DATA REPORT

Spring Discharge along the Milner to King Hill Reach of the Snake River

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INTRODUCTION

Background

Some of the most spectacular springs in the world are found along the Snake River canyon in the Milner to King Hill reach of the Snake River. Eleven of the 65 springs in the United States with a discharge greater than 100 cfs are found along this reach (Fetter, 2001). The abundance of cold, high quality spring water has spawned an extensive aquaculture industry and provides water for irrigation, hydropower, and domestic purposes. The future of these industries and uses depends upon a sustained water supply from the springs. This document provides a view of what we know about the history of the spring discharge so that we may be better able to evaluate current trends. Graphs of spring discharge are included after the narrative to improve continuity of the discussion.

This document provides the viewer with a graphical description of spring discharge and aquifer water levels. Little narrative is included in the report as this document is intended to be a data resource, not an interpretive evaluation. This work was funded by the U.S. Environmental Protection Agency's Idaho Water Quality Initiative and the U.S. Bureau of Reclamation's Regional Decision Support Systems program.

General Description

The Snake River canyon extends from Milner Dam downstream beyond King Hill. The canyon has cut a cross-section through the highly productive Snake River Plain aquifer that results in numerous high discharge springs emanating along the canyon wall (Figure 1). Some of these springs (e.g. Thousand Springs) can be observed as near-horizontal linear features on the canyon wall. These springs are apparently flowing from contacts between basalt flow layers. Other springs, for example Devils Washbowl, are found in alcoves cut back into the Snake River Plain aquifer a half-mile or more (Janczak, 2001). These alcoves apparently form preferential locations for discharge because they have provided a "short-cut" for water flowing from the aquifer. Many springs, such as Niagara and Curren Tunnel, appear to emerge from pillow basalt (Covington and Weaver, 1990) that was formed when basalt flowed into an ancestral water body. These pillow basalts may form preferential pathways that extend back into the aquifer for an unknown distance.

The springs occur mostly as discrete points of discharge, located relatively high on the canyon wall, implying that basalts beneath this level are much lower in hydraulic conductivity and likely do not contribute greatly to the ground water flow in this area. Although differences in chemistry of the spring water occur along the forty mile reach, there appears to be no distinct differences among springs in any given area (Clark and Ott, 1996; Struhs and Johnson, in preparation), suggesting that basalt layering does not produce distinctly different aquifer layers at different elevations. A detailed profile, including geology, is provided in Covington and Weaver (1990).

The discrete discharge points reflect the potential for preferential flow paths within the Snake River Plain aquifer. The lateral continuity and interconnectedness of these preferential pathways is extremely important to understanding the flow system but is poorly understood. It is also possible that the preferential flow in spring discharge areas has been enhanced by subsurface erosion processes near the springs.

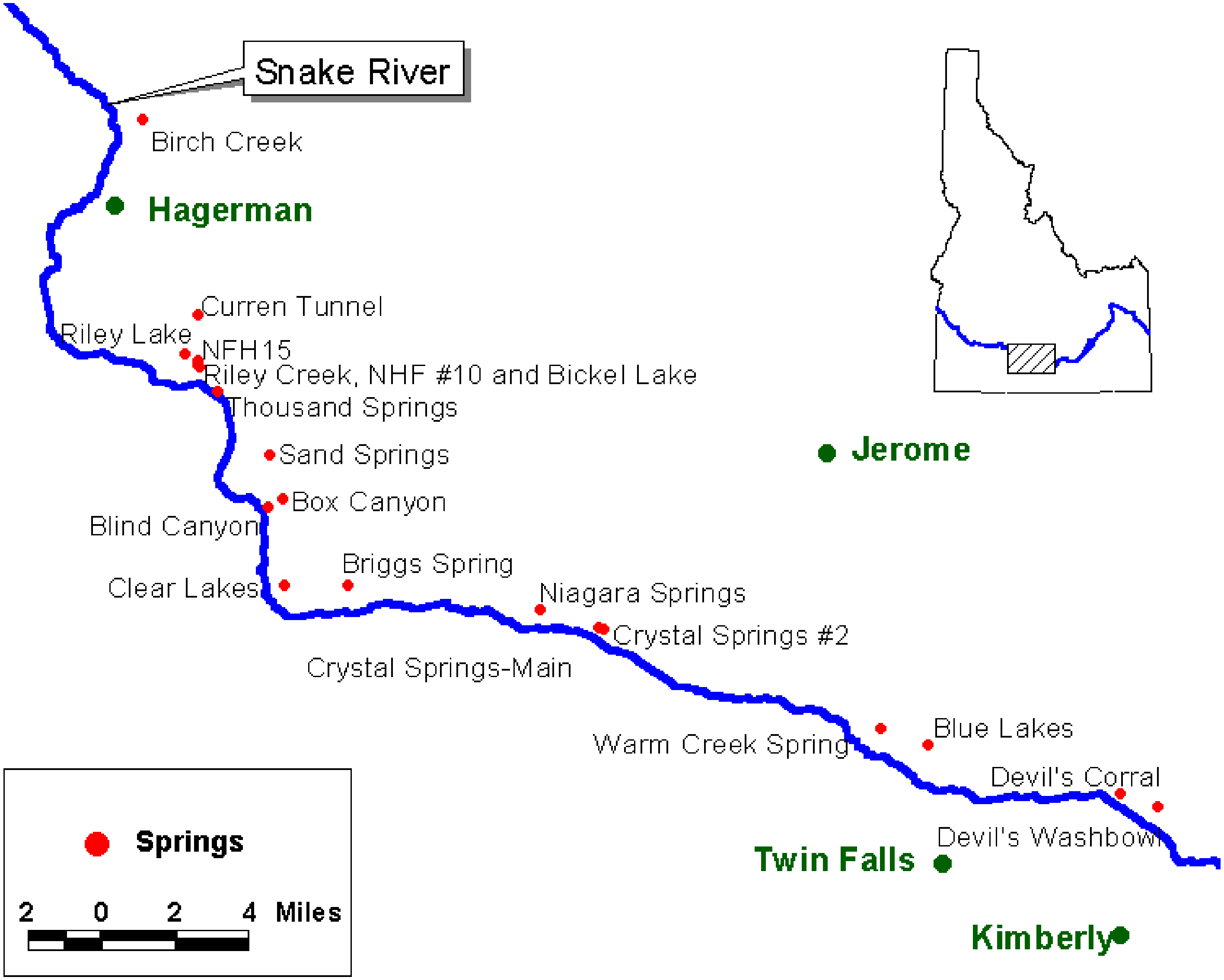

Figure 1. Spring location map.

Data Sources

Spring discharge data were graciously provided by the U.S. Geological Survey, the Idaho Department of Water Resources (IDWR), the U.S. Fish and Wildlife Service Hagerman National Fish Hatchery, and Clear Springs Foods Inc. Some additional data were collected by the University of Idaho with funding from the U.S. Environmental Protection Agency. Data collected by the IDWR is a result of state requirements for measurement and reporting of water use. IDWR also holds water use data for many springs not included in this document because the measurements do not represent the entire flow of a spring and/or are affected by diversions.

SPRING DESCRIPTIONS

Discharge data for springs for which measurements were available and meaningful are presented in a progression from upstream to downstream. In many cases, springs have not been included because measurements have been affected by upstream diversions or surface inflows to the channel. A summary of the included spring locations and elevations is presented in Table 1. The latitude and longitude in Table 1 were determined by GPS and elevations were determined by altimeter. The elevation represents the highest point where water appears. In many cases the spring may discharge from the canyon wall at a higher elevation and cascade beneath talus before becoming visible.

Devil's Washbowl

Spring discharge is measured at a USGS rated channel section downstream of Vineyard Lake. Covington and Weaver (1990) indicate that the springs emerge from basalt cooling joints. Altimeter readings place the point of spring emergence at an elevation of about 3840 feet above sea level. Daily discharge records to the nearest 1 cfs are available from the USGS from 1950 to 1959 and from 1985 to present (Figure 2). Five miscellaneous measurements were made from 1902 to 1924. There are no diversions or tributaries above the gaging station.

The historical record shows a dramatic change in discharge through the period of record. It appears that the discharge was probably in the 10 to 20 cfs range in the early 1900s and increased through the first half of the century. The average discharge from 1951 through 1958 (water years) was 22.4 cfs. From 1990 through 1999, the average discharge was 12.5 cfs, a 44 percent decrease. Despite the dramatic change in discharge, the seasonal pattern remained nearly unchanged (Figure 3). Seasonal variation was about 24 percent of the average daily flow in the 1950s and was about 34 percent of the average flow in the 1990s. Although the relative seasonal change is greater in the latter period, the absolute difference is less.

Devil's Corral

Spring discharge has been measured intermittently by the USGS using a current meter in a natural channel. Discharge records are available from 1902 through present. The springs discharge at an elevation of about 3560 feet through talus that is an erosional remnant of the Sands Springs Basalt (Covington and Weaver, 1990).

Table 1. Identification, location, and elevation of included springs.

Spring Name	USGS ID Number	Township	Range	Section	Latitude (of spring, not gaging station)	Longitude (of spring, not gaging station)	Elevation (of spring in ft above msl)
Devils Washbowl	13089600	10 S	18 E	3 bb	42^{o} 35.52’	114^{o} 20.62’	3840*
Devils Corral	13090101	9 S	18 E	32 ad	42^{o} 36.01’	114^{o} 21.94’	3560**
Blue Lakes (pre-1950)	13091500	9 S	17 E	28 ad	42^{o} 36.93’	114^{o} 27.91’	3300*
Blue Lake (post 1950)	13091000	9 S	17 E	28ad	42^{o} 36.93’	114^{o} 27.91’	3300*
Warm Creek	NA	9 S	17 E	29 ba	42^{o} 37.18’	114^{o} 29.64’	3140**
Ellisons	13093300	9 S	16 E	22 a	42^{o} 38.22’	114^{o} 33.67’	3290**
Crystal No.2 & No.3	NA	9 S	15 E	12 bd	42^{o} 39.53’	114^{o} 38.36’	3150*
Crystal Main	13093400	9 S	15 E	12 db	42^{o} 39.60’	114^{o} 38.60’	3150*
Niagara	13093700	9 S	15 E	11 db	42^{o} 39.89’	114^{o} 40.48’	3240*
Clear Lakes	13094500	9 S	14 E	2 ad	42^{o} 40.45’	114^{o} 46.62’	3070**
Briggs	13095200	9 S	14 E	3 bd	42^{o} 40.42’	114^{o} 48.30’	3040*
Banbury	13095300	8 S	14 E	33 bc	42^{o} 41.38’	114^{o} 29.13’	3120*
Blind Canyon	13095400	8 S	14 E	28 db	42^{o} 42.20’	114^{o} 48.96’	3150*
Box Canyon	13095600	8 S	14E	27 ba	42^{o} 42.50’	114^{o} 48.18’	3060*
Sand Springs	13132600	8 S	14 E	21 ab	42^{o} 43.47’	114^{o} 49.05’	3150*
Thousand Springs	13132800	8 S	14 E	8	42^{o} 44.32’	114^{o} 50.24’	3090*
Bickel Lake	NA	8 S	14 E	6 da	42^{o} 45.47	114^{o} 51.30’	2980**
Riley Lake	NA	8 S	14 E	6 da	42^{o} 45.60’	114^{o} 51.35’	2980**
NFH10	NA	8 S	14 E	6 ac	42^{o} 45.57’	114^{o} 51.35’	3010*
NFH 15	NA	8 S	14 E	6 ac	42^{o} 45.68’	114^{o} 51.40’	3030*
Riley Creek	13133800	8 S	14 E	NA	42^{o} 45.52’ ***	114^{o} 51.33’ ***	NA
Curren Tunnel	NA	7 S	14 E	32 bc	42^{o} 46.60’	114^{o} 50.84’	3140*
Birch Creek	13135100	6 S	13 E	35 cd	42^{o} 51.20’	114^{o} 52.98’	3020*

* determined by U of I using altimeter calibrated to local benchmarks
** from Covington and Weaver (1990)
*** represents location of gage

The historical record (Figure 4) has a high degree of variability but may indicate an increase in discharge during the first half of the century, and a decrease since the 1960s. Data are too infrequent to show definitive seasonal variation.

Blue Lakes Spring

Spring discharge has been measured by the USGS at two locations. Prior to 1950 discharge was measured at station 13091500, near the point where the spring discharges into the Snake River. Since 1950, daily discharge data are available for station 1309100, which is nearer the point where springs discharge from the canyon wall. Since 1994, the City of Twin Falls has been diverting part of the municipal supply from wells installed at the spring discharge point, upstream of the gaging station. The pumping records are summed with the open channel flow by the USGS to estimate total discharge. The springs emerge from beneath talus on the alcove floor (Covington and Weaver, 1990) at an elevation of approximately 3300 feet. The canyon wall above the discharge point is composed of Sand Springs Basalt.

The historic record shown in Figure 5 is a combination of records from the two locations. Although channel seepage and measurement location may cause differences between the two stations, they appear to record approximately the same discharge during the 1940s and 1950s. The historic record indicates that spring discharge may have increased several fold during the first half of the 20th century. Since 1950, a relatively steady decline in spring discharge (ignoring seasonal variation) has been apparent. Average discharge in the 1950s (1951-57 & 59) was 228 cfs and during the 1990s (1990-99) was 166 cfs, a decline of approximately 31 percent. The seasonal variation indicated by average daily discharge for the 1950s and the 1990s (Figure 6) is, in both cases, about 13 percent of the respective average annual discharge. The minimum discharge occurs in May or June and the maximum occurs in October, similar to other springs.

Warm Creek Spring (Sunny Brook Springs)

Warm Creek Spring emerges from the Melon Gravel, at the contact with the Banbury Basalt at an elevation of 3140 feet (Covington and Weaver, 1990). Staff gage readings at an 8-foot sharp crested suppressed weir are used to estimate discharge. The USGS made intermittent measurements at Warm Creek (station 13091700) from 1902 through 1967. The recorded discharge during this period was erratic, and ranged between 15 and 25 cfs. Since 1994, discharge has been reported to the IDWR. The flows recorded by IDWR are less than 10 cfs and are not consistent with flows recorded earlier by the USGS due to channel modifications.

