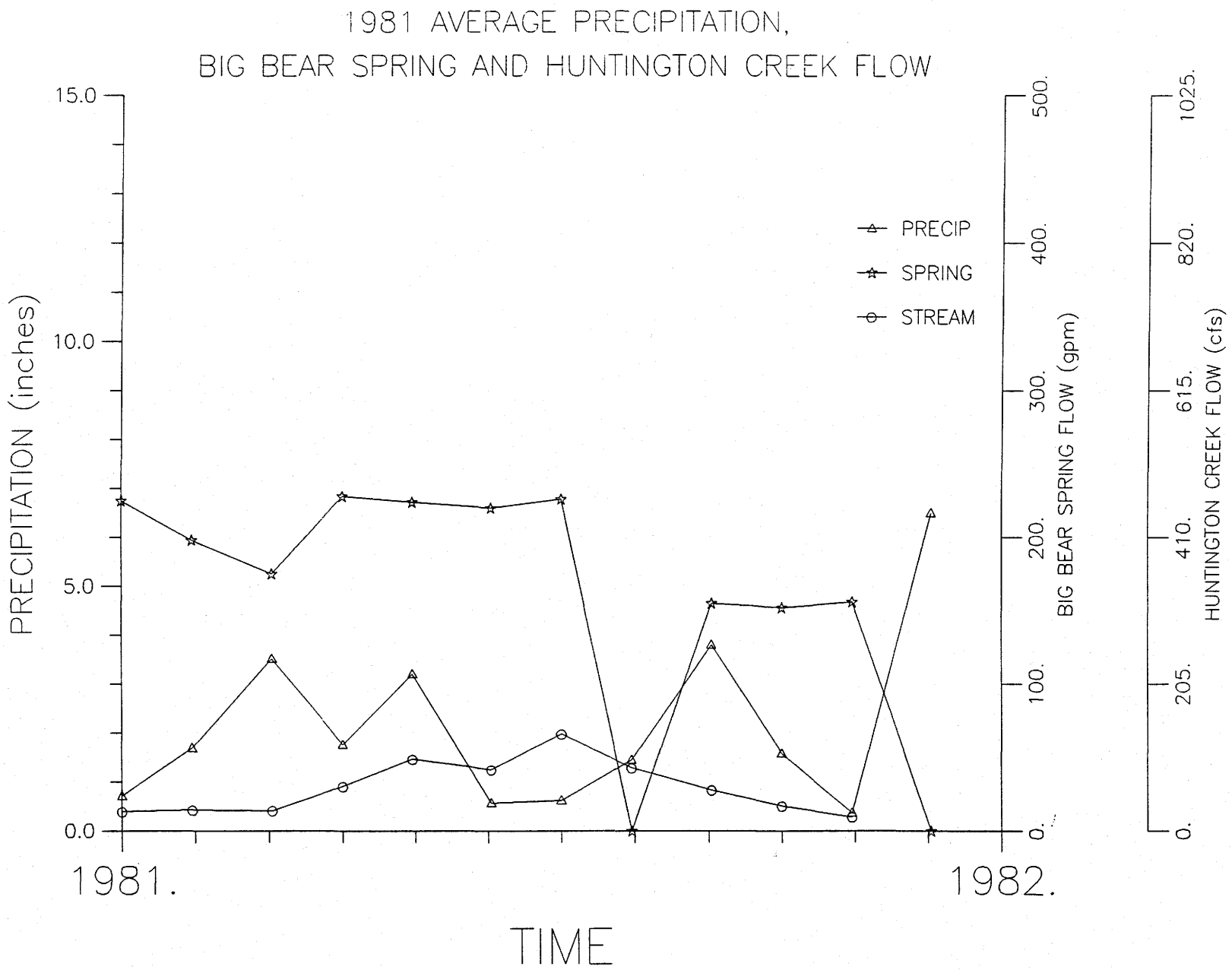
## BIRCH SPRING AVERAGE MONTHLY FLOW (gpm)

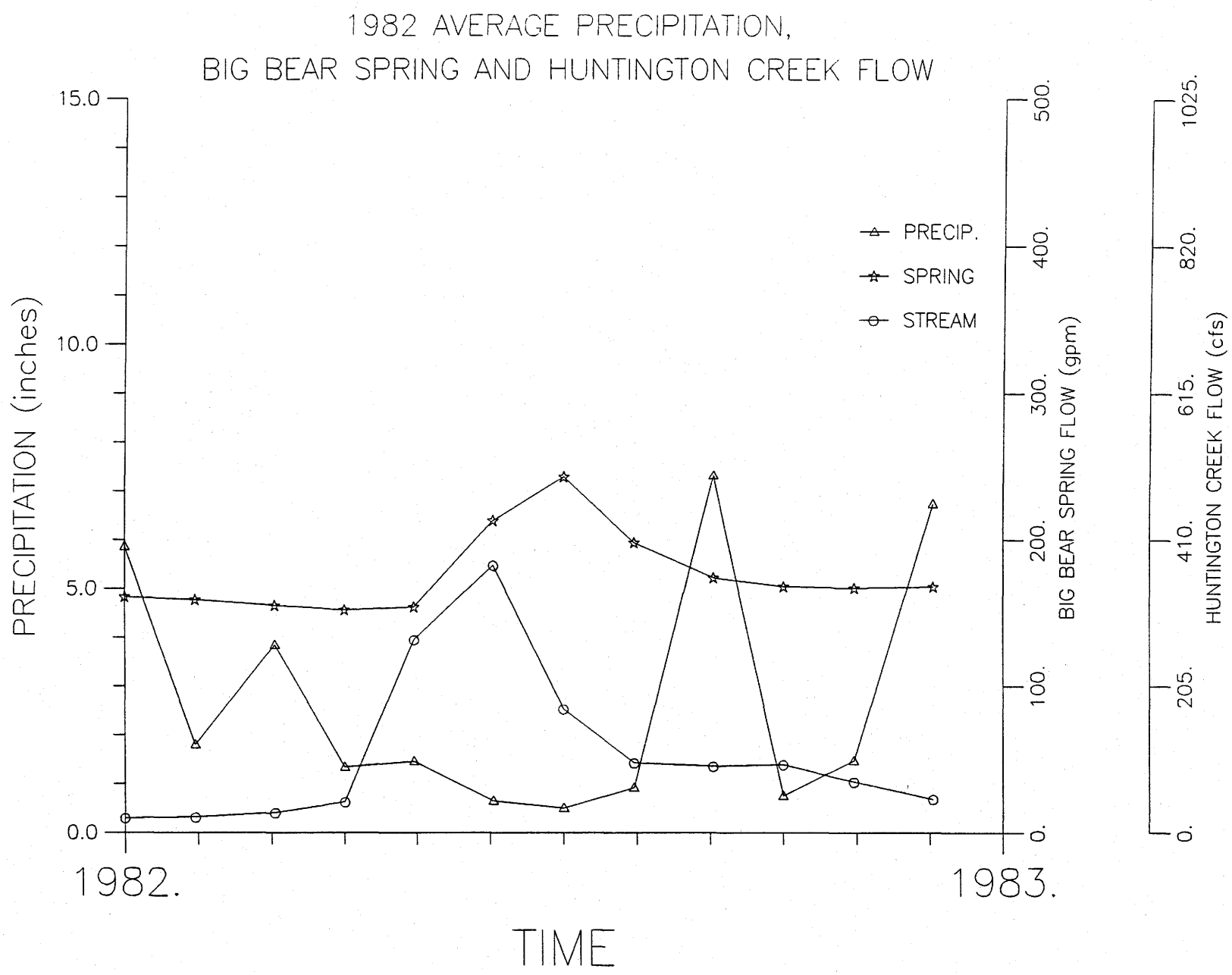
| YEAR | JAN AVG FLOW | FEB AVG FLOW | MAR AVG FLOW | APR AVG FLOW | MAY AVG FLOW | JUNE AVG FLOW | JULY AVG FLOW | AUG AVG FLOW | SEPT AVG FLOW | OCT AVG FLOW | NOV AVG FLOW | DEC AVG FLOW |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| 1989 | 70.0 | 65.0 | 60.0 | 55.0 | 85.0 | 100.0 | 90.0 | 85.0 | 80.0 | 230.0 | 230.0 | 230.0 |
| 1990 | 230.0 | 70.0 | 65.0 | 60.0 | 70.0 | 85.0 | 75.0 | 55.0 | 40.0 | 40.0 | 38.0 | 37.0 |
| 1991 | 35.0 | 33.0 | | | | | | | | | | |