Historic observations since 1994 (Figure 7) show no trend or consistent seasonal variation. The lack of consistent trend and variation is likely due to upstream diversion effects.

Ellison Spring

Ellison Spring was intermittently measured by the USGS from 1950 though 1979. The spring emerges from talus at what is inferred to be the top of the Banbury Basalt.

The historic record indicates that discharge of Ellison Spring decreased during the period of record (Figure 8) to possibly 50 percent of the flow that existed in the 1950s.

Crystal Springs #2, #3, and hatchery house

The Crystal #2, Crystal #3, and hatchery house measurements are made by Clear Springs Foods and on file with the IDWR. Flow from both sets of observations is summed to represent total discharge of springs on the east side of the raceways. Crystal #2 is measured by two 7-foot suppressed rectangular weirs. Crystal #3 is measured by a 4-foot suppressed rectangular weir. Approximately weekly data are available from 1994 through present.

The collective discharge record of Crystal #2, #3 and the hatchery house (Figure 9) is of insufficient duration to identify trends. Consistent seasonal variation is apparent with a maximum discharge in October, and a minimum in May. The average seasonal variation during the 1996 through 2000 water years (Figure 10) was about 20 percent of the average annual flow.

Crystal Springs Main

Springs to the west of the Clear Springs Food hatchery are collected in a collection ditch and measured in a rated concrete section. The springs are thought to emerge from pillow facies of the Sand Springs basalt beneath a talus slope (Covington and Weaver, 1990). The springs discharge at an elevation of about 3150 feet.

Spring discharge has been measured by Clear Springs Foods since 1978 (Figure 11). Discharge was also measured by the University of Idaho since 1999 with a pressure transducer recording at hourly intervals. The period of record is insufficient to observe long-term trends, however, the seasonal cycle appears similar to that of other springs, with a maximum discharge in early October, and a minimum in May. The average variation in the seasonal cycle in the 1991 through 2001 water years (Figure 12) is about 30 cfs or 17 % of the average annual discharge.

Niagara Springs

Niagara Springs issue from pillow basalts deposited in an ancestral channel of the Snake River (Malde, 1971). Springs discharge from the canyon wall at an estimated elevation of about 3240 feet. Daily discharge data are available from the USGS from 1958 to 1972. Miscellaneous measurements are available for the preceding and succeeding periods. The comparability of the measurements from the different periods is unknown, although there does not appear to be any significant offset in the data, with the possible exception of the 1972 transition.

The historical data (Figure 13) show a substantial increase in discharge in the first half of the century and a possible declining trend superimposed over a substantial seasonal cycle since 1950. The elimination of the continuous measurement in 1972 makes it difficult to discern a trend. The daily average discharge over the period of record exhibits a 29 percent variation from the low in May to the high in October (Figure 14). This seasonal variation is greater than that observed in most other springs.

Clear Lakes Springs

Clear Lakes Springs discharge from pillow lava of the Sand Springs Basalt and surface at an elevation of about 3070 (Covington and Weaver, 1990). Talus above the discharge point hides the point of emergence from the canyon wall which may be as much as 130 feet above the point where the spring is visible. Flow has been measured approximately annually by the USGS from 1963 through 1998. Flow through the Clear Springs Foods Inc. and the Idaho Trout Processors fish farms also originates from Clear Lakes Springs and has been measured by Clear Springs Foods Inc. from 1982 to present. The flow through the fish farms represents a part of the flow at the USGS gage and is believed to be representative of seasonal and long term variation.

Long term trends cannot be easily interpreted from the available USGS data (Figure 15). The low frequency of observations do not permit evaluation of seasonal variation. If observations are limited to measurements made in springtime, then a slight decrease in discharge may be evident over time. Average discharge is about 500 cfs, however, this estimate may be biased due to the observation frequency (e.g. observations during spring would probably result in a smaller discharge than observations in fall). Observations of collective discharge through the Clear Springs Foods and Idaho Trout Processors fish farms are more frequent and more definitive of seasonal variation (Figure 16). A seasonal variation of only about seven percent is apparent in the data. However, because observations are performed quarterly, the observations may not have captured the seasonal highs and lows and the true seasonal variation may be greater than seven percent.

Briggs Spring

Briggs Spring emerges from talus of the Sand Springs Basalt (Covington and Weaver, 1990) at an elevation of about 3040 feet. The true point of emergence of the springs from the canyon wall is hidden by talus but may be as much as 110 feet higher than where the springs appear from beneath the talus. Intermittent observations are available from 1902 to 1989 and a continuous discharge record is available from the USGS for the period from 1989 to present. Records prior to 1950 may be inconsistent due to measurement by different entities and at different locations.

Prior to the continuous record starting in 1989, it is difficult to determine long-term or seasonal variation (Figure 17). Since 1989, there may be a modest decline in average annual discharge. The continuous data show a relatively consistent pattern of highest discharge in October and minimum discharge in either May or August. A short-term increase in discharge during June followed by a decline in July also frequently appears. This “summer peak” is also apparent in the discharge records for Curren Tunnel and Box Canyon. Averaged daily discharge for water years 1990 through 1997 (Figure 18) show the seasonal cycle and show an attenuated “summer peak”. The eight-year average attenuates the summer peak because the timing varies slightly among years. During the 1990 to 1997 period the average seasonal variation was 14 cfs or 11 percent of the mean annual flow.

Banbury Springs

A series of springs discharge from pillow lava (behind talus) of the Sand Springs basalt at an elevation of about 3120 feet above sea level. The entire 2000 foot lateral section of springs appears to discharge from an ancestral river channel incised into the Banbury Basalt and subsequently filled with Sand Springs Basalt (Covington and Weaver, 1990).

Discharge records have been maintained by the USGS from 1949 to 2000 (Figure 19). The historic record indicates that discharge has averaged about 120 cfs. No long-term trend or seasonal variation can be determined from the record.

Blind Canyon Spring

The springs discharge from the Sand Springs Basalt (Covington and Weaver, 1990) at an elevation of about 3150 feet. Less permeable sedimentary materials, associated with pillow basalts, appear to cause the springs to discharge at this elevation. Discharge was intermittently measured by the USGS from 1917 to 1997. Discharge was also estimated in 1901 at 1.5 cfs and several measurements from the 1950s are not shown because they may be in error due to surface inflows. The University of Idaho installed a sharp-crested contracted weir with a pressure transducer and recorder in 1999. The device is installed below a fish hatchery and consequently is subject to short-term flow variations resulting from hatchery operations.

The long-term discharge record available from the USGS does not provide adequate resolution to determine long-term trends or seasonal variation (Figure 20). The continuous record provided by the University of Idaho instrumentation shows some unexplained erratic behavior in 1999 superimposed on an apparent seasonal cycle. During the 2000 water year (October 1999 through September 2000) the discharge varied from a maximum flow of about 9 cfs in November to a minimum of about 7 cfs in July. This is equivalent to a seasonal variation of about 25 percent of the average annual flow.

Box Canyon Spring

Box Canyon Spring discharges from the Sand Springs Basalt (Covington and Weaver, 1990) at an elevation of about 3060 feet. Continuous discharge records are available from the USGS for the period of 1950 to 1998. Prior to 1950, several discharge measurements were made (as early as 1915).

The historical discharge exhibits a declining trend between the 1950s and present (Figure 21). Average discharge for the water years of 1951 through 1960 was 416 cfs. Discharge declined to 341 cfs during the period of 1991 through 2000, a change of 20 percent relative to the average flow. The seasonal variation appears to have significantly changed during the period of record (Figure 22). In the 1951 through 1960 water years, the seasonal variation was about 16 percent of the average annual flow. The amplitude of the seasonal cycle declined to about 10 percent of the annual flow in the 1990s. A second notable change in the seasonal cycle is that discharge began increasing in May in the earlier period and does not show significant increases until late August in the hydrograph representing the 1990s. The later period also exhibits a “summer peak” with a brief increase in discharge during June and subsequent decline during July. This can be seen in Figure 21 and somewhat in Figure 22, although attenuated due to the averaging of ten years of data in the latter. This pattern is similar to that observed in Curren Tunnel and Briggs Spring.

Sand Springs

Sand Springs discharges from beneath a contact between the Thousand Springs Basalt and the Sand Springs Basalt at an elevation of about 3150 feet. Discharge has been measured intermittently since 1912, mostly by the USGS. Discharge is determined from a rated section and flow measurement in one diversion upstream of the rated section.

Measurements (Figure 23) indicate that discharge probably increased during the first half of the 20th century and have likely decreased since the 1950s. No seasonal cycle can be determined. The apparent wide variation in discharge since the 1950s is partially due to measurements made in both spring and fall of some years.

Thousand Springs

Thousand Springs emerges from the pillow lava facies of the Thousand Springs Basalt contact with the Banbury Basalt at an elevation of about 3090 feet. Discharge is diverted into a collection channel above the Thousand Springs power plant. Diversions from Sand Springs Creek and Snow Bank Spring are intermingled with the water of Thousand Springs before entering the power plant. Consequently, discharge estimates based on power production reflect a combination of discharge from the three sources. Of the three sources, however, Thousand Springs is by far the largest.

Discharge, estimated from power production at the Thousand Springs Power Plant, shows no evidence of long-term trend or seasonal variation (Figure 24). It is likely that the record is influenced by changes in the mixture of water from different sources and other external factors and therefore does not provide sufficient detail to observe either long-term or seasonal variation.

Bickel Lake

Springs emerge from beneath talus at an elevation of about 2980 feet and flow into Bickel Lake at the Hagerman National Fish Hatchery. The lake discharges over a 15-foot long Cipolletti weir. A staff gage mounted in the lake, upstream of the weir is used to determine discharge. Due to the long weir crest at this location, staff gage readings are insensitive to changes in discharge.

Historic data collected by the Hagerman National Fish Hatchery and data collected by the University of Idaho since May 1999 show no patterns of long-term or seasonal change (Figure 25). This is likely due to data resolution.

Riley Lake

Similar to Bickel Lake, springs discharging from beneath talus and flow into Riley Lake on the Hagerman National Fish Hatchery at an elevation of about 2980 feet. Discharge from the lake is measured as stage over a seven foot long Cipolletti weir. Stage is insensitive to changes in discharge due to the large weir length. Riley Lake discharge has been monitored by the US Fish and Wildlife Service and the University of Idaho (Figure 26). The reason for the higher observed discharge in the 1960s is unknown. Discharge may have declined slightly since the late 1960s but the resolution of the data makes interpretation questionable.

National Fish Hatchery Spring 10

The spring discharges from vegetation-covered talus of the Thousand Springs Basalt at an elevation of about 3010 feet. Discharge was measured by the Hagerman National Fish Hatchery using a 4-foot contracted weir until 12/20/96 at which time the device was replaced with a 1.83 foot contracted weir. The University of Idaho has also been measuring discharge since May, 1999.

Seasonal variation, to an unknown degree, is apparent from the hourly pressure transducer records of the University of Idaho (Figure 27). What appear to be occasional surges in flow, of an unknown origin, make the record difficult to interpret. The earlier data, recorded by the Hagerman National Fish Hatchery, show a high degree of variation, but the cause of the variability is unknown.

National Fish Hatchery Spring 15

The spring discharges from beneath talus of the Thousand Springs Basalt at an elevation of about 3030 feet. Discharge is measured using a v-notch weir. Discharge records from the Hagerman National Fish Hatchery and the University of Idaho are plotted in Figure 28. During the 2000 water year, the University of Idaho data indicate that discharge varied by 10 percent (of average annual flow), ranging from a high of 4.3 cfs in November to a low of 3.9 cfs in July. A modest peak in May is apparent with the Spring 15 data similar to that observed in Curren Tunnel and Box Canyon. Similar variation is observed in data provided by the National Fish Hatchery.

Riley Creek below Lewis Spring

The USGS measured Riley Creek below Lewis Spring from 1951 to 1960. This measurement represents a cumulative discharge of several upstream springs. The amount of upstream regulation and diversion is unknown.

Discharge of Riley Creek in the 1950s shows a seasonal variation somewhat atypical of most springs measured in this period (Figures 29 and 30). The dramatic decline in discharge in early summer and recovery in fall appears as though the measurement may be compromised by irrigation diversions.

Curren Tunnel

The springs at Curren Tunnel discharge from a pillow lava facies of the Malad Basalt at an elevation of 3140 feet. A pressure transducer located near the tunnel outlet provides estimates of discharge based on a channel rating. Prior to 1999, water levels in the tunnel were determined by an ultrasonic sensor. Some water is diverted into a six inch pipe upstream of the gaging station and is not accounted for in the discharge records. Daily discharge data are available from the IDWR beginning in 1994.

Discharge records for Curren Tunnel show that year to year and seasonal variations are extreme relative to other springs examined (Figure 31). The yearly minimum flows (compared because of the completeness of record) vary by 67 percent of the average during the 1994-2001 water years. The peak seasonal discharge normally occurs in early November and the low occurs in July (Figure 32). The seasonal variation of the average daily values from water years 1994-01 is 95 percent of the average discharge. This degree of variation is not observed in any of the other springs with available records. There is also evidence of a brief increase in flow in May or June followed by a decline in late June and July. This “summer peak” pattern is similar to that observed in Box Canyon and Briggs Spring, but is more prominent at Curren Tunnel. The seasonal high that is observed in November may be lagged slightly from that observed in other springs. Small variations in the hydrograph of Figure 32 are a result of missing data in some of the years that were used to produce the averages.

Birch Creek

Springs discharge from a talus deposit of the Malad Basalt at an elevation of about 3020. Attempts to measure discharge by the University of Idaho from 1999-2001 were unsuccessful due to diversion of flow and vegetative growth in the channel.

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Spring Discharge Graphs

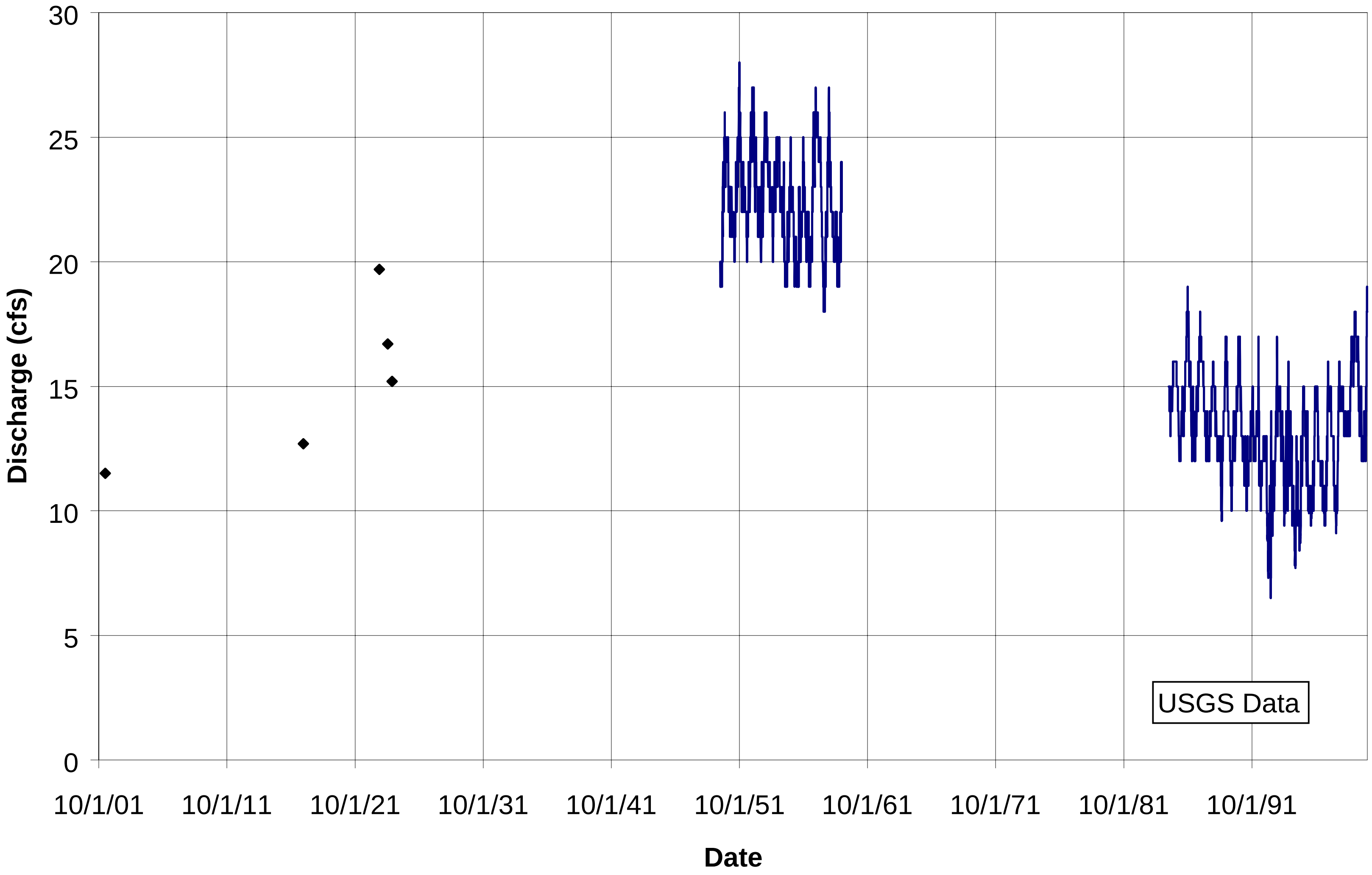

Figure 2. Devil's Washbowl Spring historic discharge.

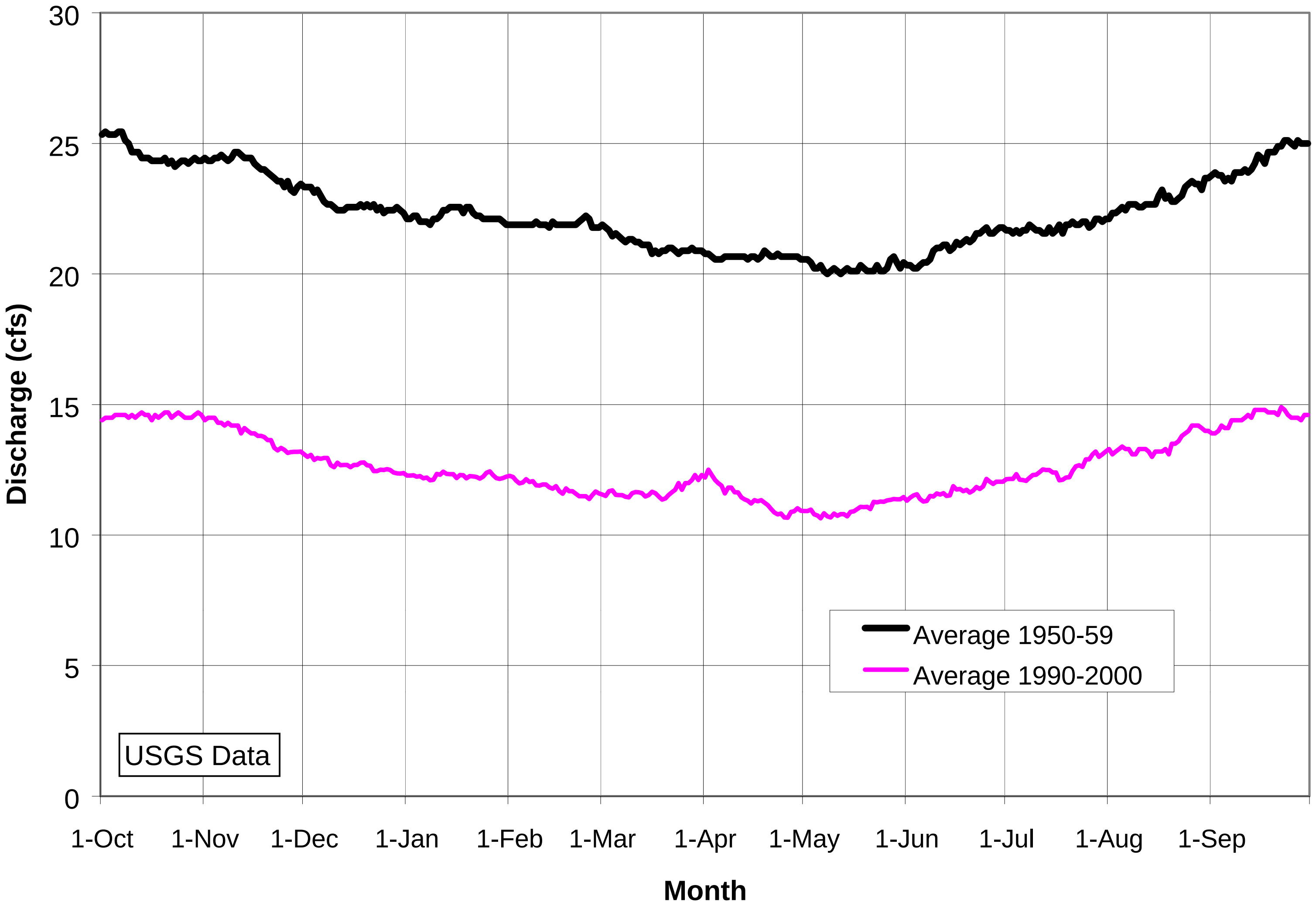

Figure 3. Devil's Washbowl average daily discharge.

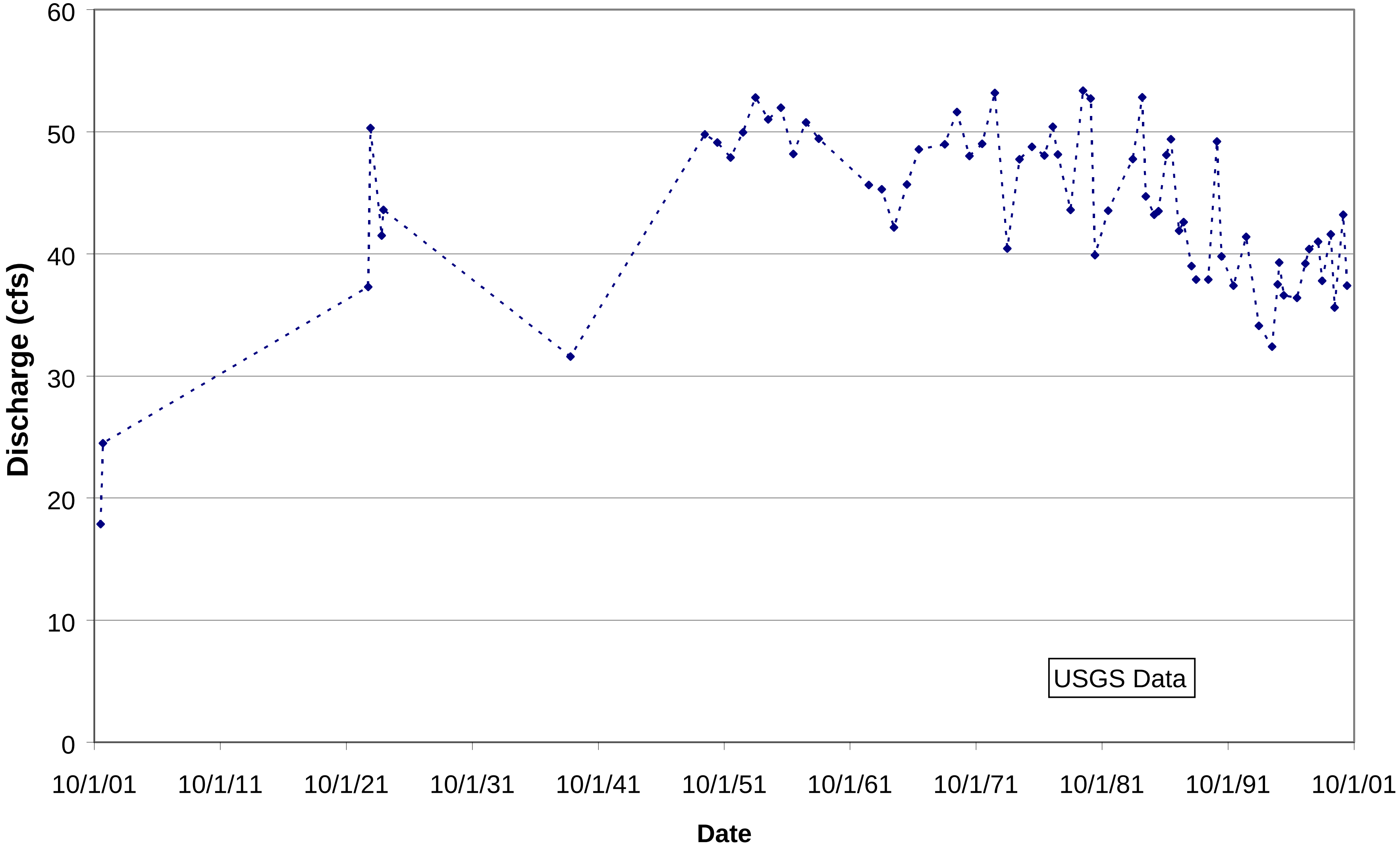

Figure 4. Devil's Corral spring historic discharge.

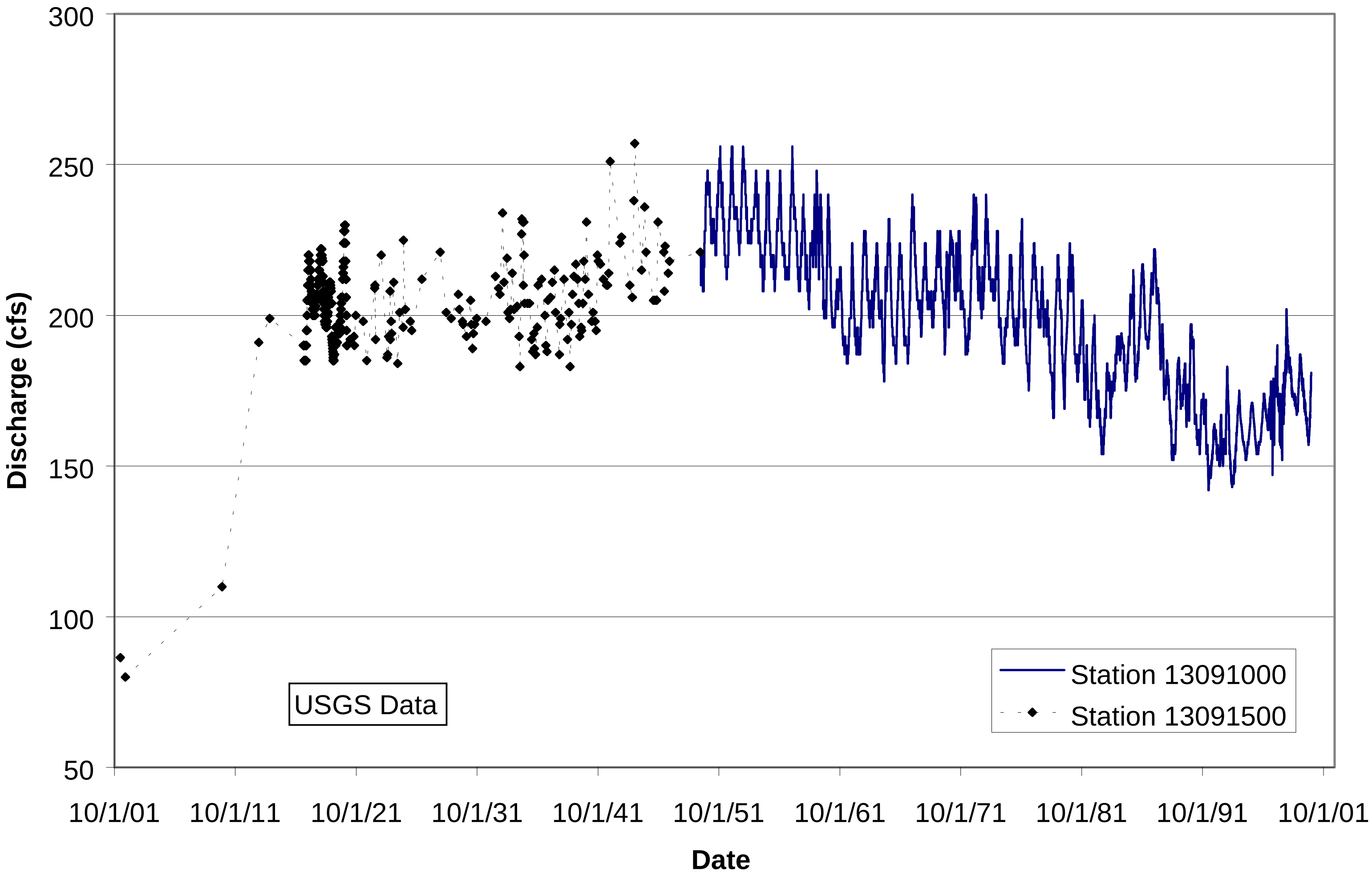

Figure 5. Blue Lakes Spring historic discharge.