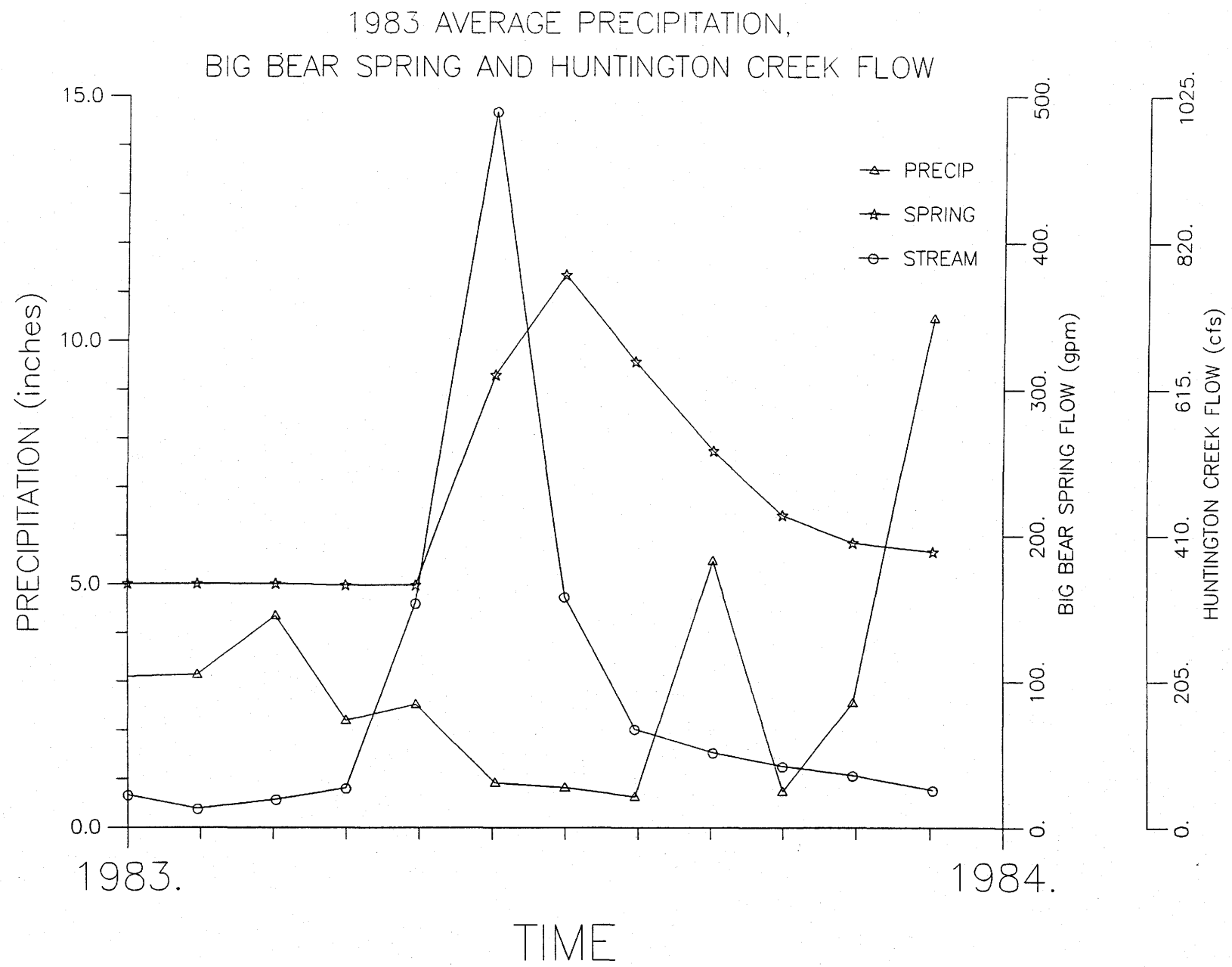
# Appendix E

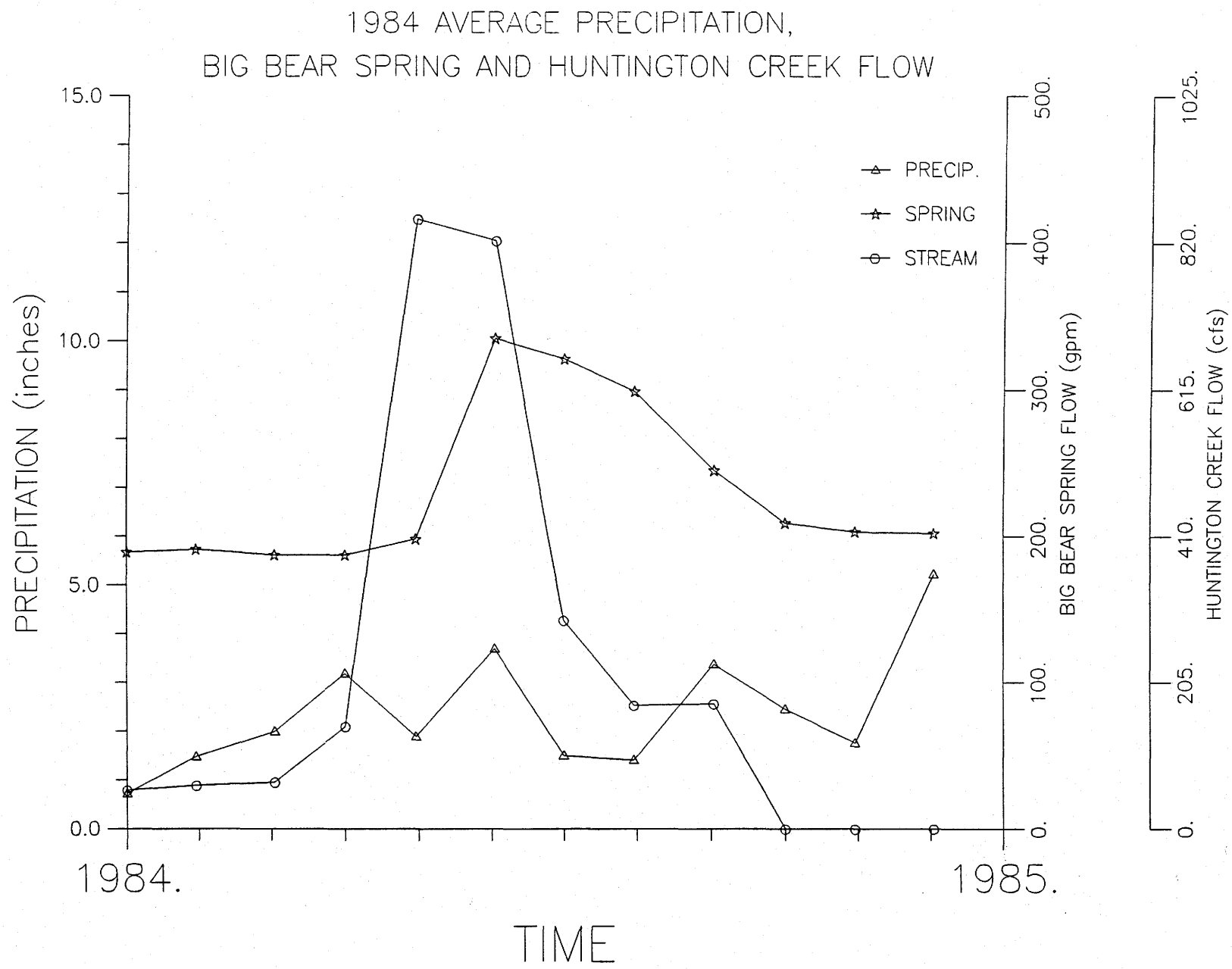
# Spring Flow Plots

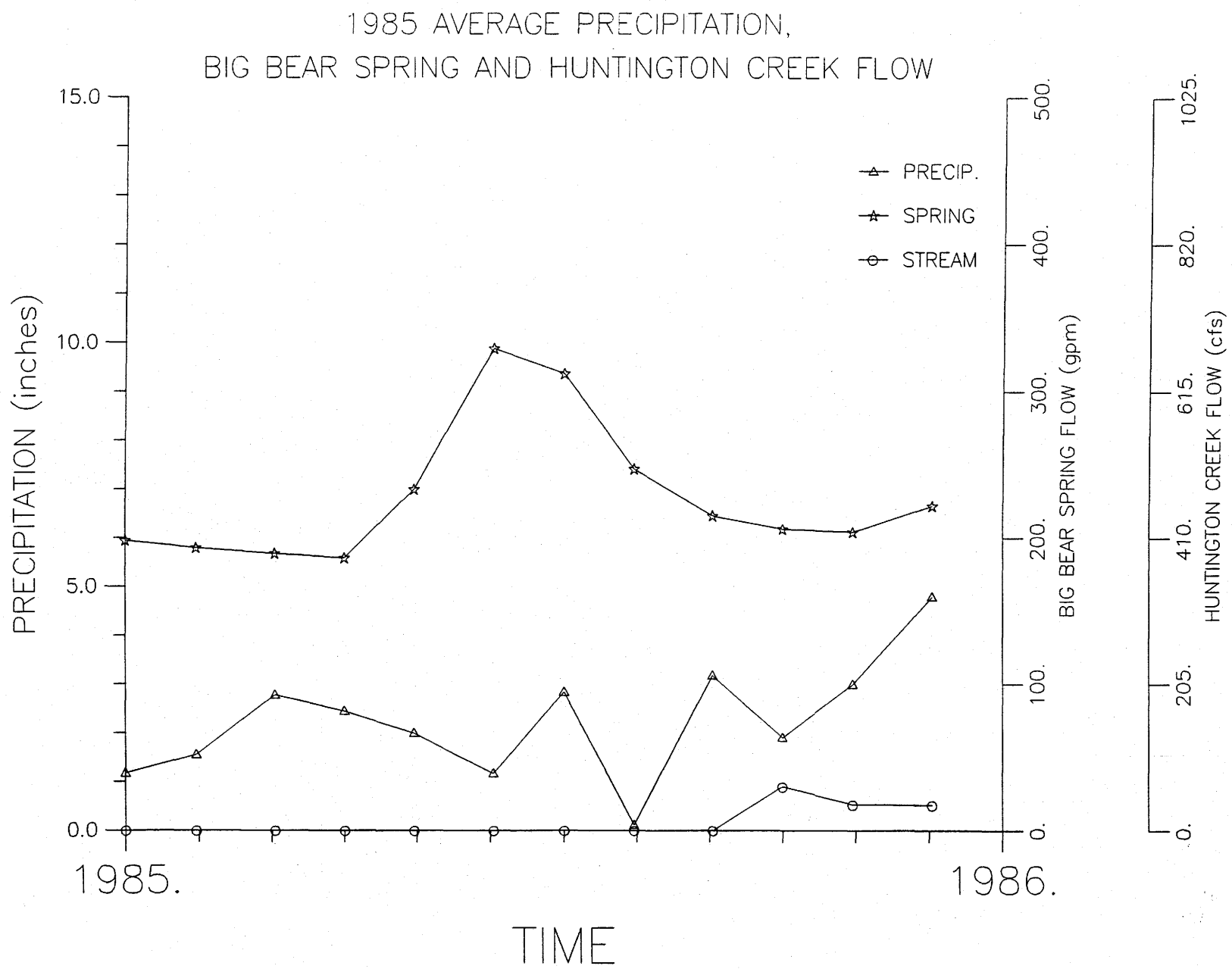

1980 AVERAGE PRECIPITATION AND
BIG BEAR SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
BIG BEAR SPRING FLOW (gpm)
500.0
400.0
300.0
200.0
100.0
0.0
PRECIP
SPRING
1980.
1981.
TIME

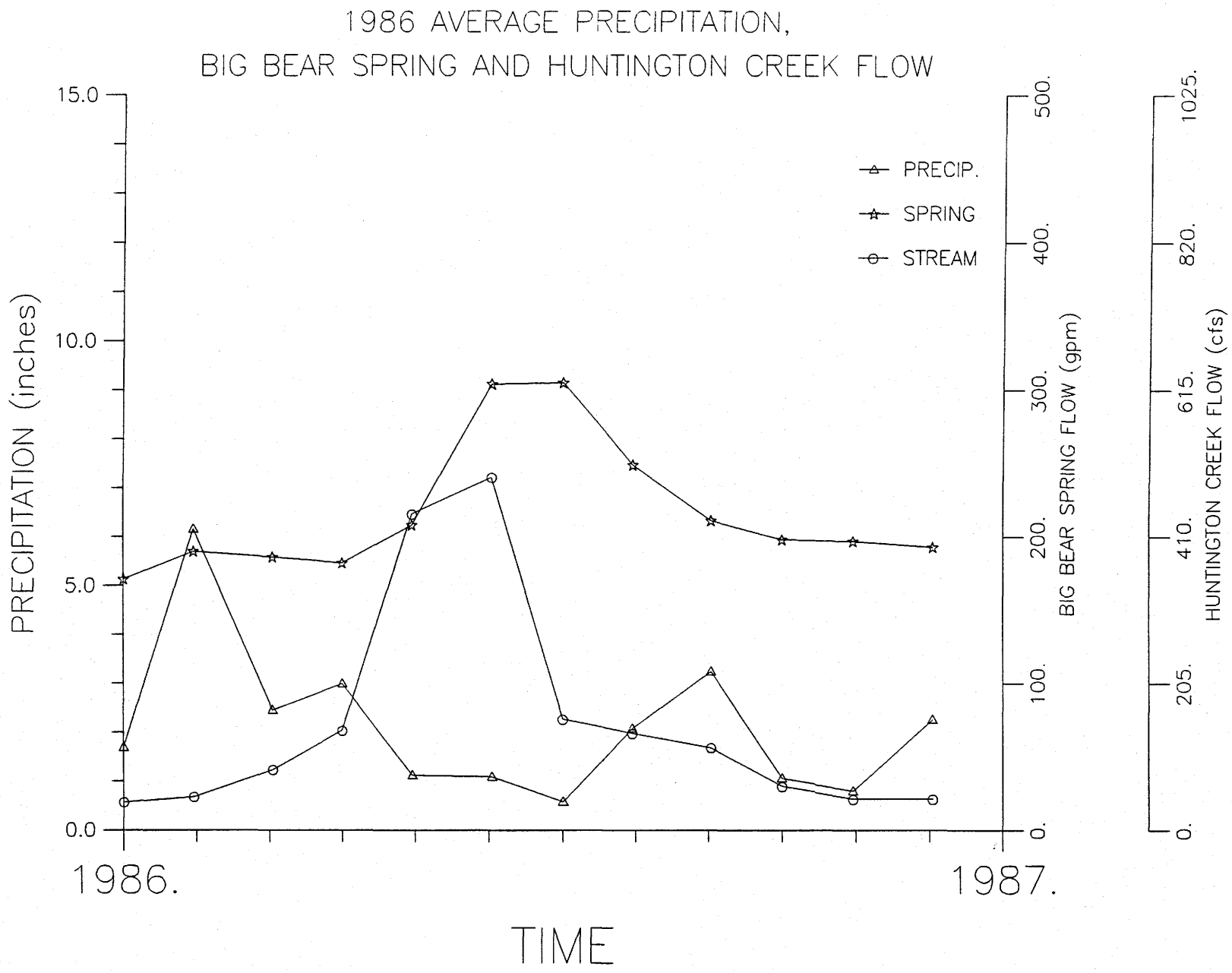

1981 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1981.
1982.
TIME

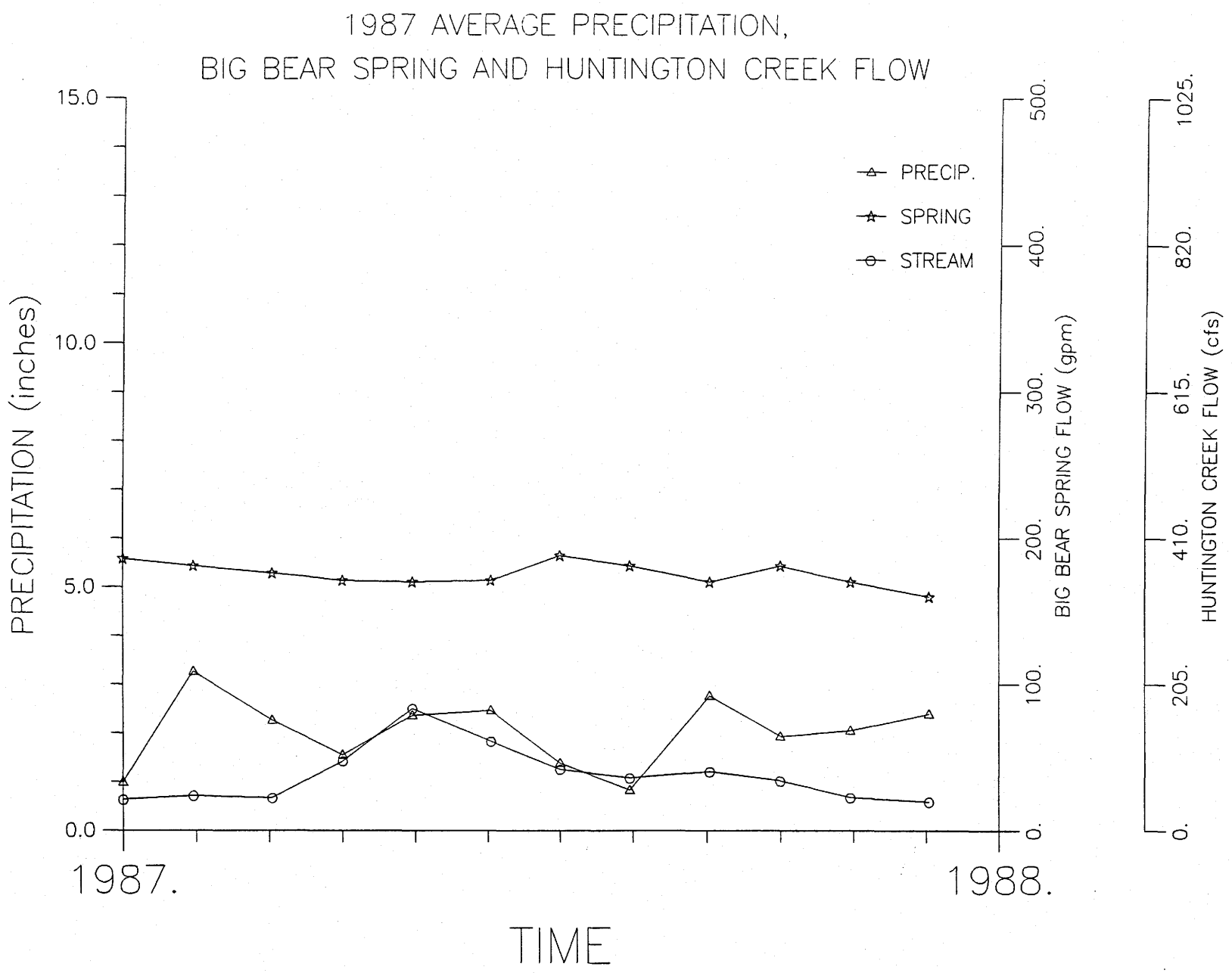

1982 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1982.
1983.
TIME

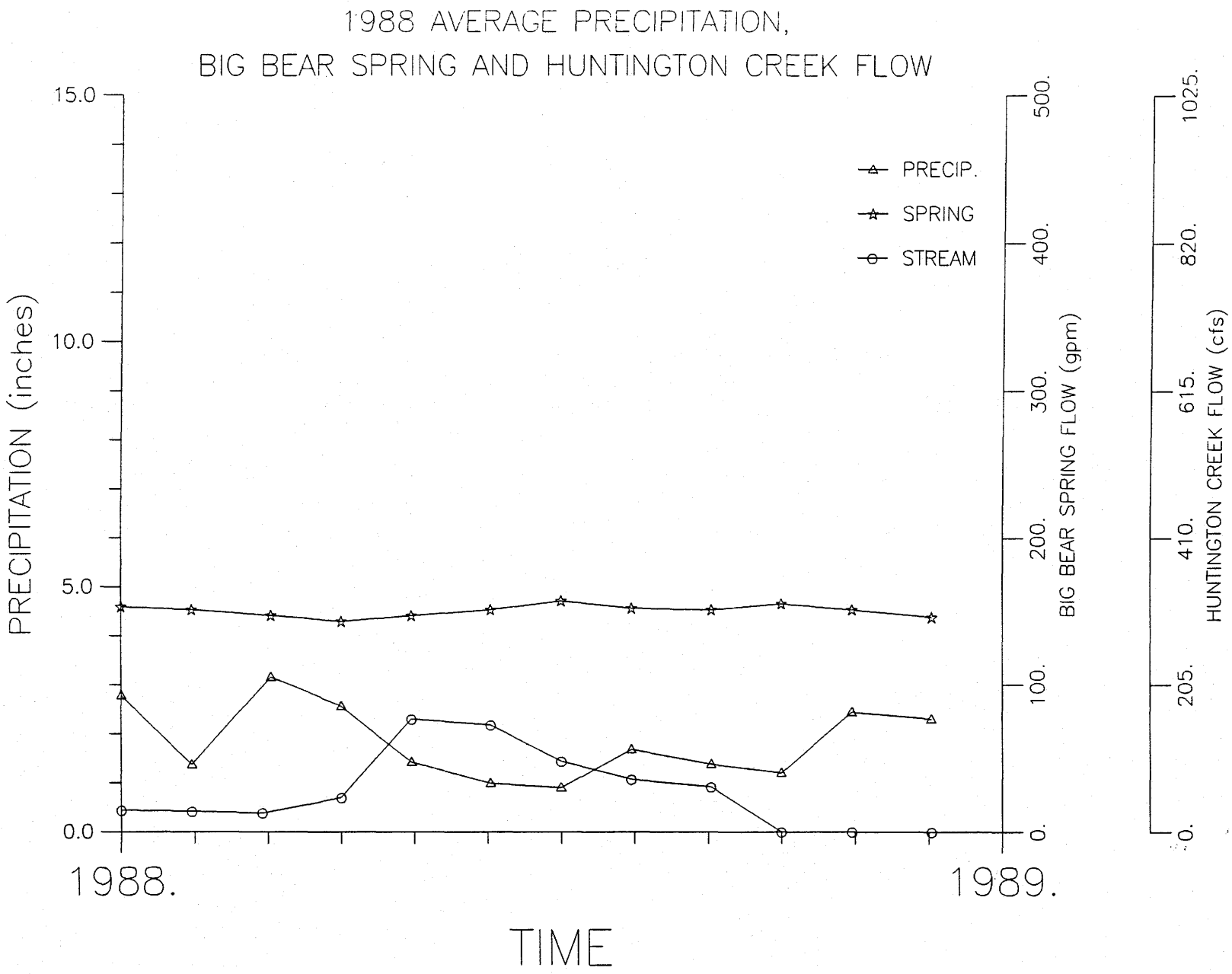

1983 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1983.
1984.
TIME

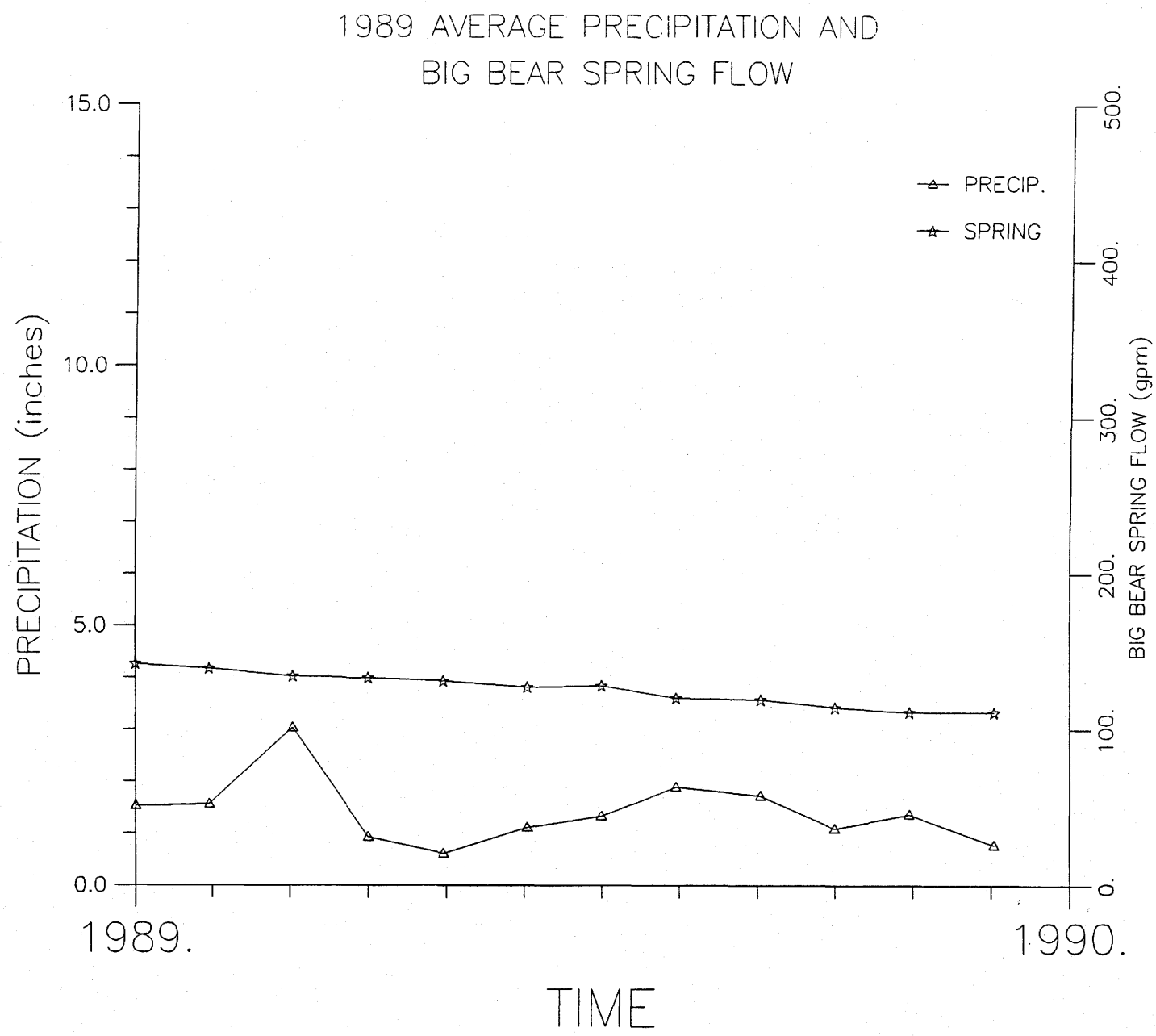

1984 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1984.
1985.
TIME

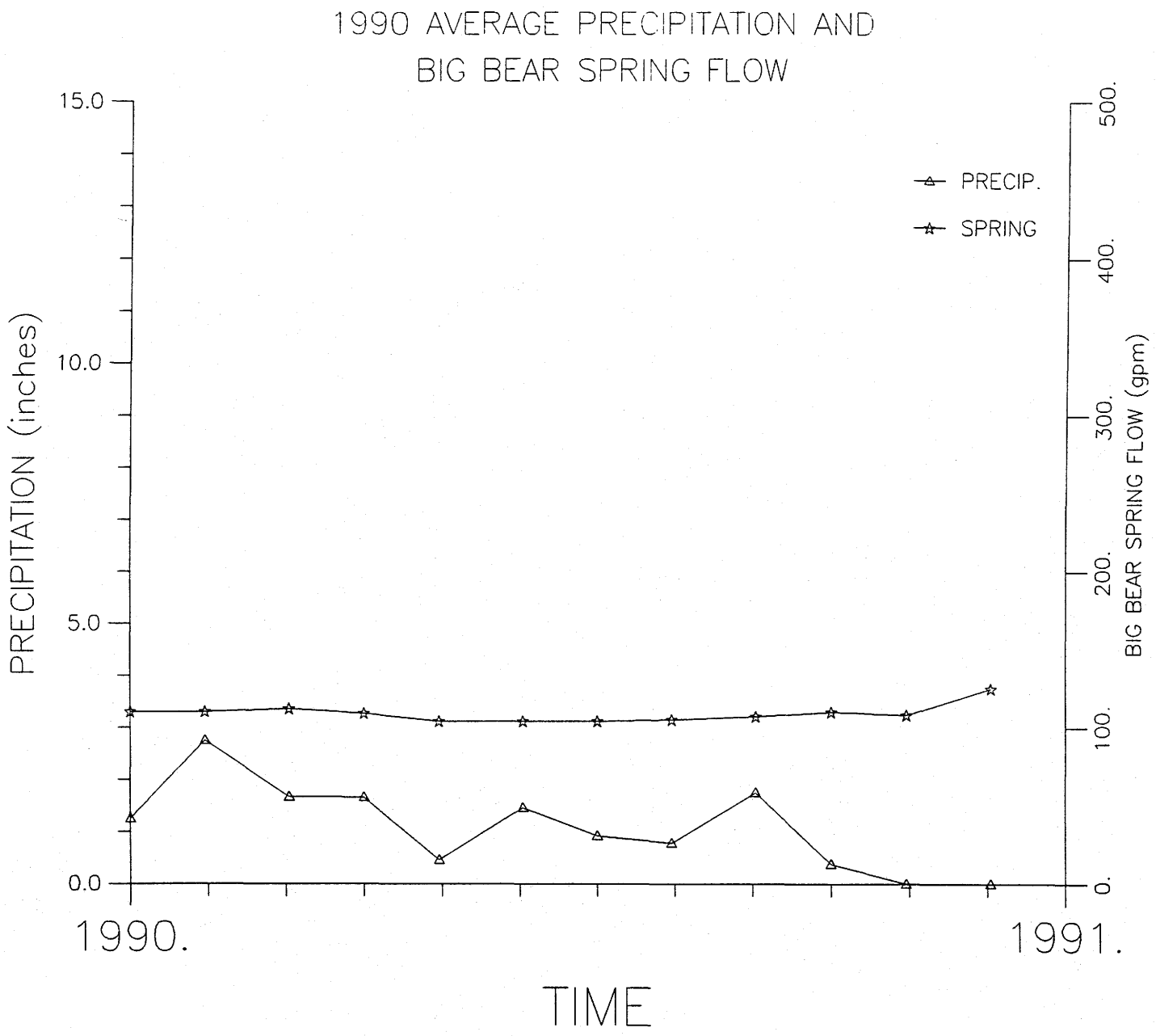

1985 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1985.
1986.
TIME

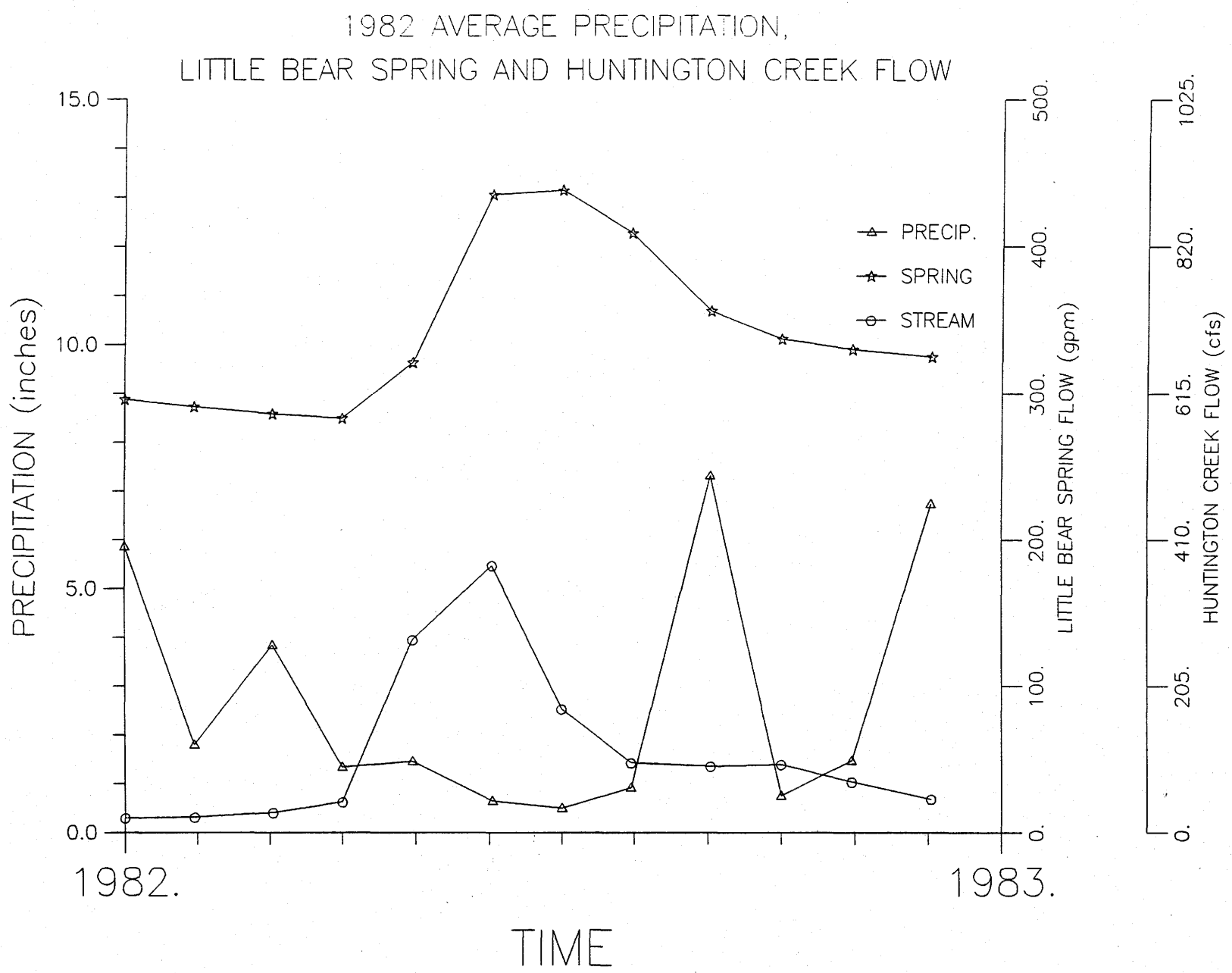

1986 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
PRECIP.
SPRING
STREAM
1986.
1987.
TIME