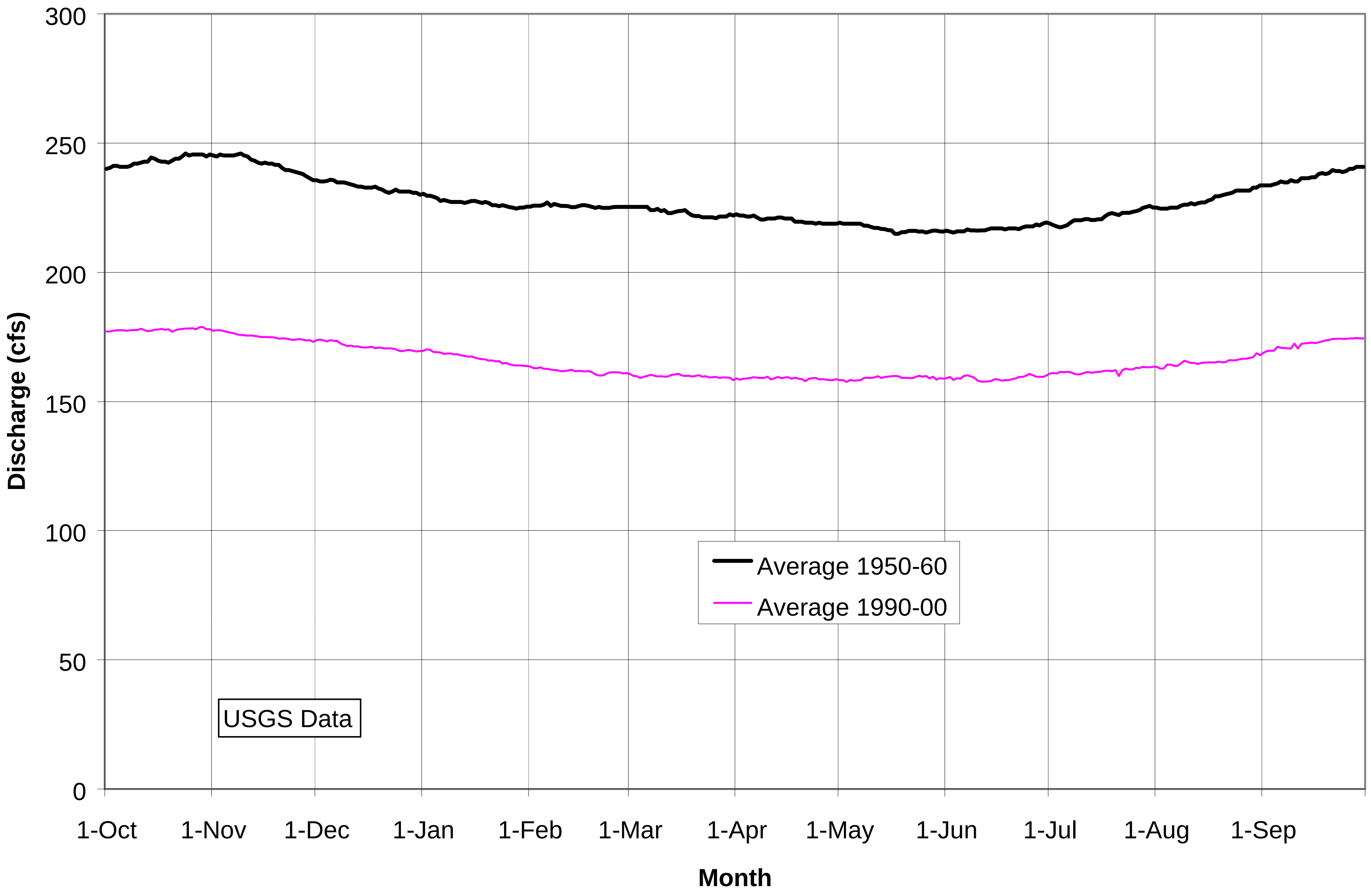

Figure 6. Blue Lakes Spring average daily discharge.

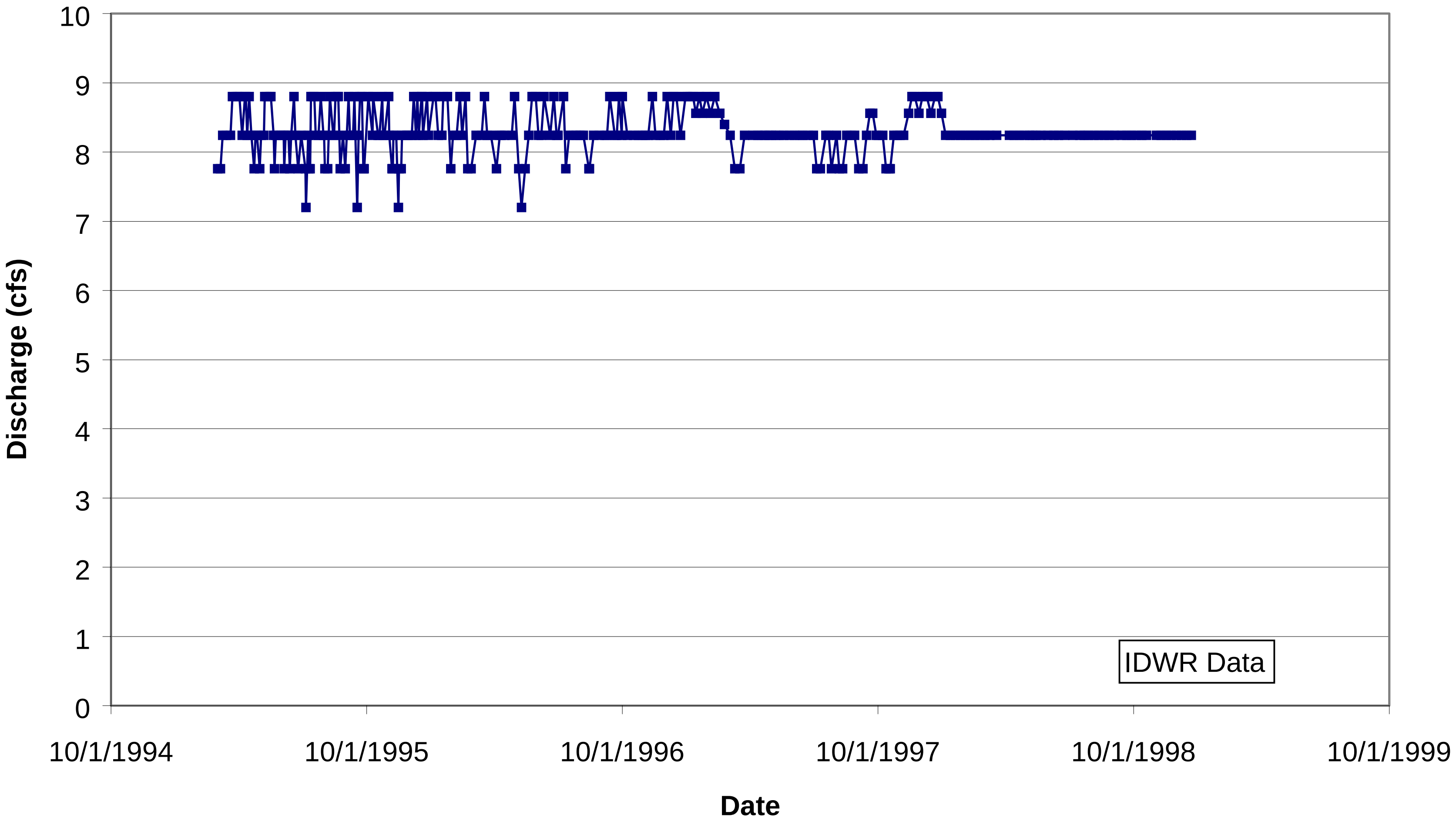

Figure 7. Warm Creek Springs (Sunny Brook Springs) historic discharge.

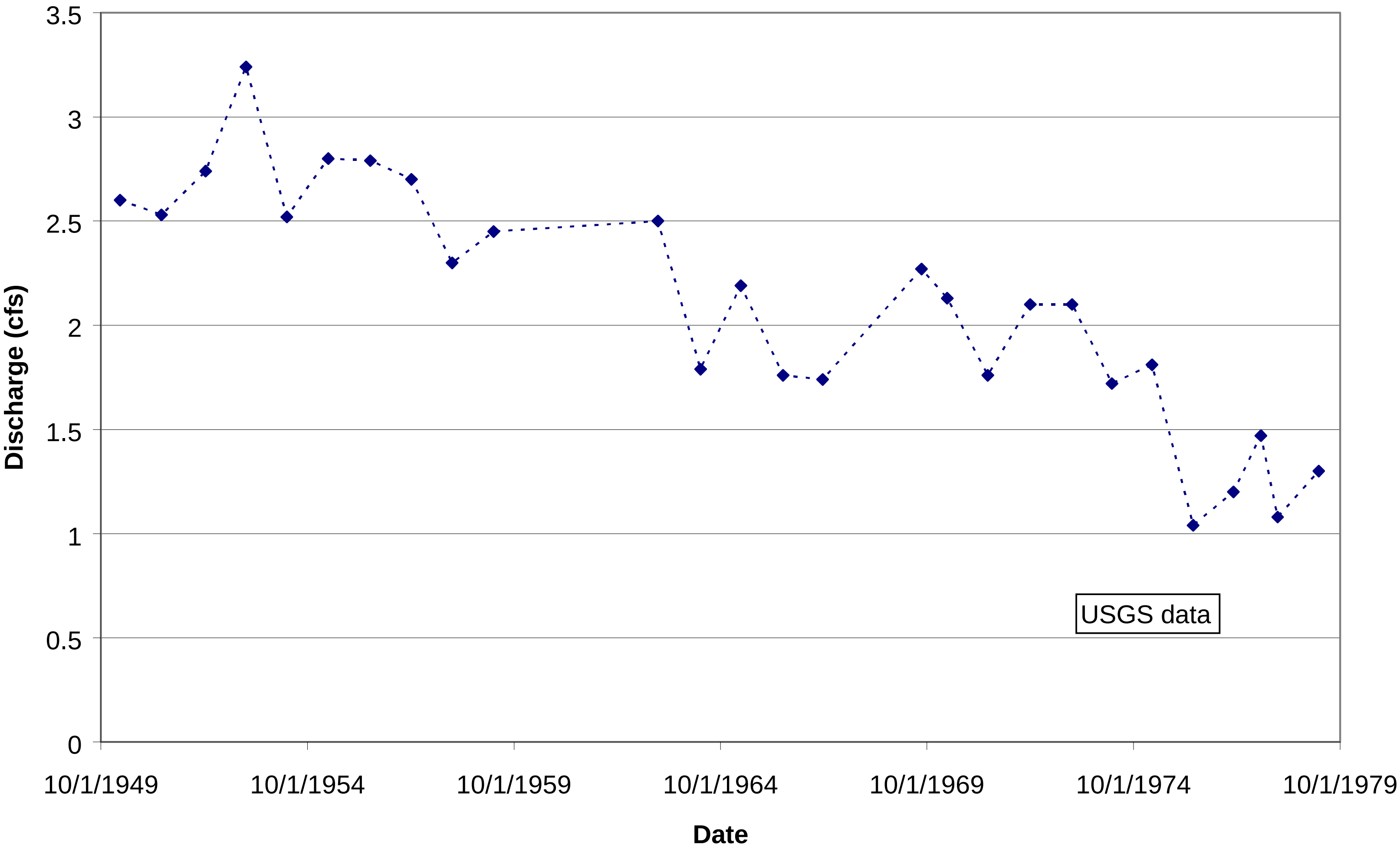

Figure 8. Ellison Spring historic discharge.