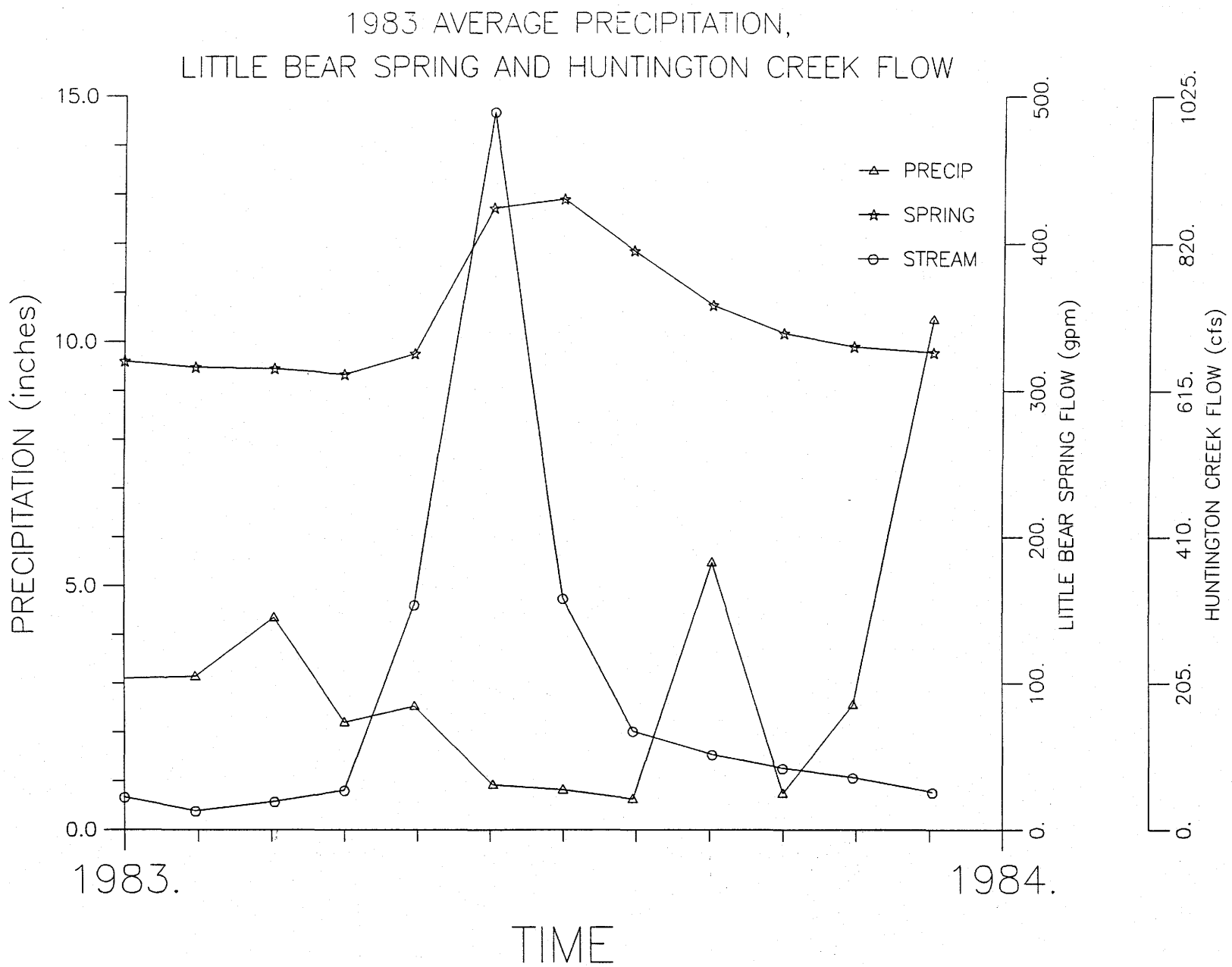

1987 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1987.
1988.
TIME

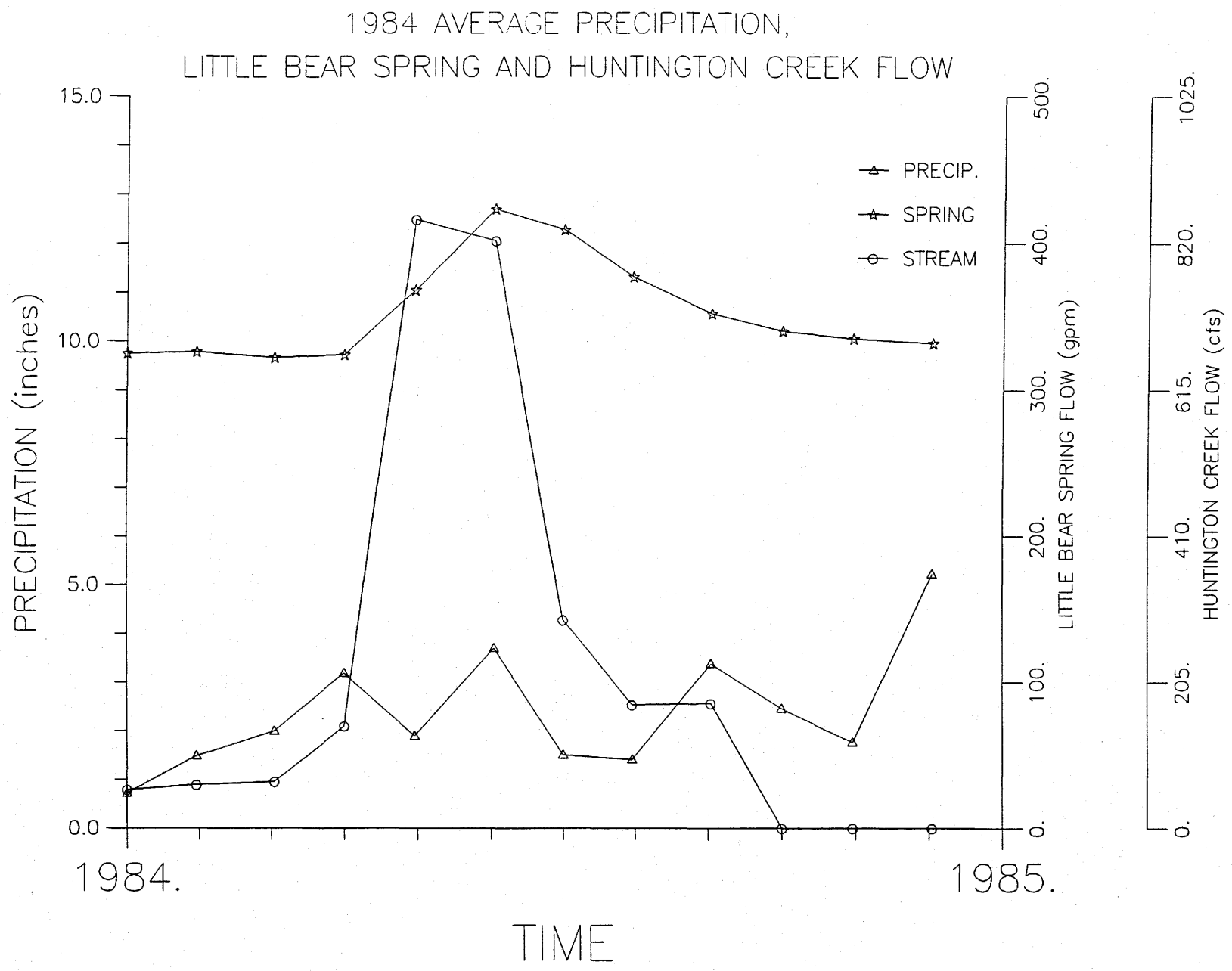

1988 AVERAGE PRECIPITATION,
BIG BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1988.
1989.
TIME

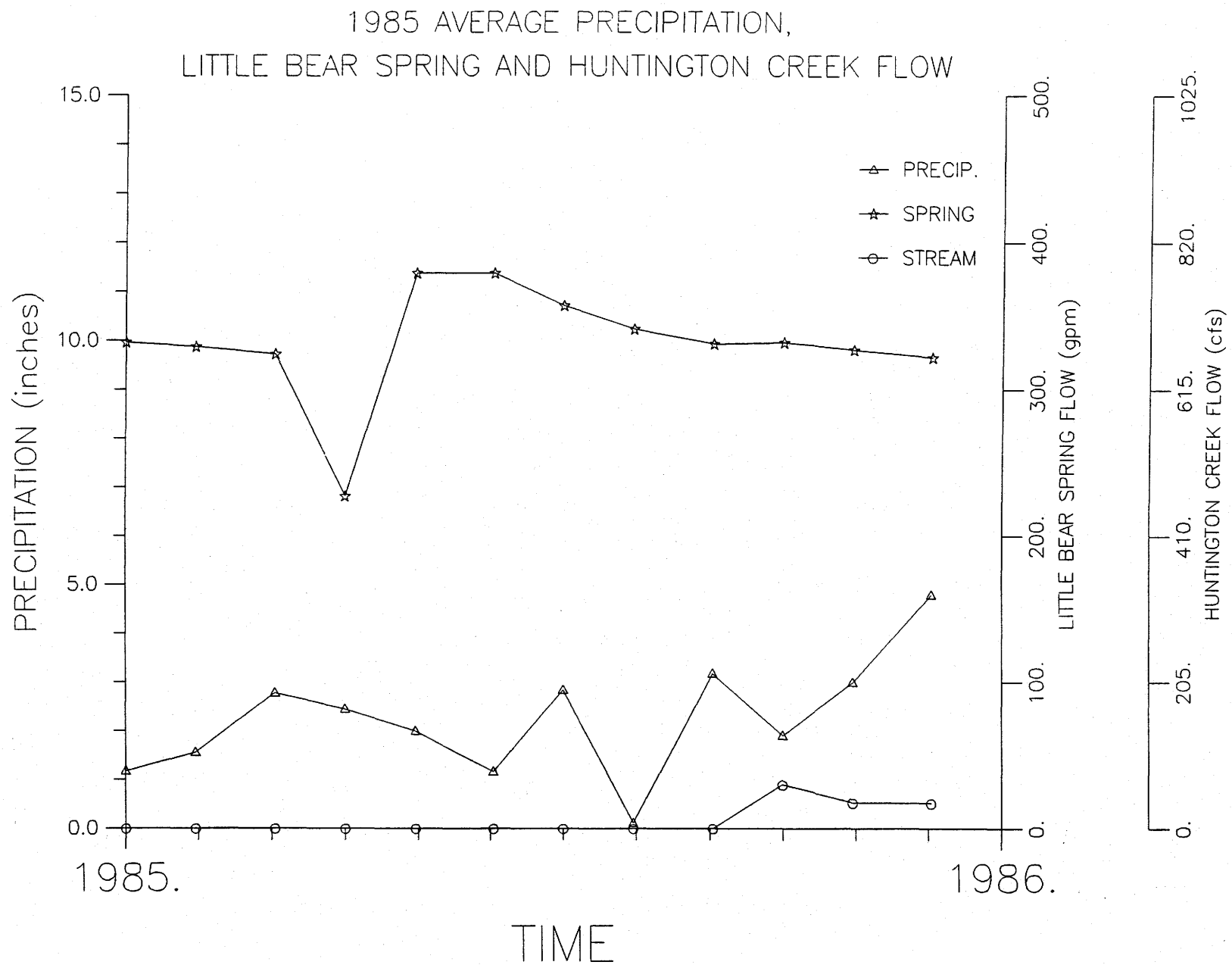

1989 AVERAGE PRECIPITATION AND
BIG BEAR SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1989.
1990.
TIME

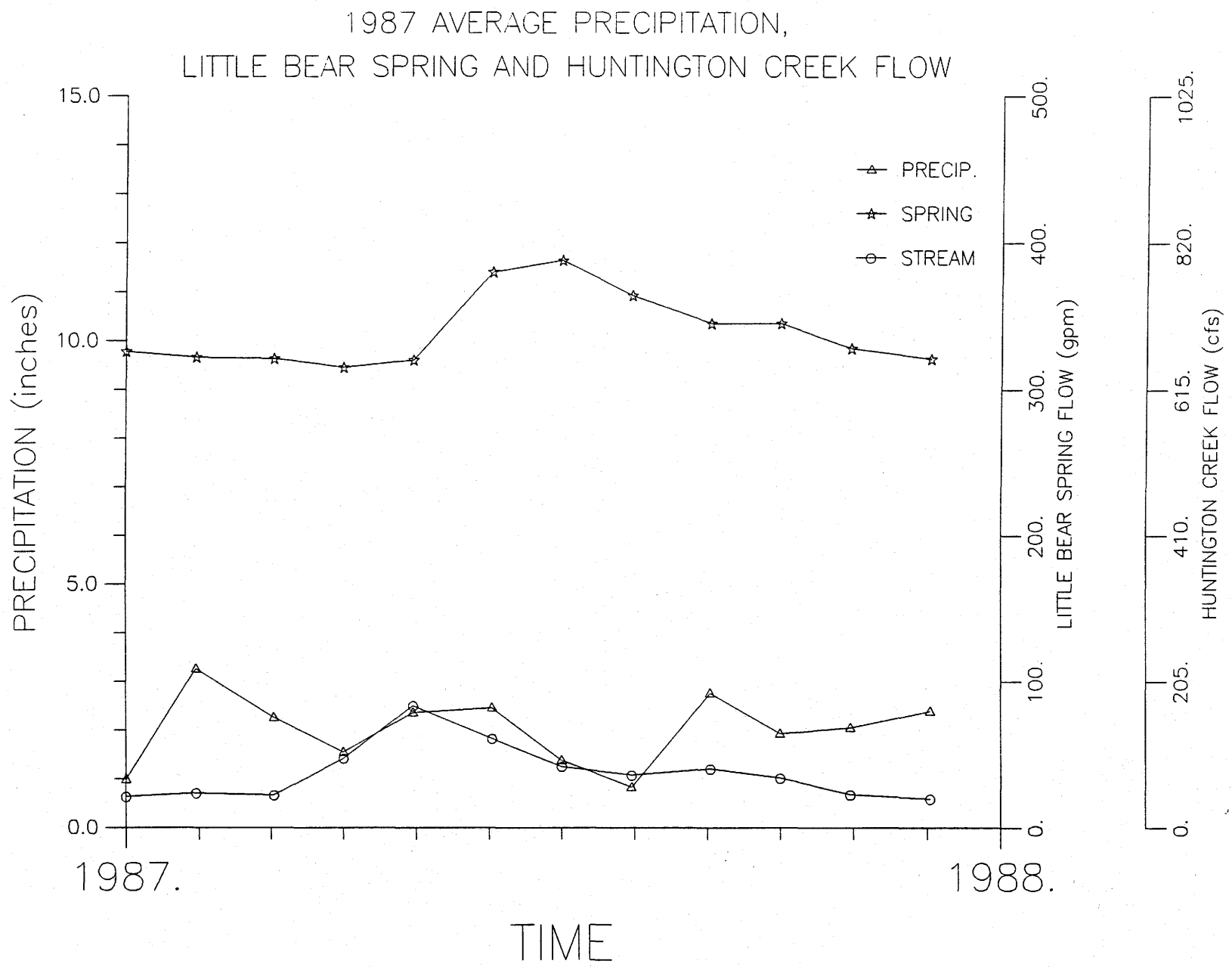

1990 AVERAGE PRECIPITATION AND
BIG BEAR SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
BIG BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1990.
1991.
TIME

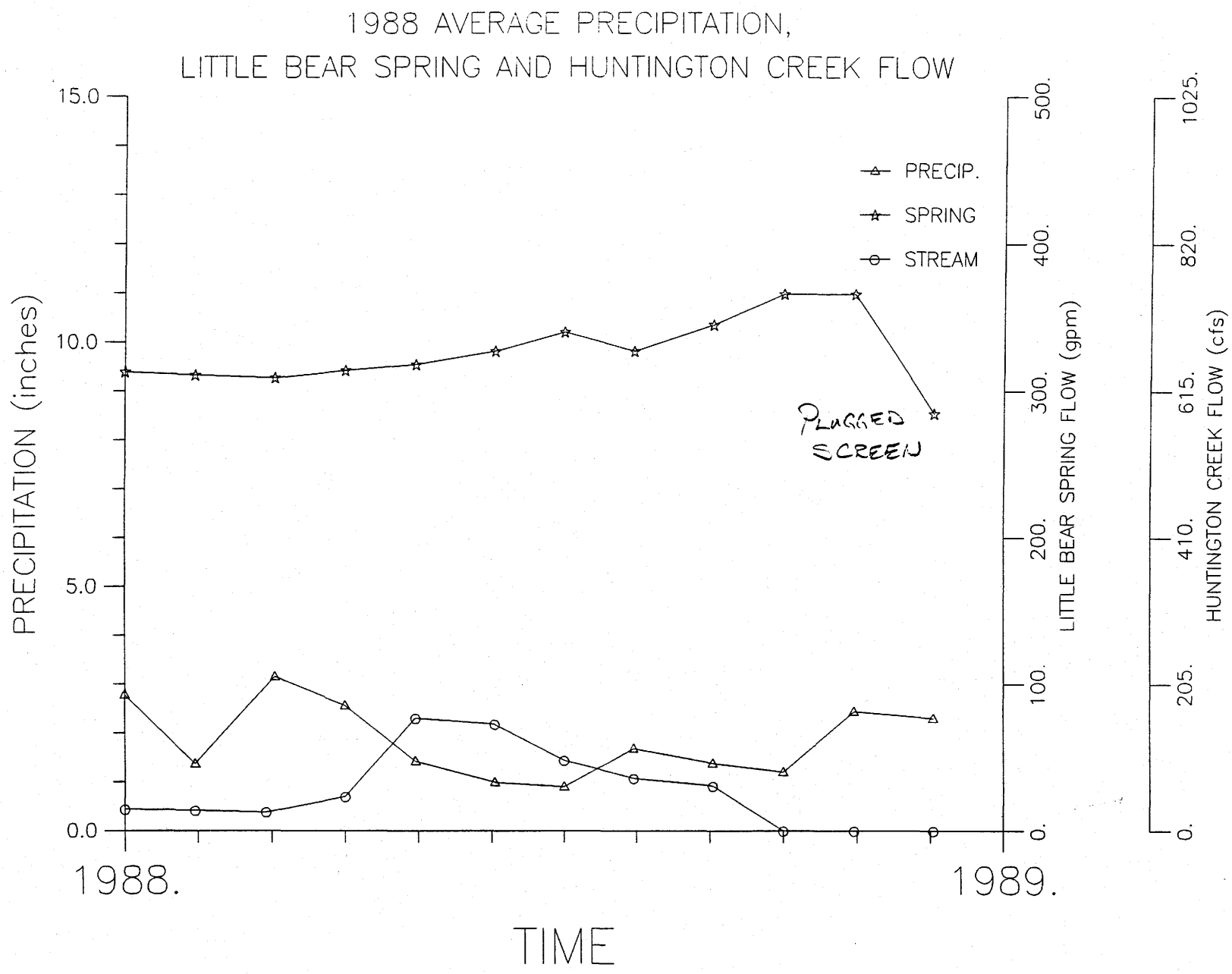

1982 AVERAGE PRECIPITATION,
LITTLE BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1982.
1983.
TIME

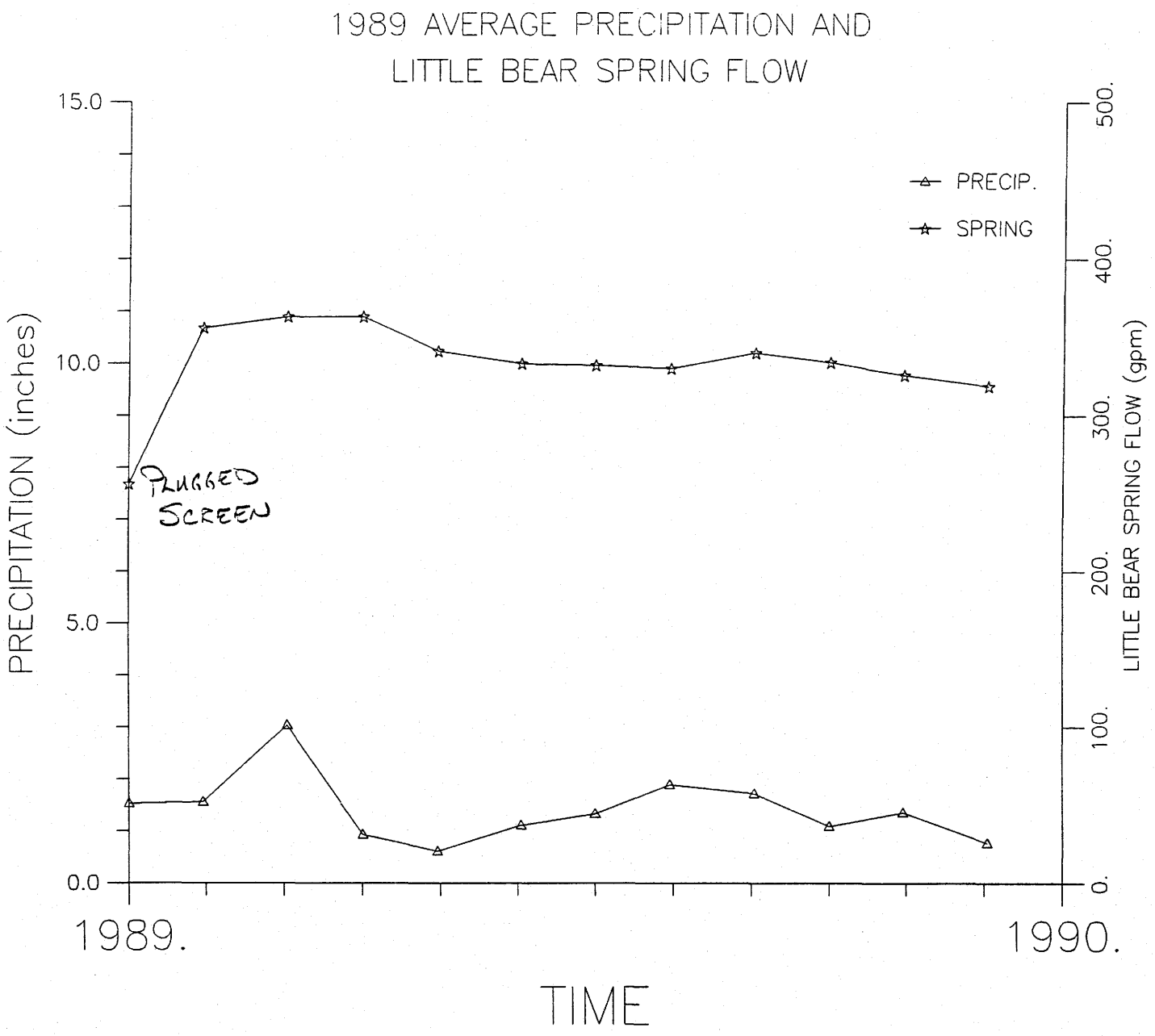

1983 AVERAGE PRECIPITATION,
LITTLE BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
PRECIP
SPRING
STREAM
1983.
1984.
TIME