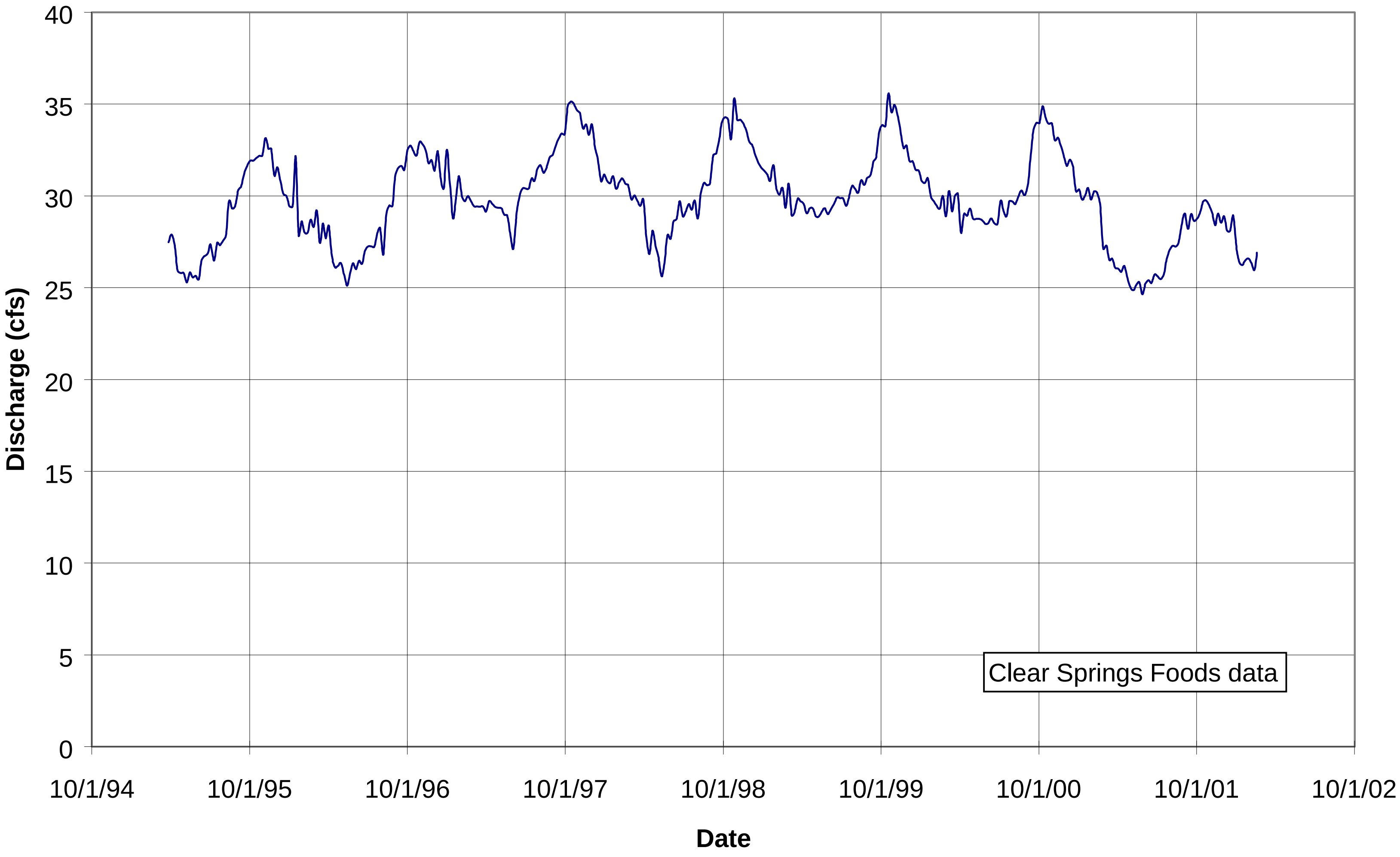

Figure 9. Summed discharge of Crystal Springs #2, #3 and Hatchery House.

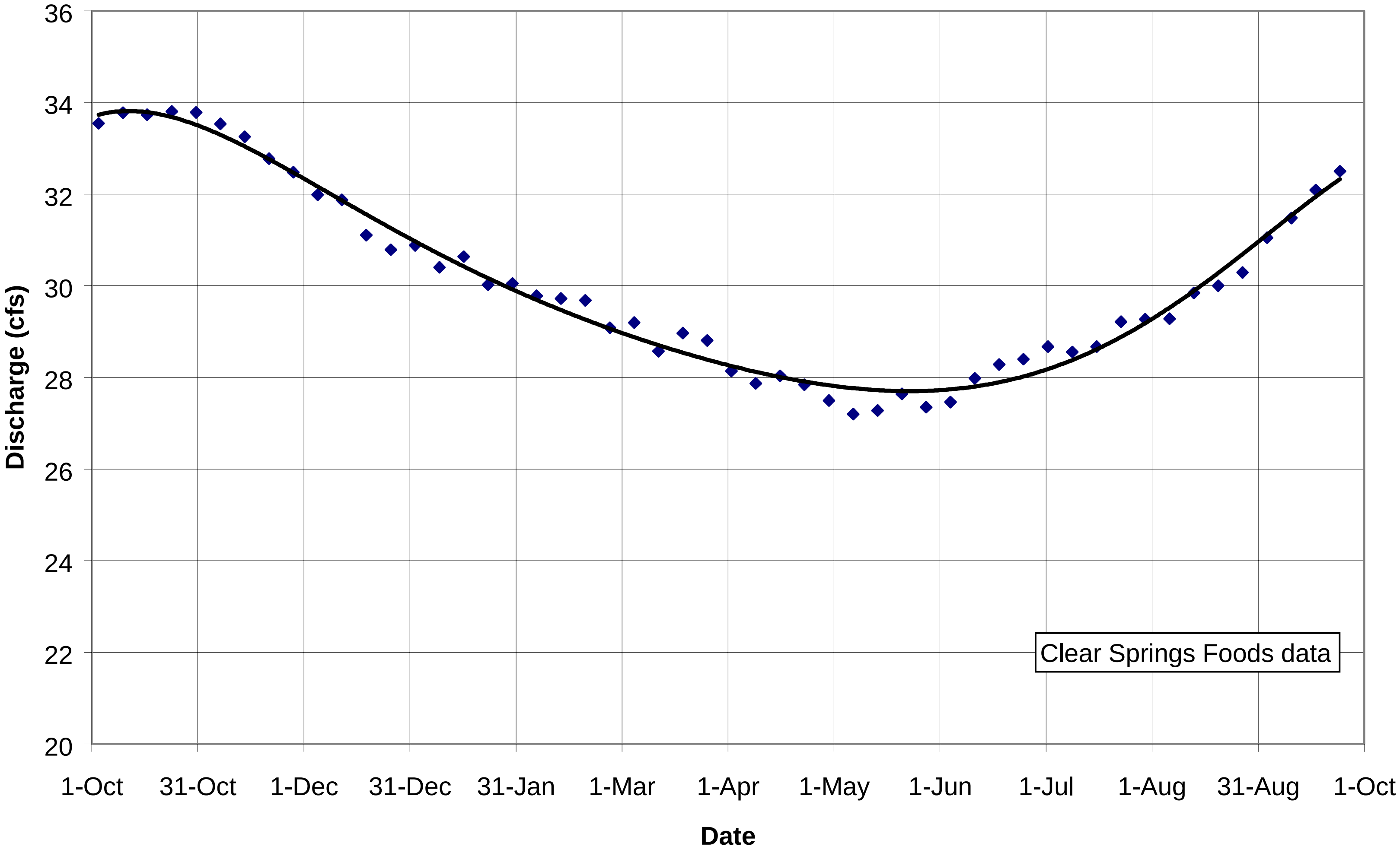

Figure 10. Crystal Springs #2+#3+Hatchery House average discharge (Oct 1995 - Sept 2000).

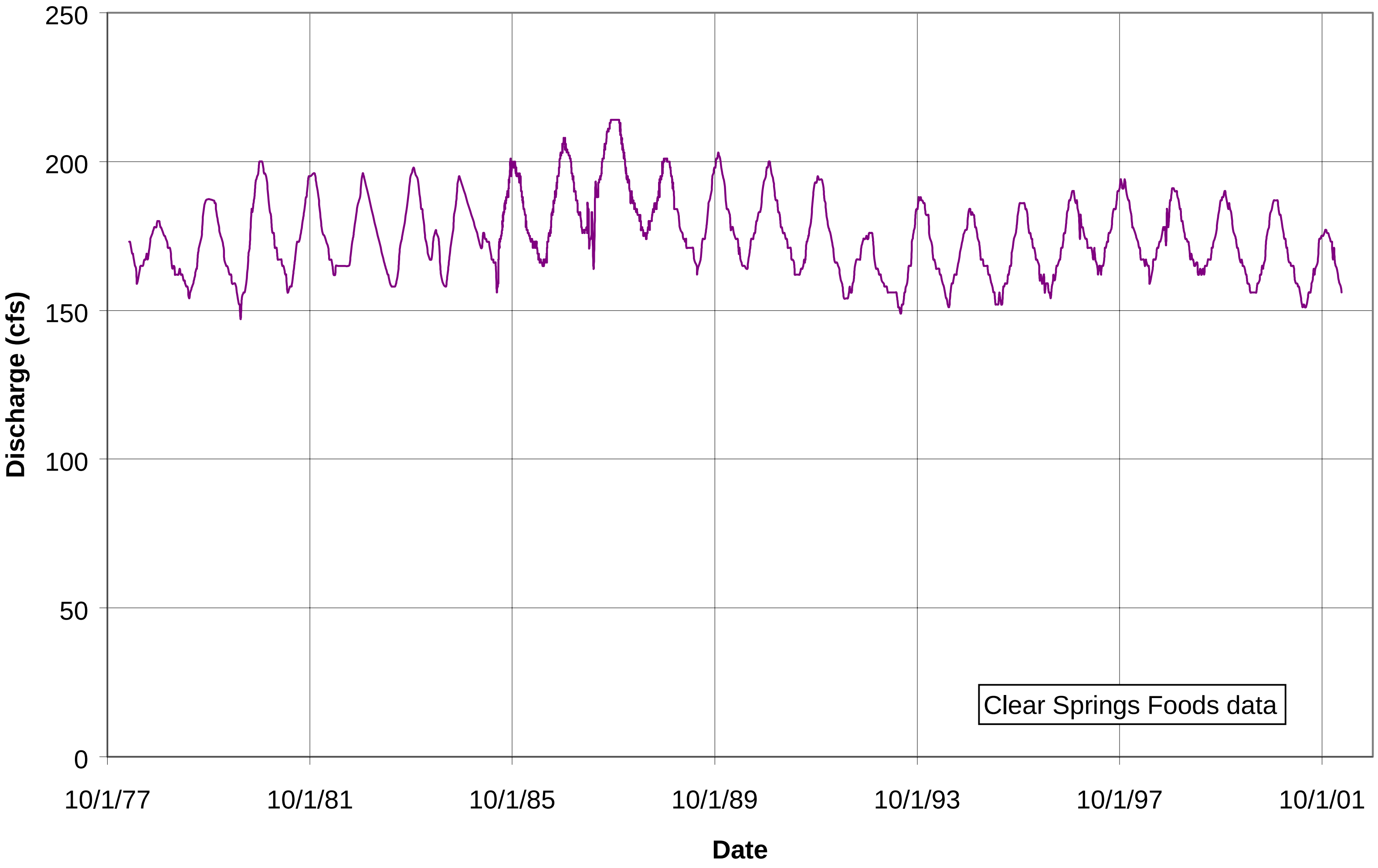

Figure 11. Crystal Springs Main historical discharge.

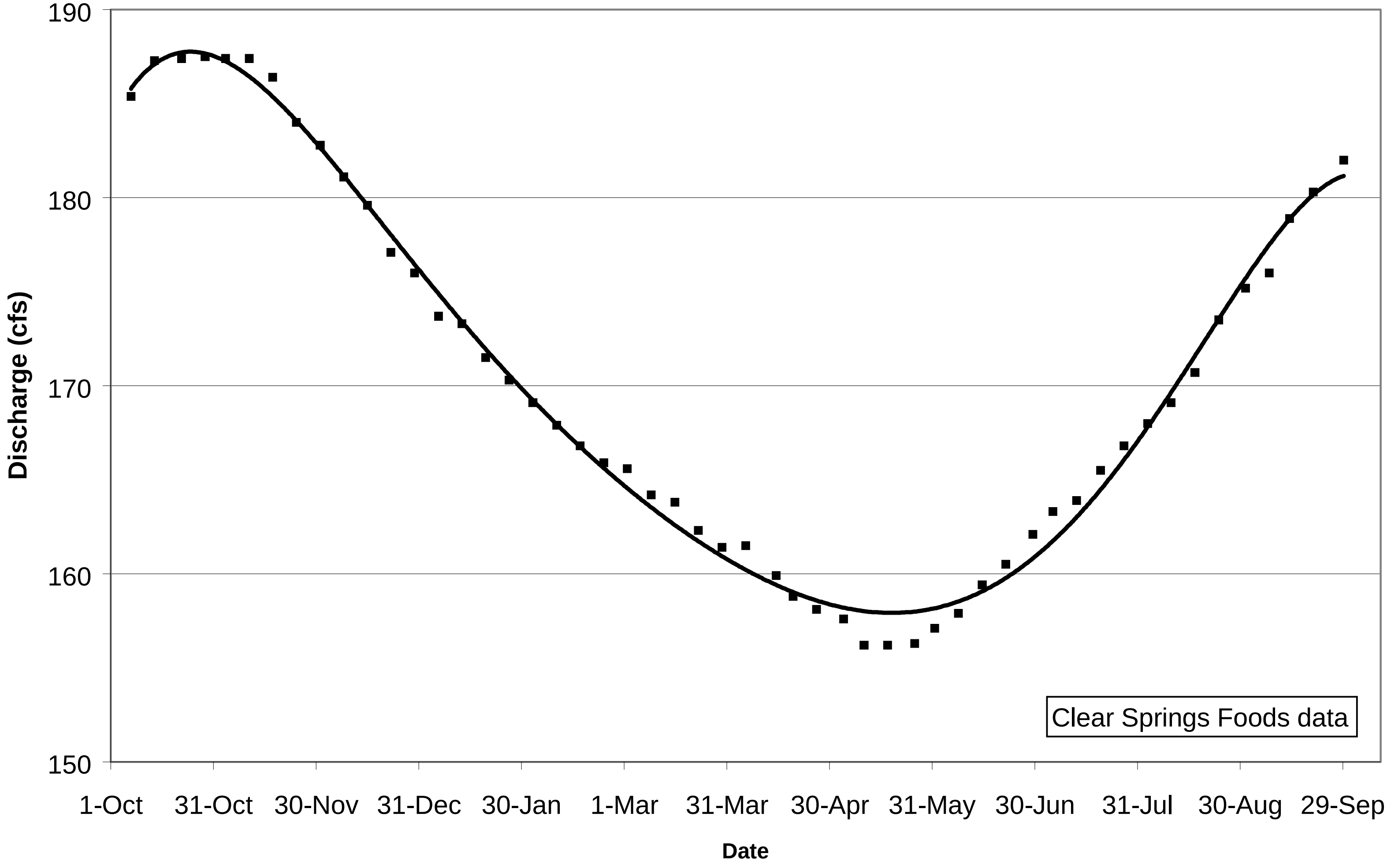

Figure 12. Crystal Springs Main average weekly discharge, 1991-2001.