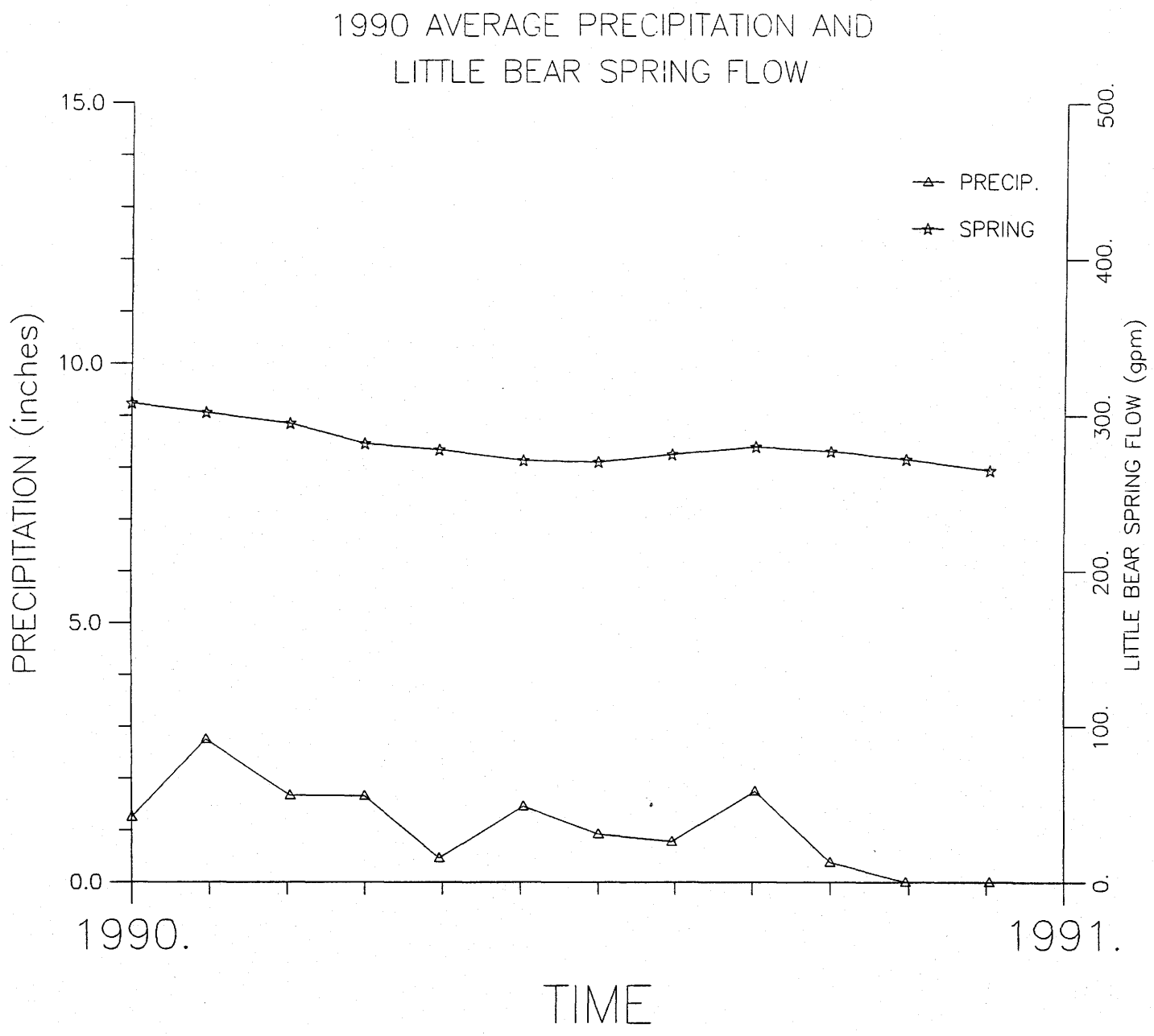

1984 AVERAGE PRECIPITATION,
LITTLE BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1984.
1985.
TIME

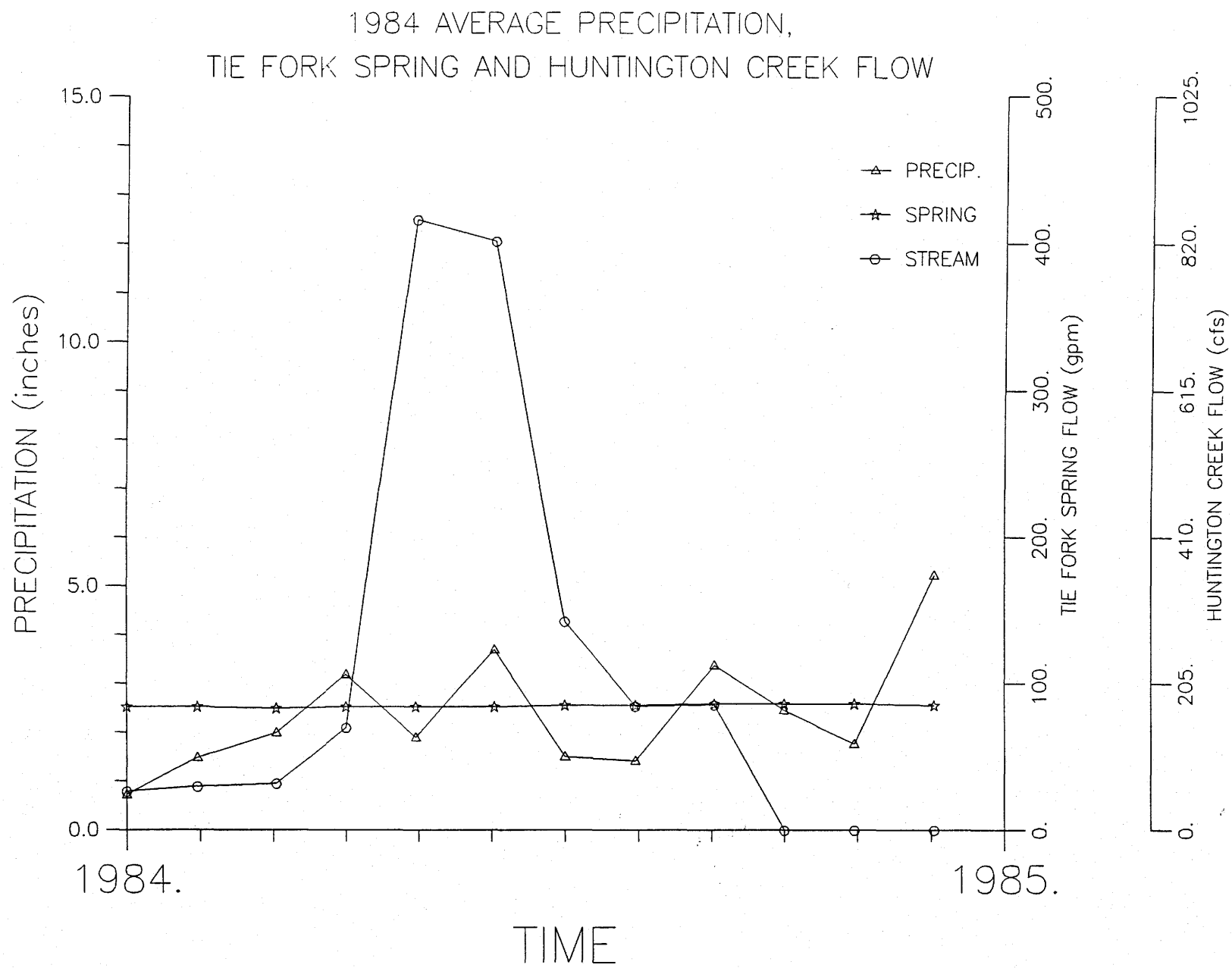

1985 AVERAGE PRECIPITATION,
LITTLE BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1985.
1986.
TIME

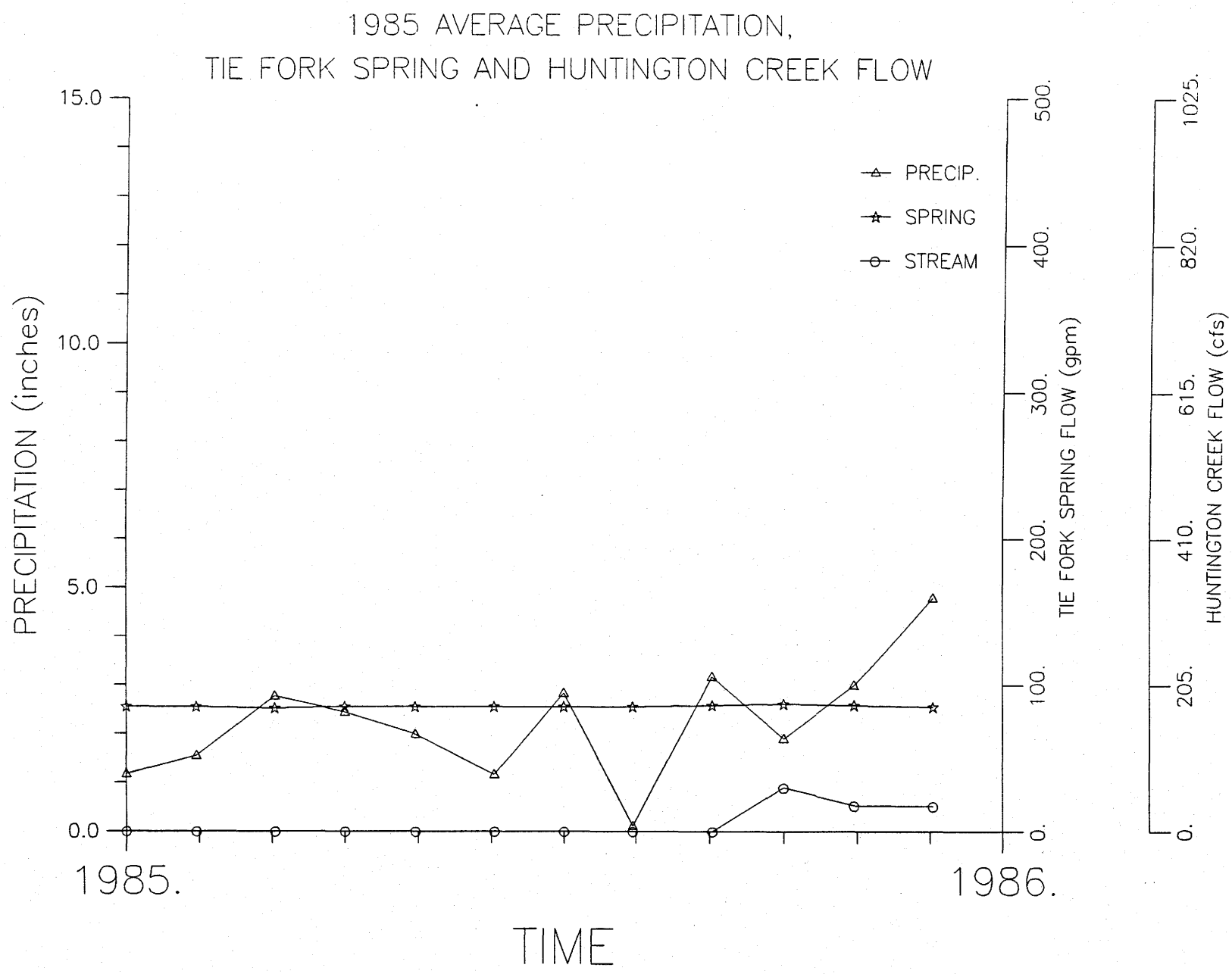

1987 AVERAGE PRECIPITATION,
LITTLE BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1987.
1988.
TIME

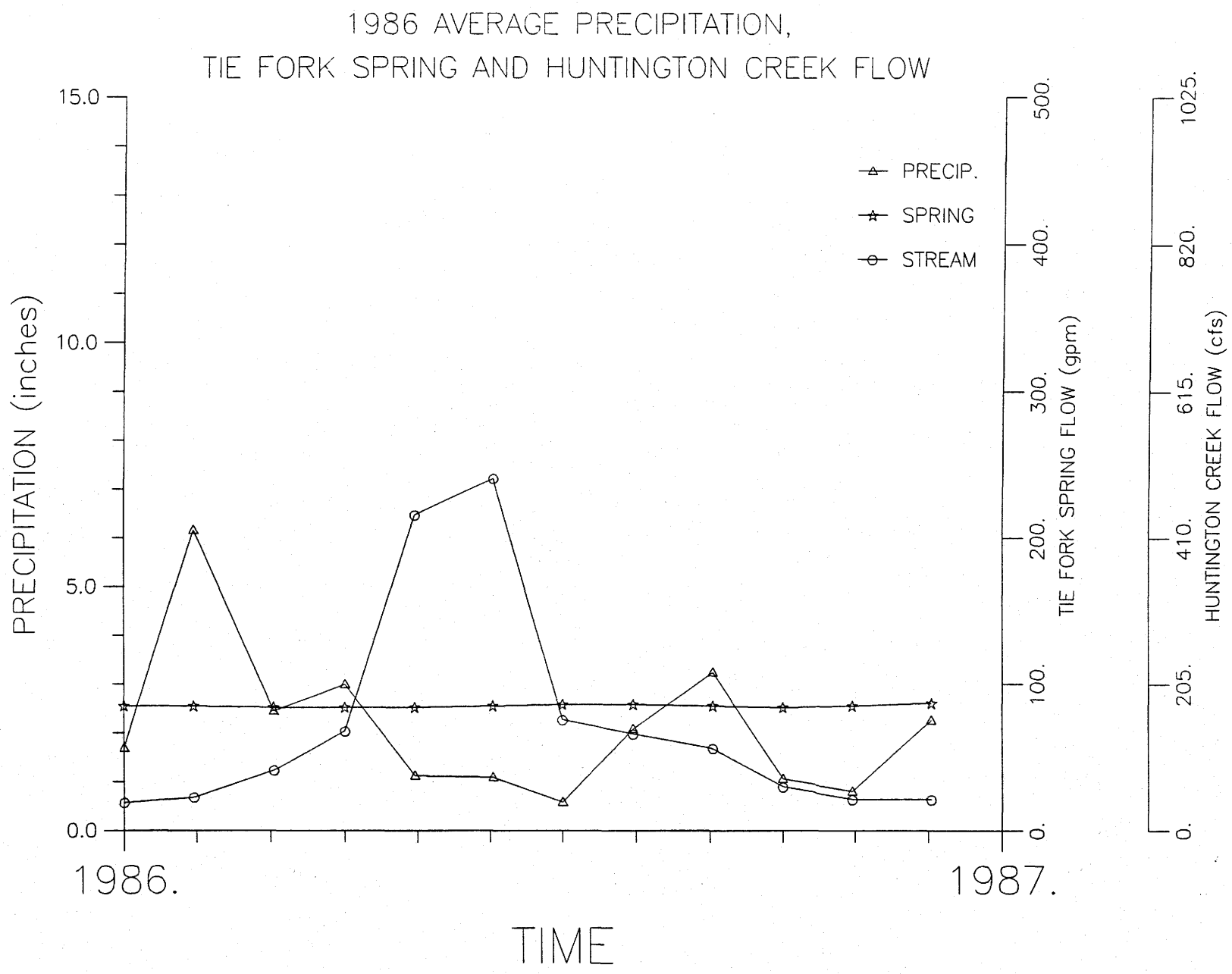

1988 AVERAGE PRECIPITATION,
LITTLE BEAR SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
PLUGGED SCREEN
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1988.
1989.
TIME

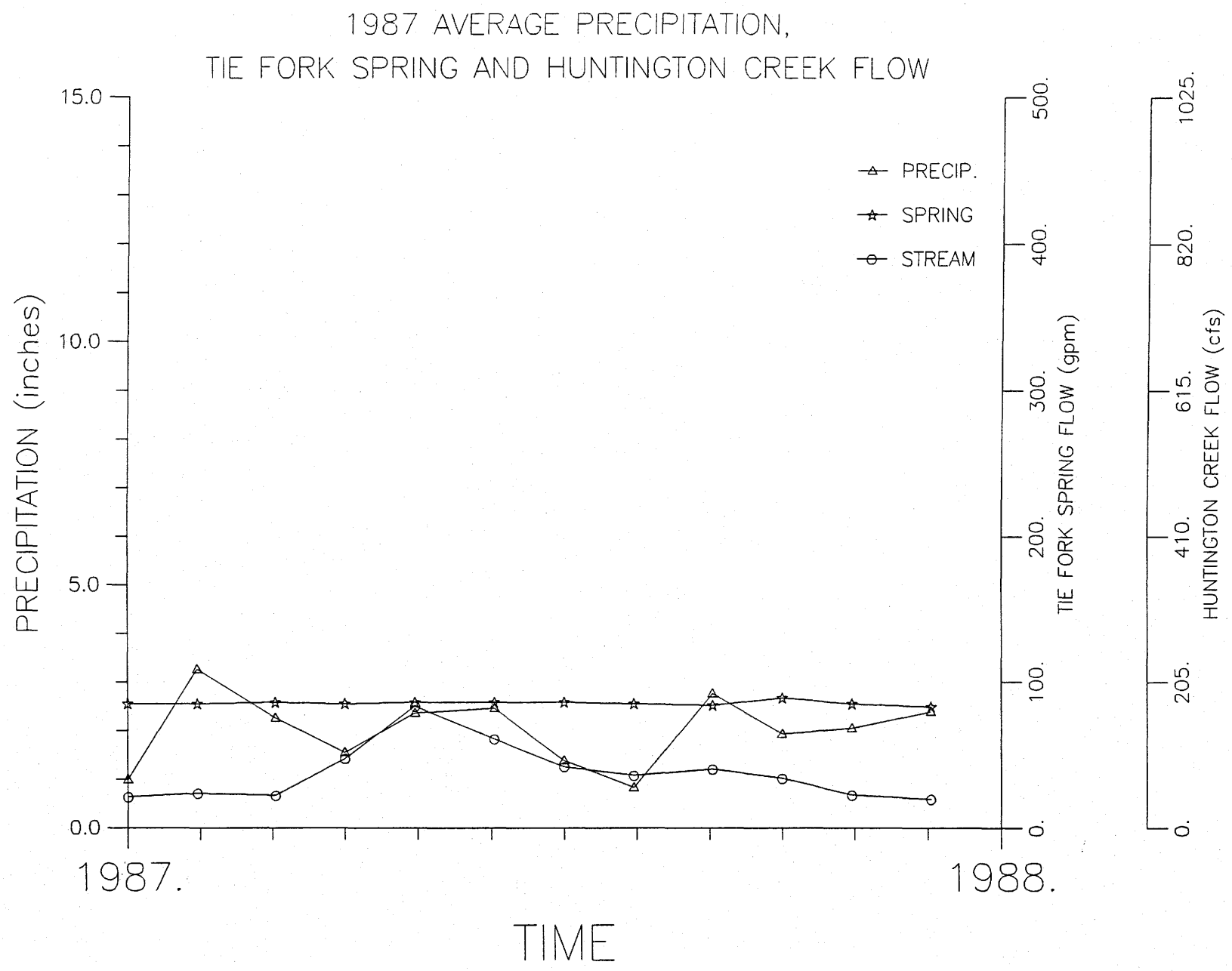

1989 AVERAGE PRECIPITATION AND
LITTLE BEAR SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
PLUGGED
SCREEN
1989.
1990.
TIME

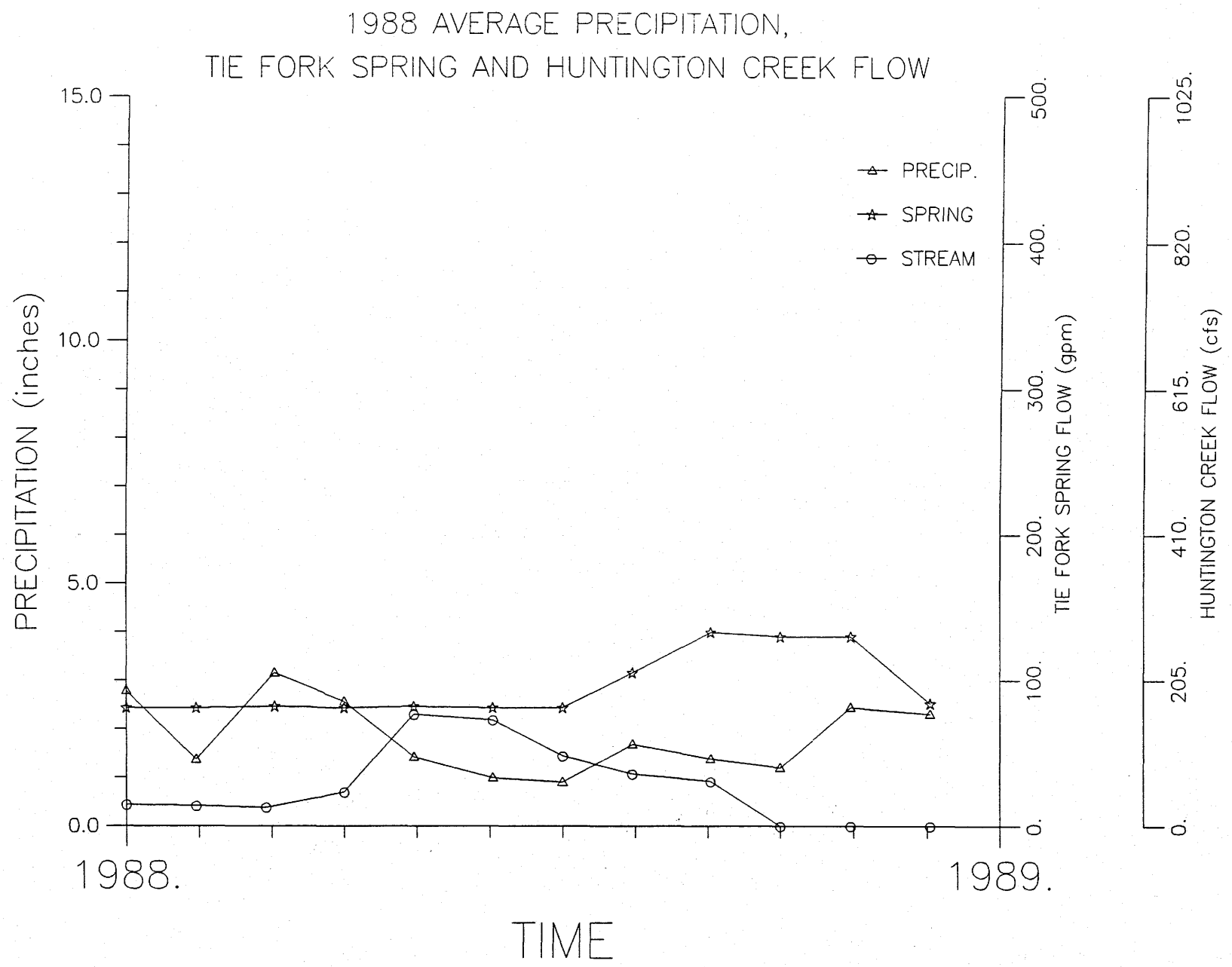

1990 AVERAGE PRECIPITATION AND
LITTLE BEAR SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
LITTLE BEAR SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1990.
1991.
TIME