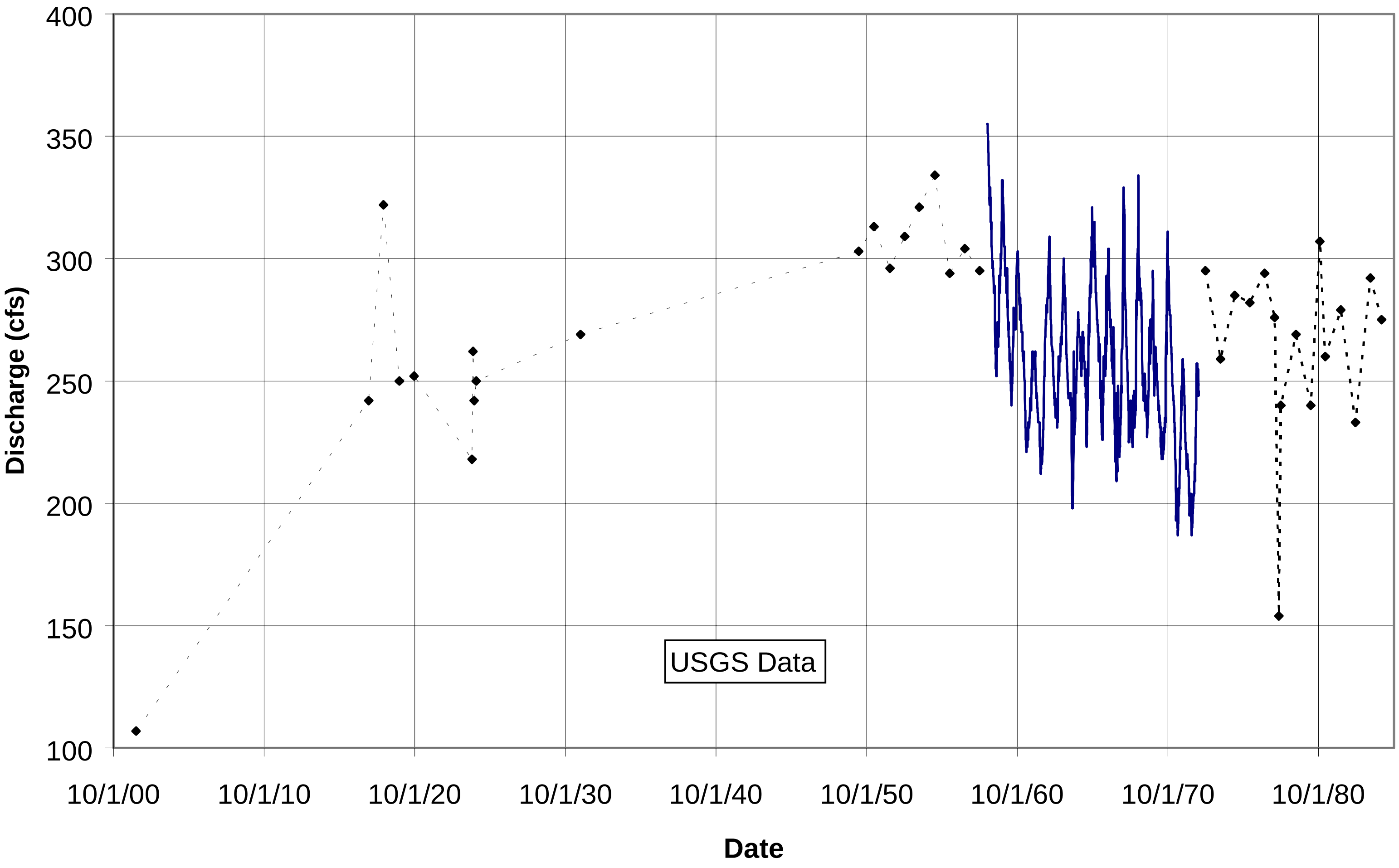

Figure 13. Niagara Springs historic discharge.

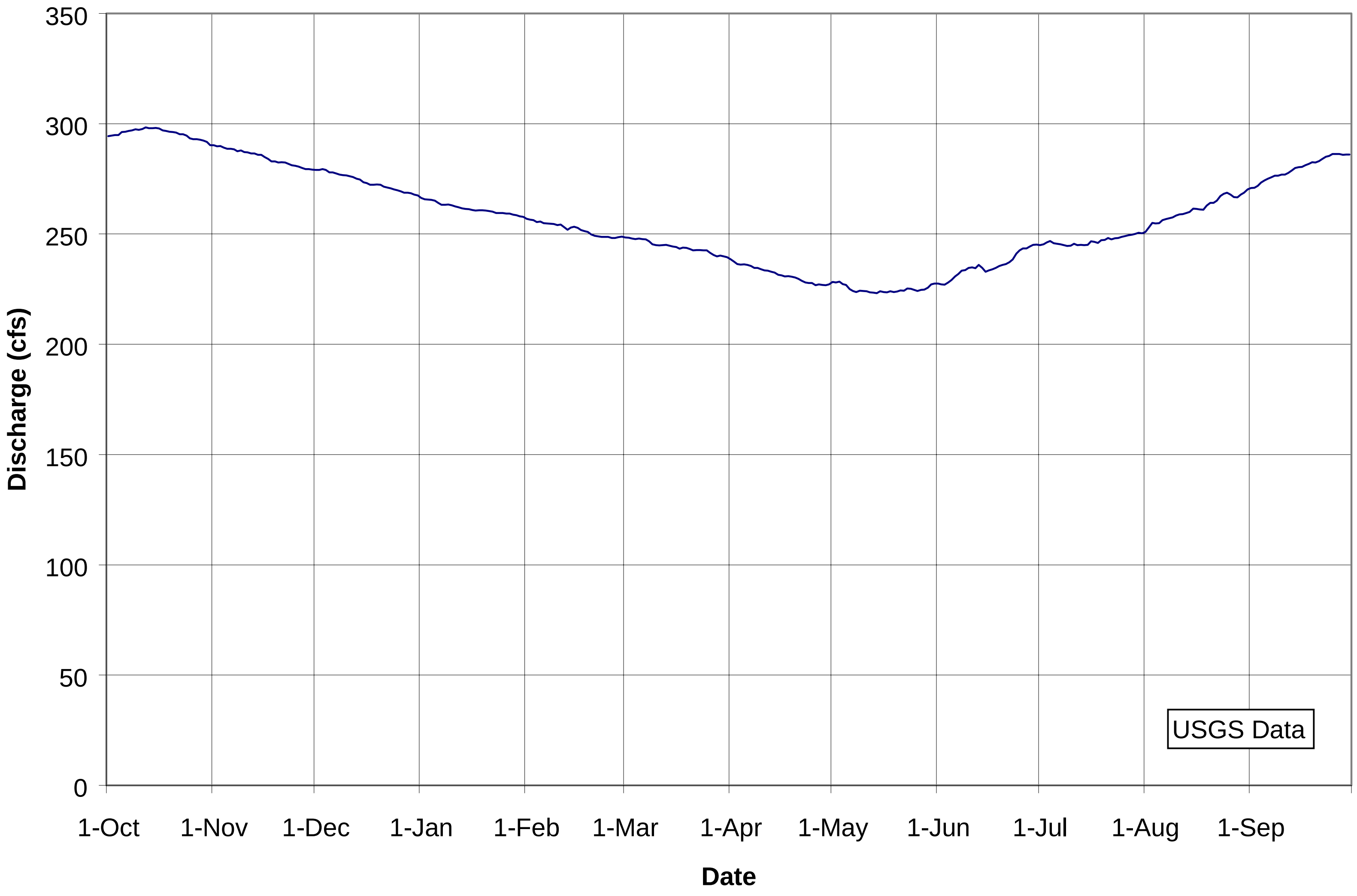

Figure 14. Niagara Springs average daily discharge (Oct 1958 - Sept 1972).

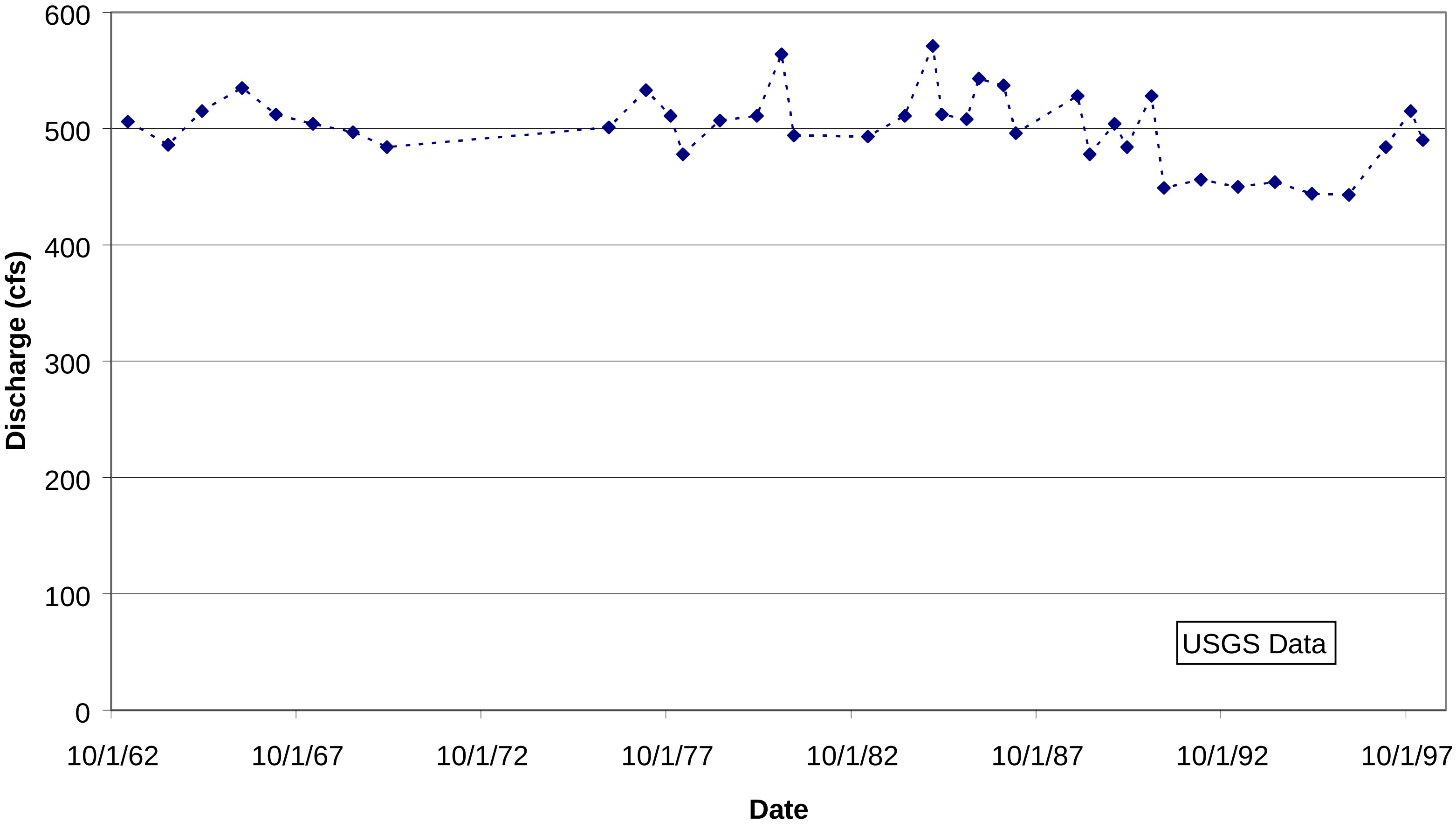

Figure 15. Clear Lakes Springs historic discharge.

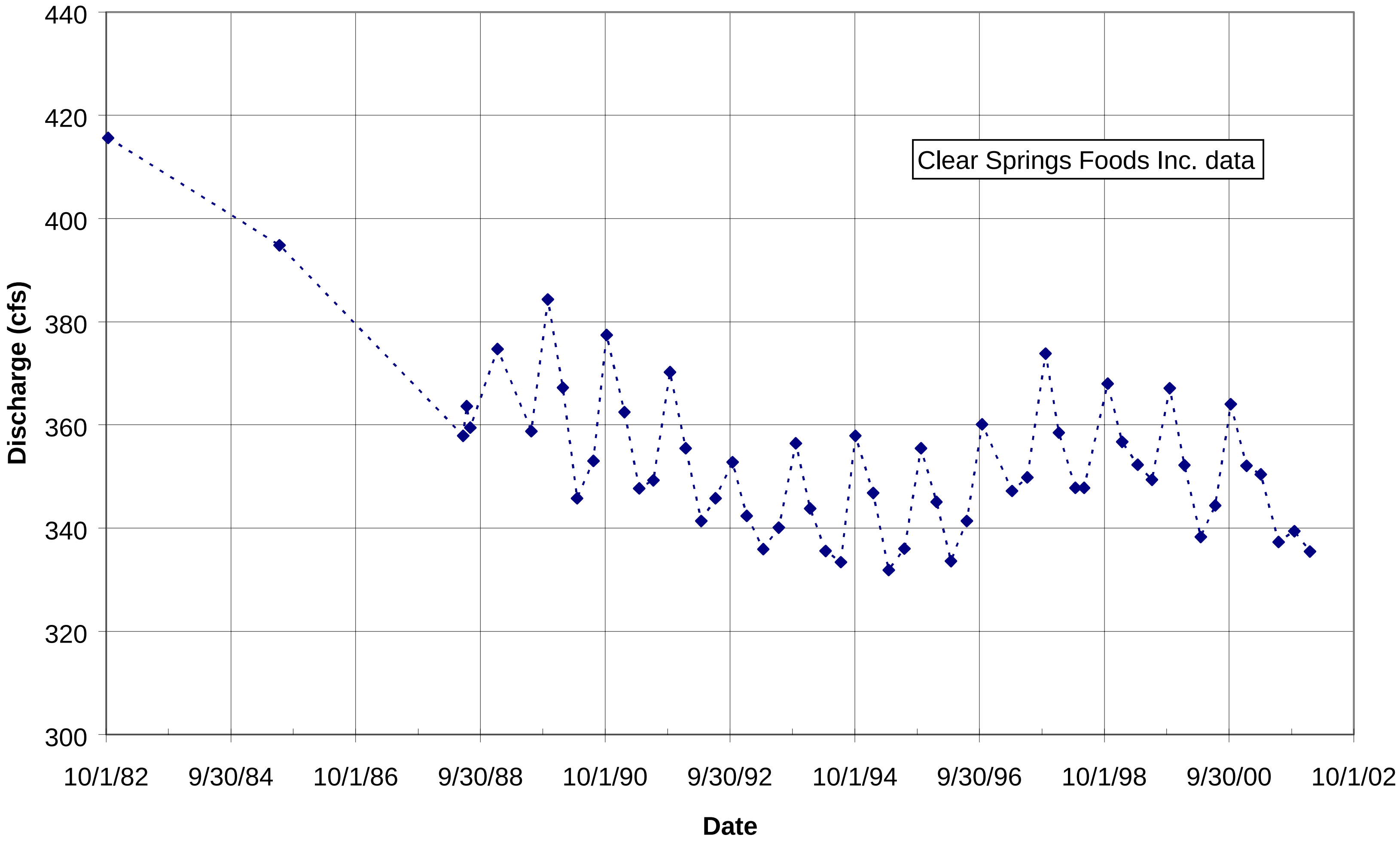

Figure 16. Clear Lakes Springs discharge through the Clear Springs Foods and Idaho Trout Processors Farms.