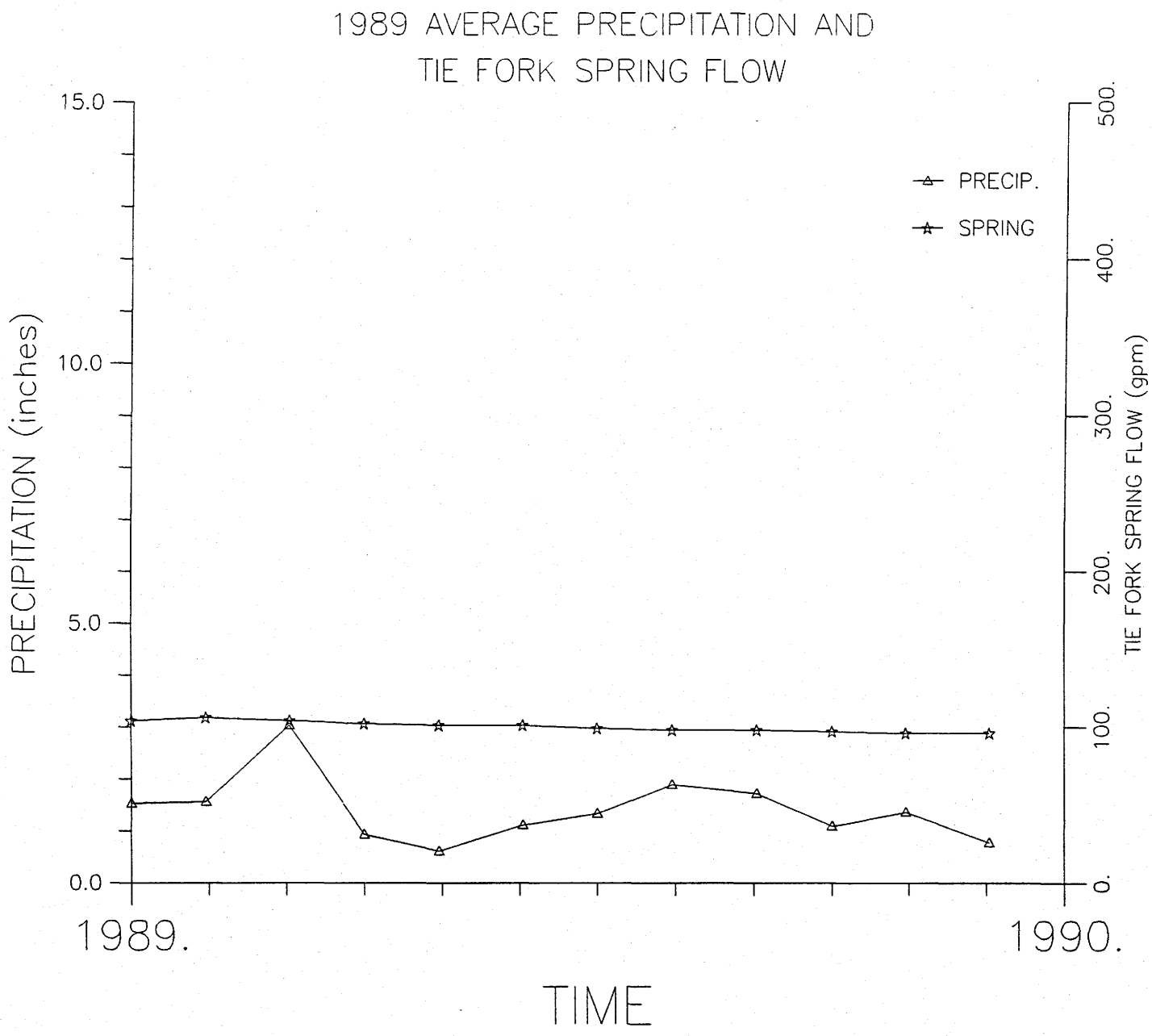

1984 AVERAGE PRECIPITATION,
TIE FORK SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1984.
1985.
TIME

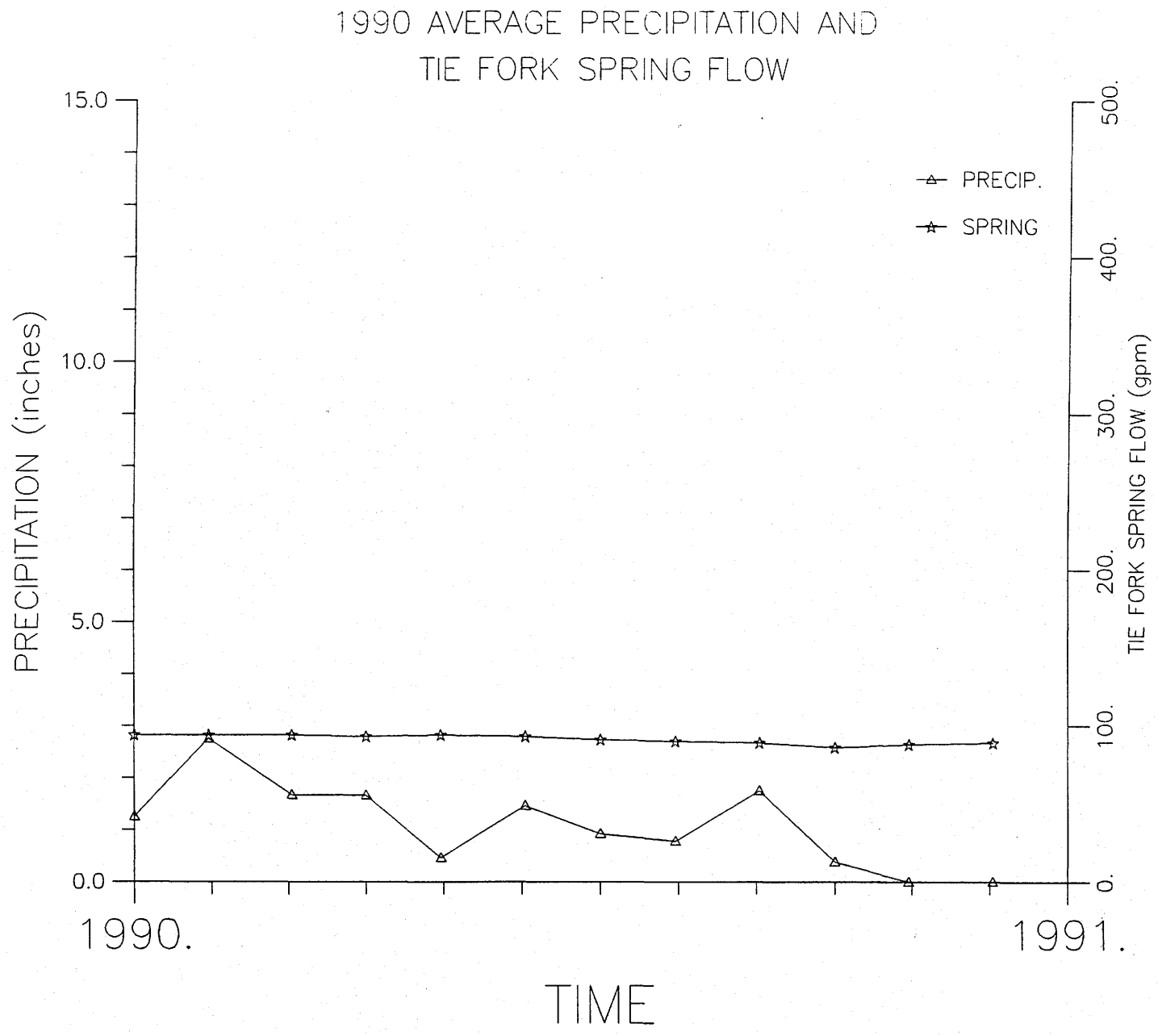

1985 AVERAGE PRECIPITATION,
TIE FORK SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1985.
1986.
TIME

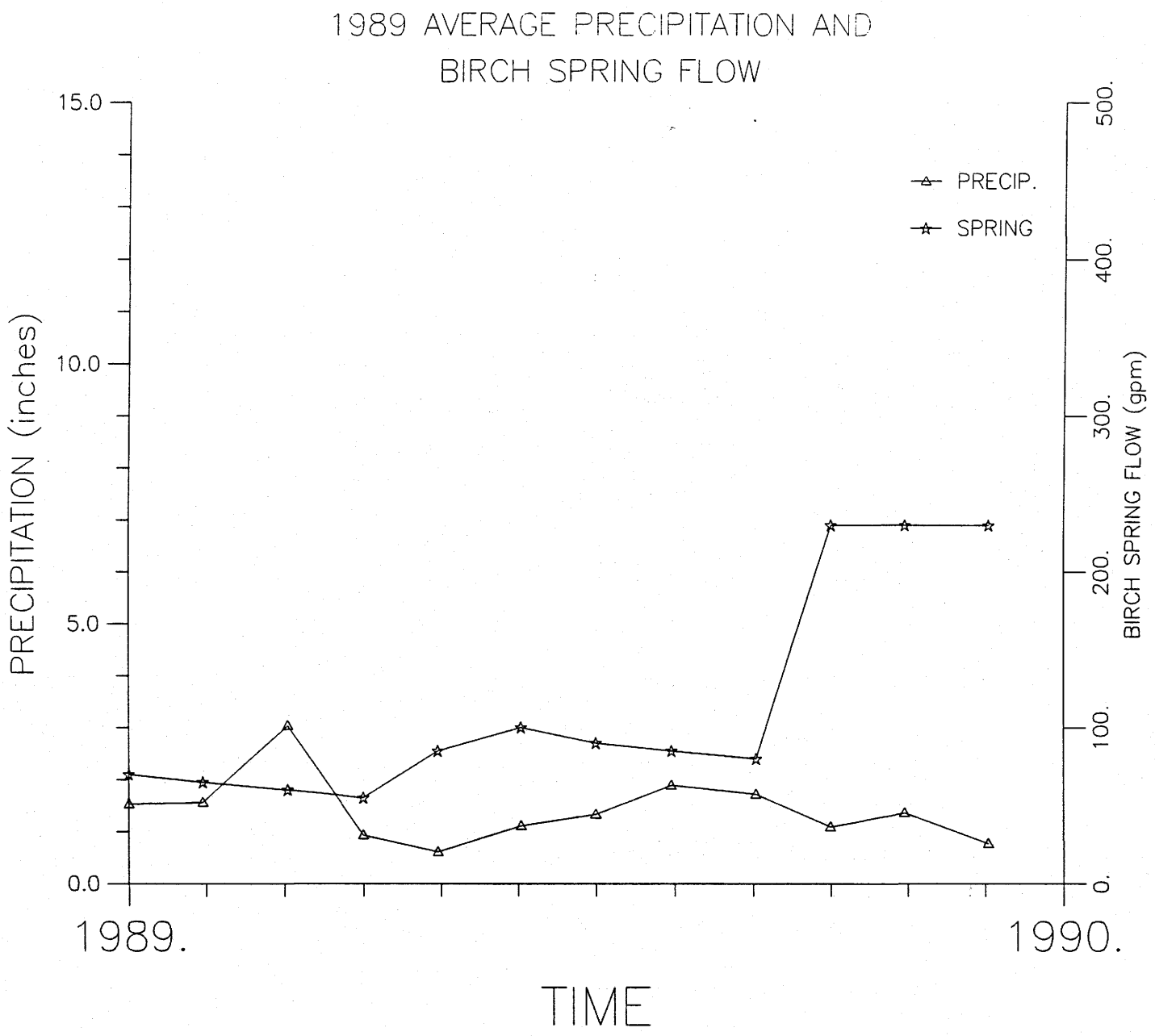

1986 AVERAGE PRECIPITATION,
TIE FORK SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1986.
1987.
TIME

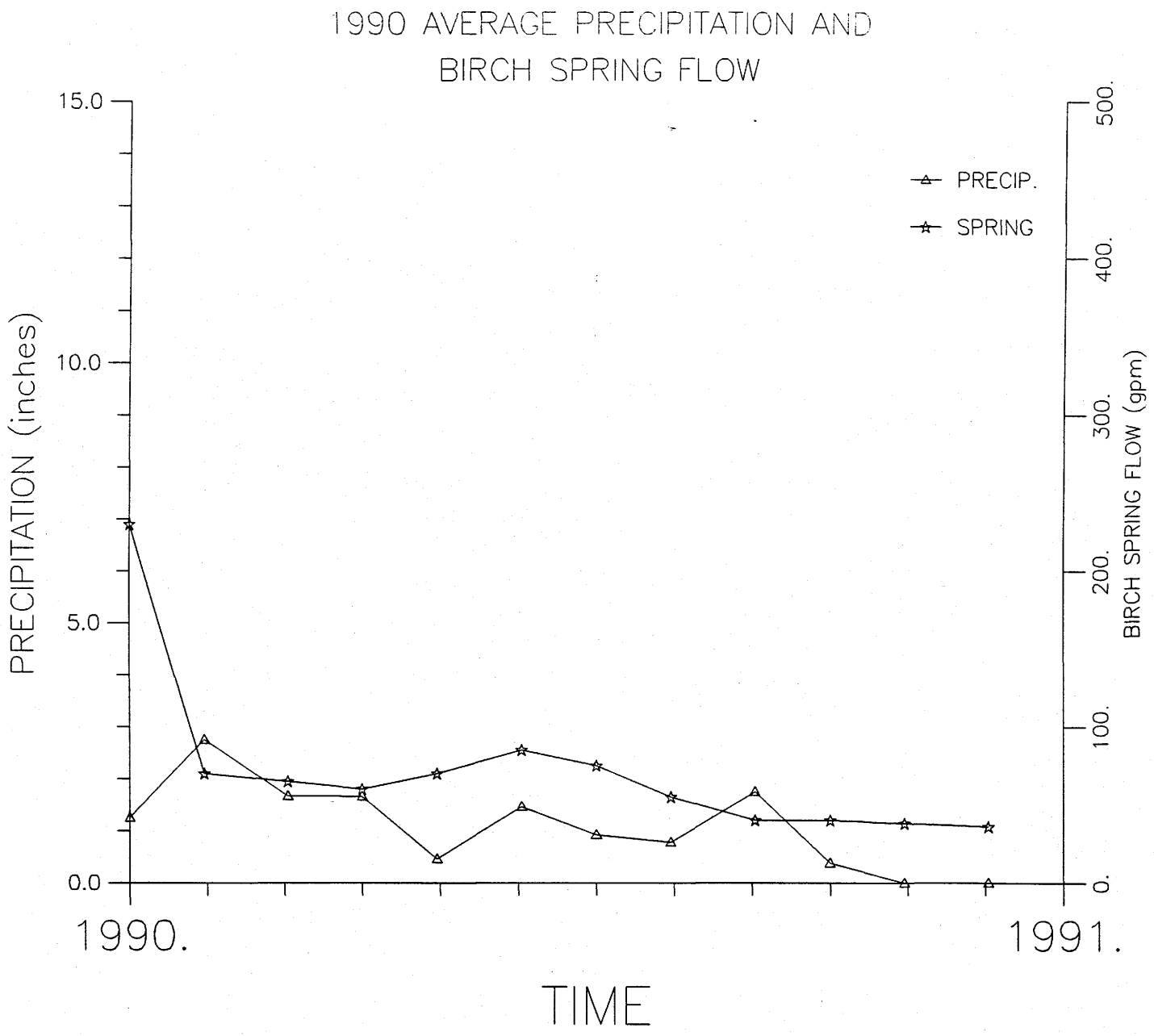

1987 AVERAGE PRECIPITATION,
TIE FORK SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1987.
1988.
TIME


1988 AVERAGE PRECIPITATION,
TIE FORK SPRING AND HUNTINGTON CREEK FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
PRECIP.
SPRING
STREAM
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
HUNTINGTON CREEK FLOW (cfs)
1025.
820.
615.
410.
205.
0.
1988.
1989.
TIME


1989 AVERAGE PRECIPITATION AND
TIE FORK SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1989.
1990.
TIME


1990 AVERAGE PRECIPITATION AND
TIE FORK SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
TIE FORK SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1990.
1991.
TIME


1989 AVERAGE PRECIPITATION AND
BIRCH SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
BIRCH SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1989.
1990.
TIME


1990 AVERAGE PRECIPITATION AND
BIRCH SPRING FLOW
PRECIPITATION (inches)
15.0
10.0
5.0
0.0
BIRCH SPRING FLOW (gpm)
500.
400.
300.
200.
100.
0.
PRECIP.
SPRING
1990.
1991.
TIME