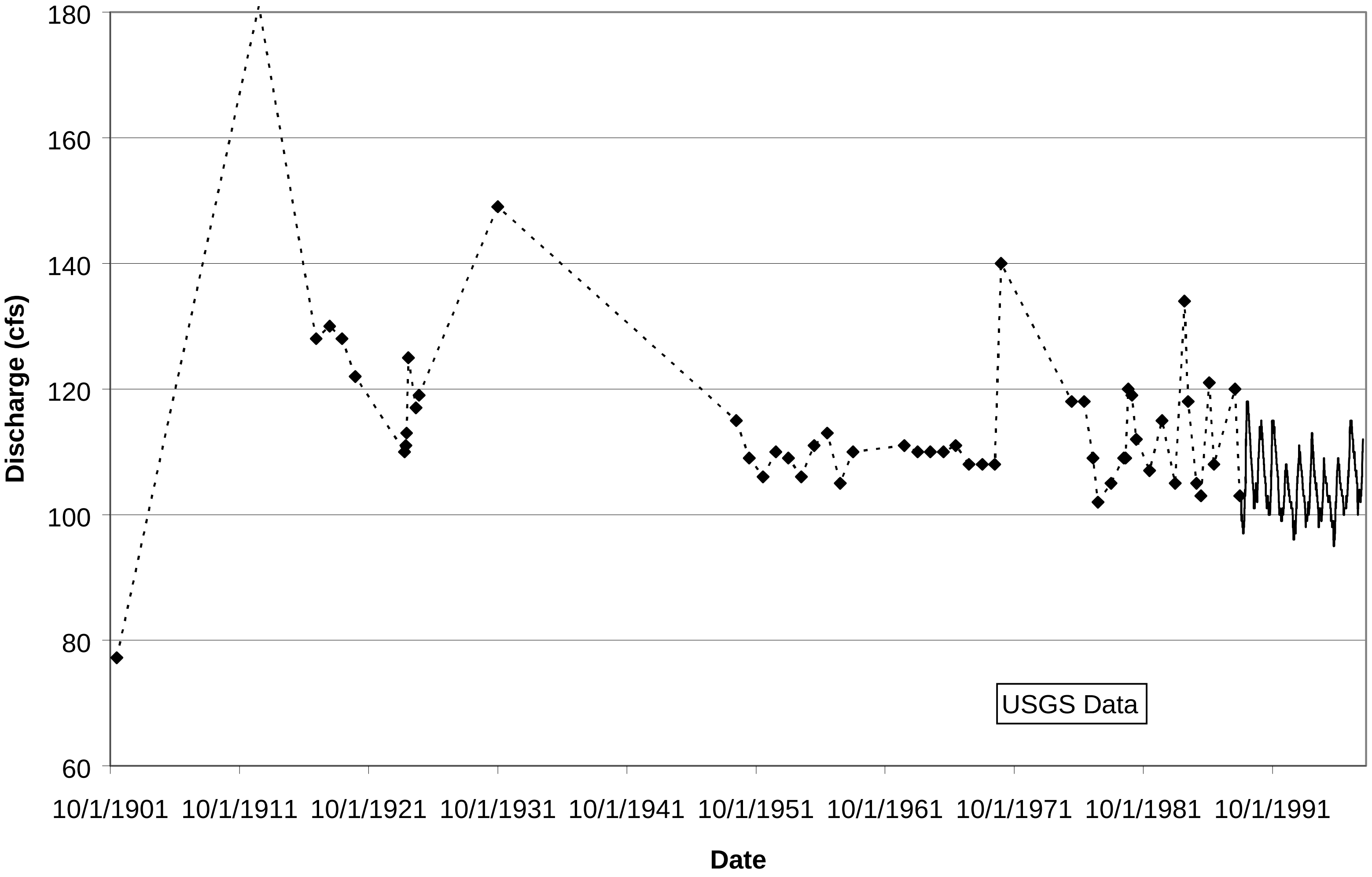

Figure 17. Briggs Spring historic discharge.

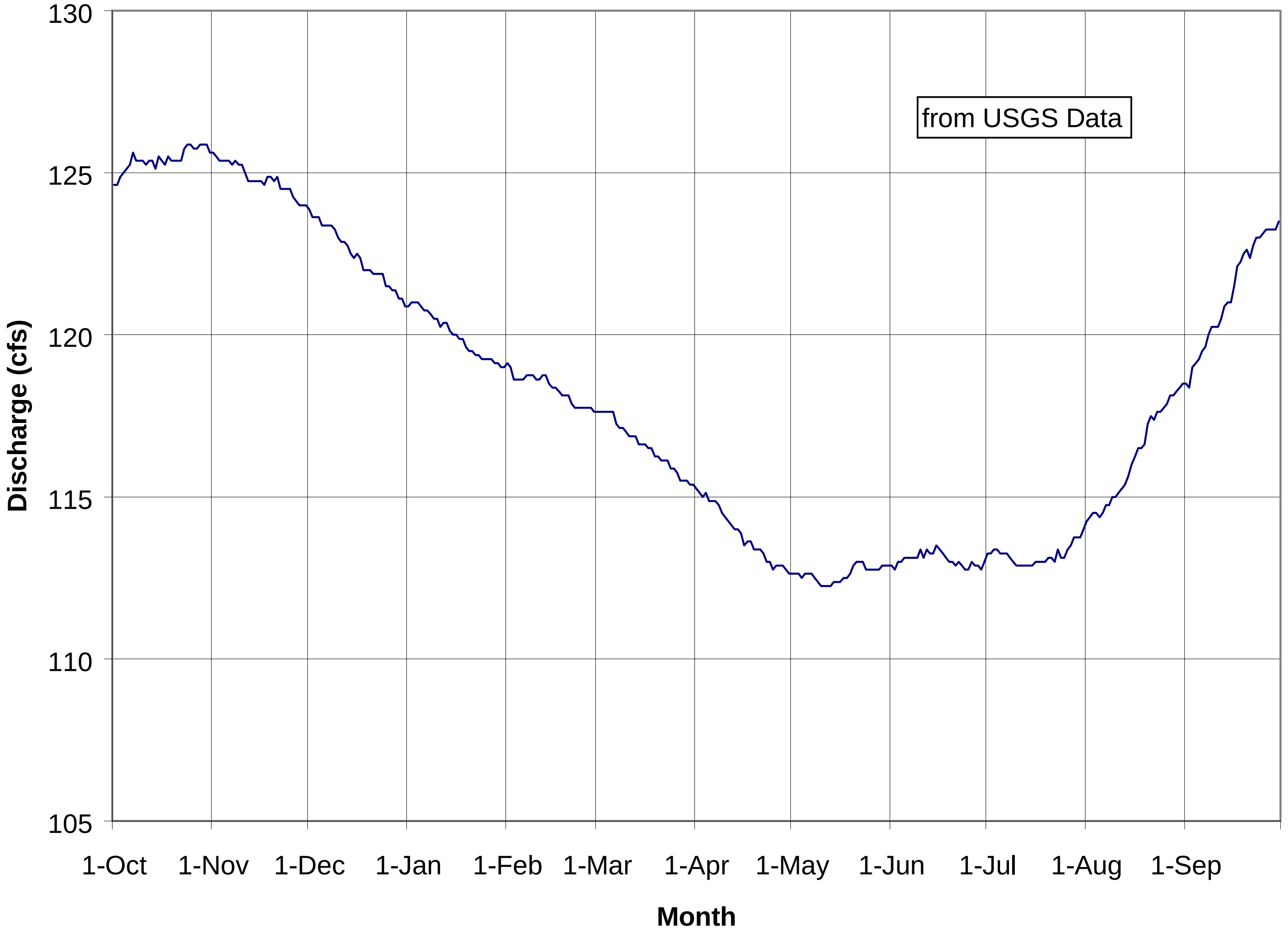

Figure 18. Briggs Spring average daily discharge (averaged for 1990-97 water years).

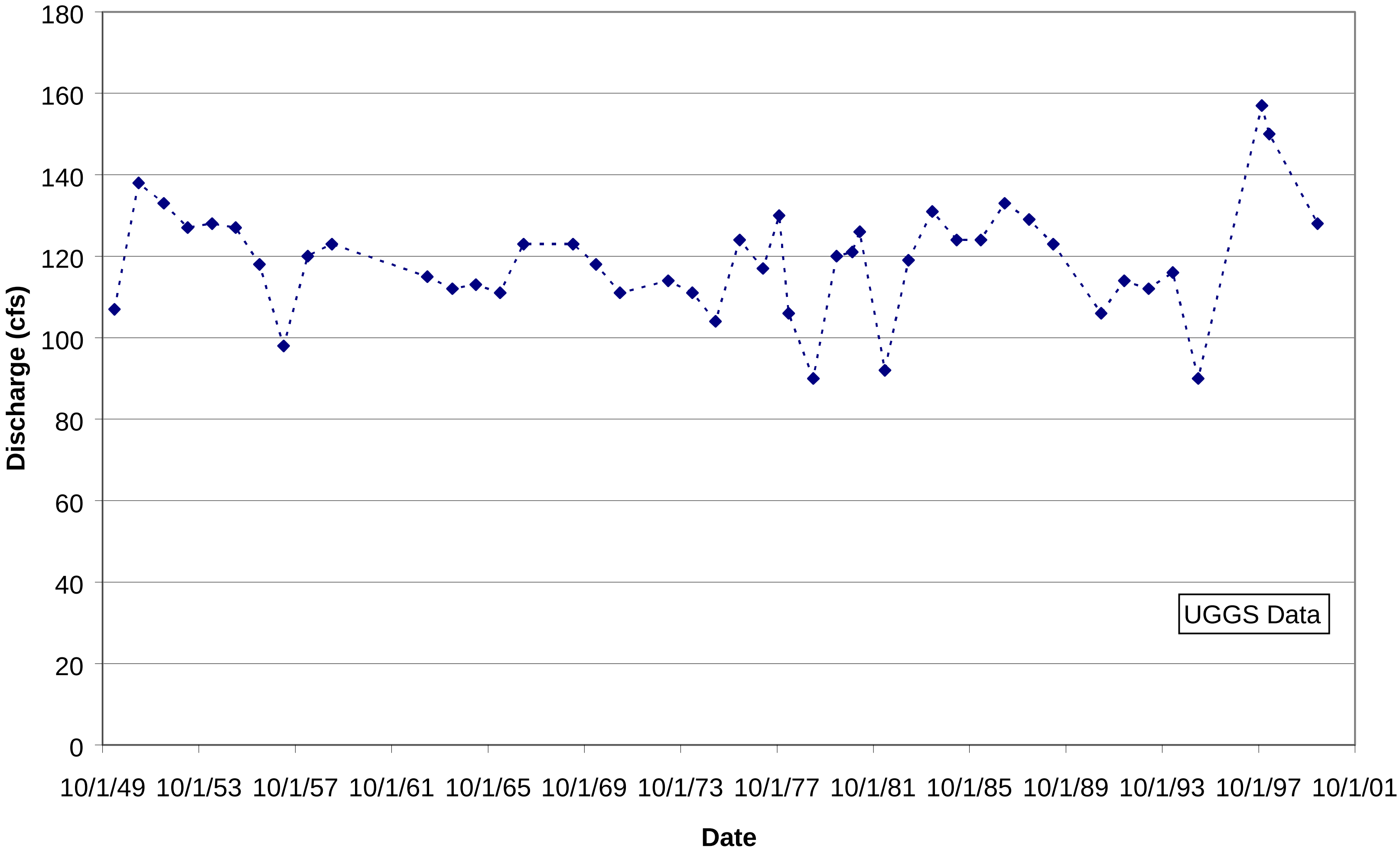

Figure 19. Banbury Springs historic discharge.

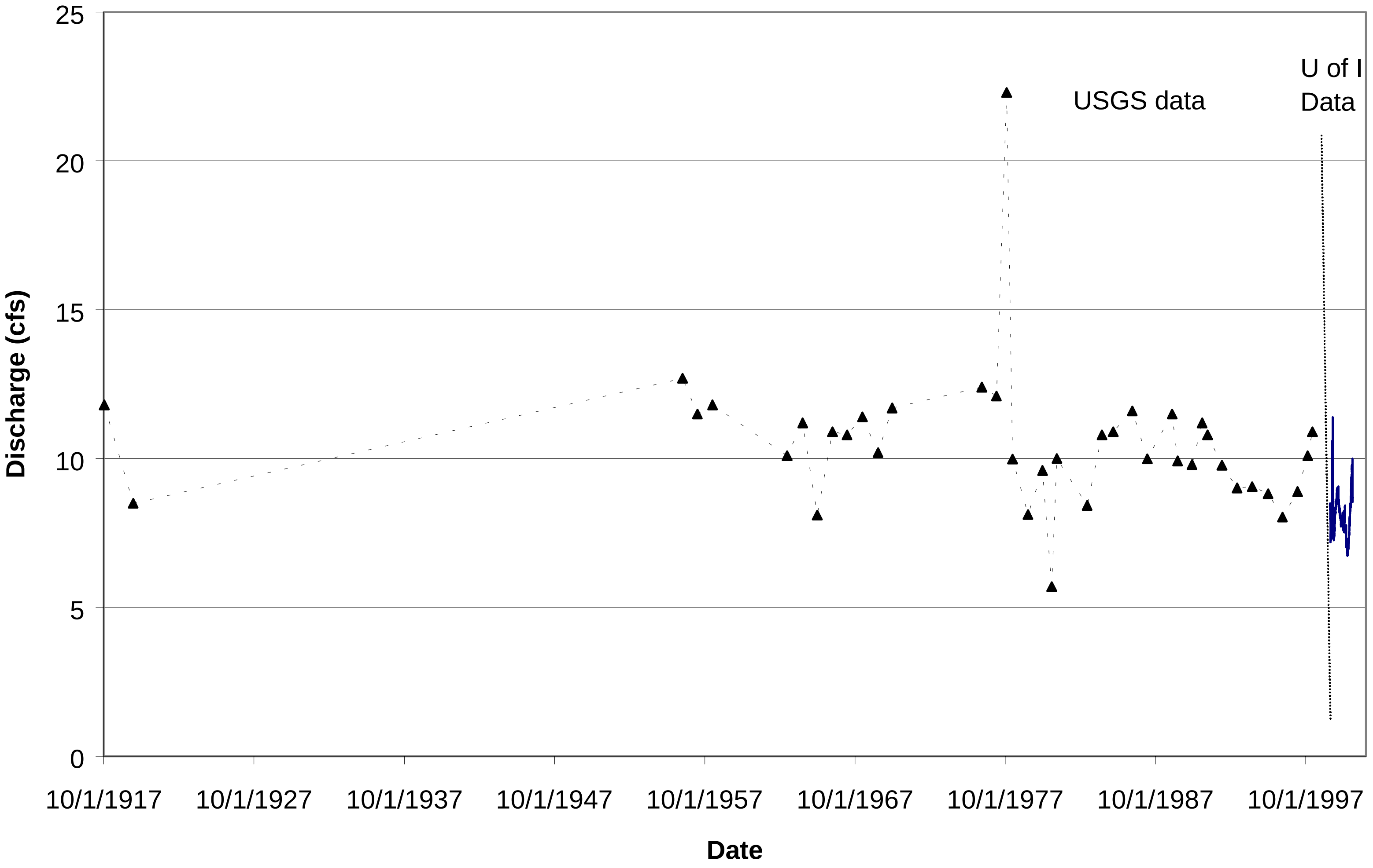

Figure 20. Blind Canyon historic discharge.

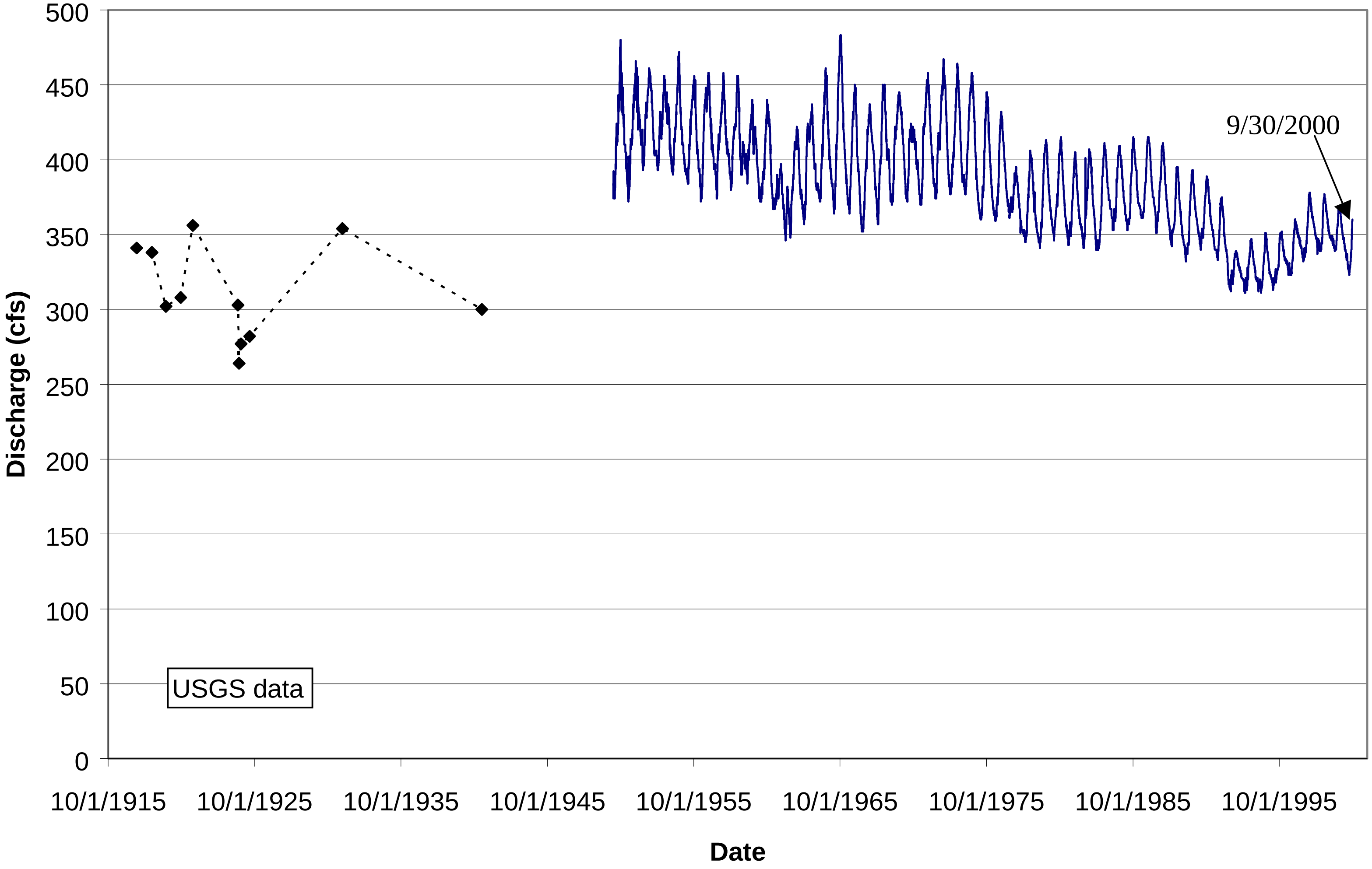

Figure 21. Box Canyon historic spring discharge.

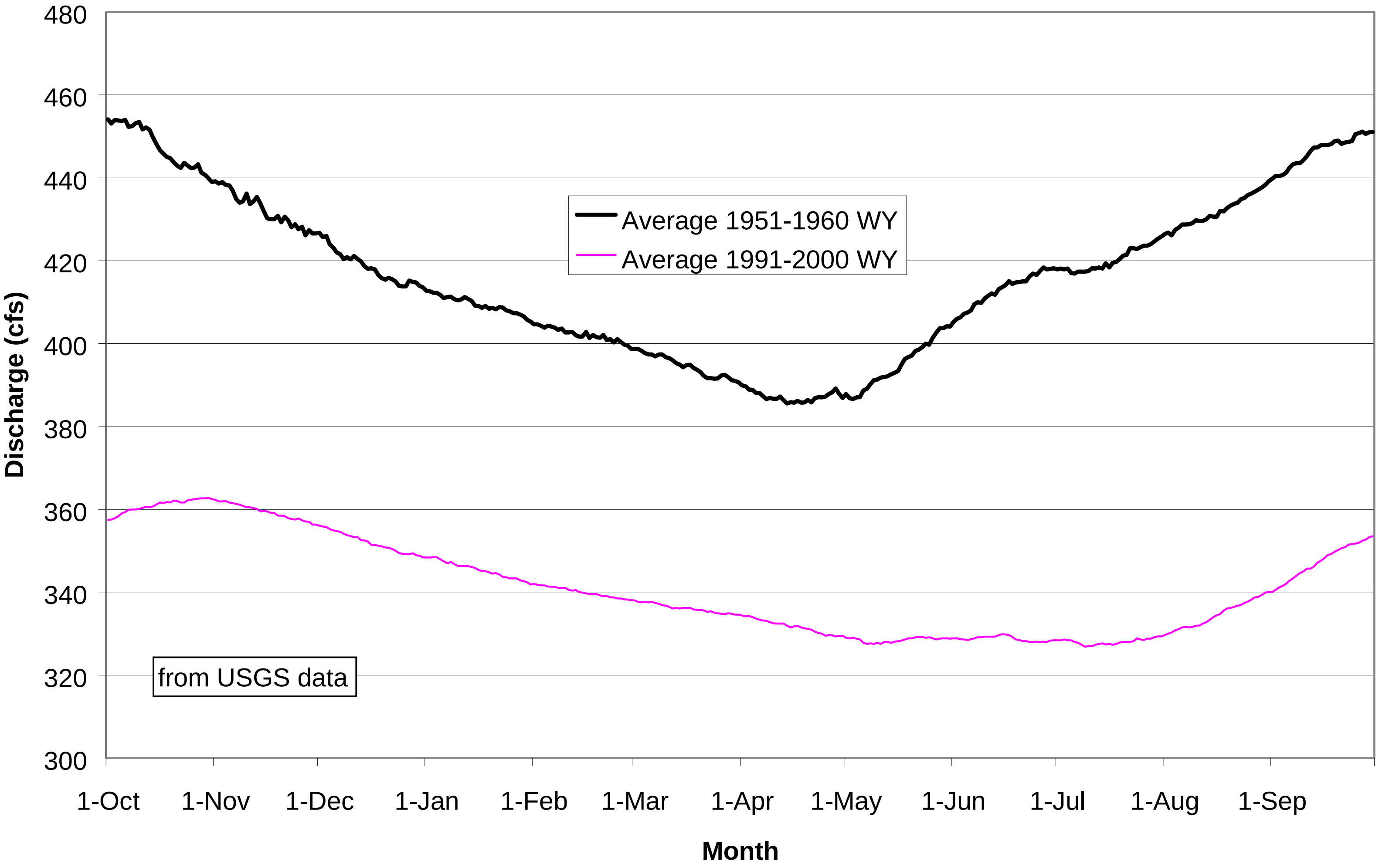

Figure 22. Box Canyon daily average discharge.

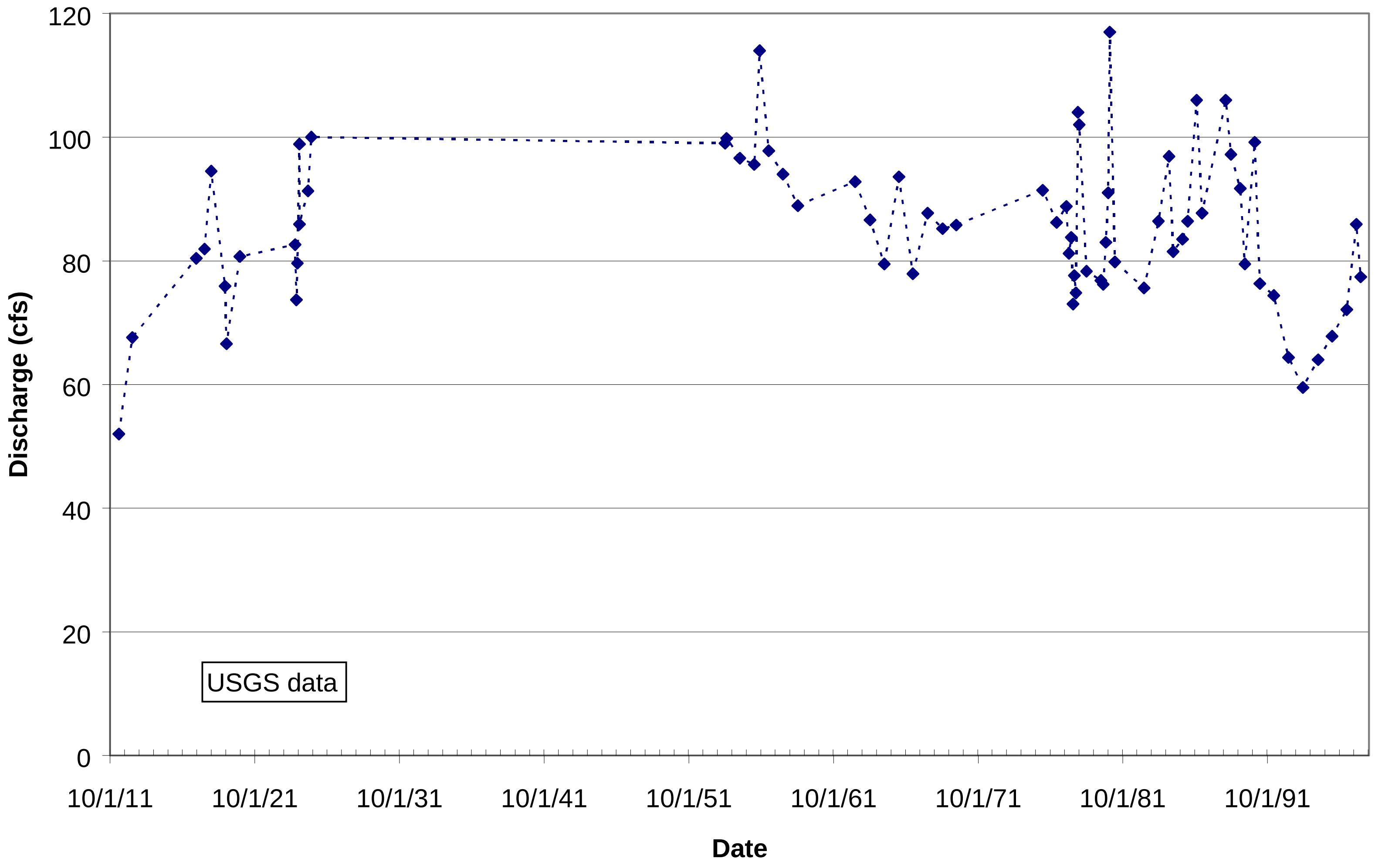

Figure 23. Sand Spring historic discharge.

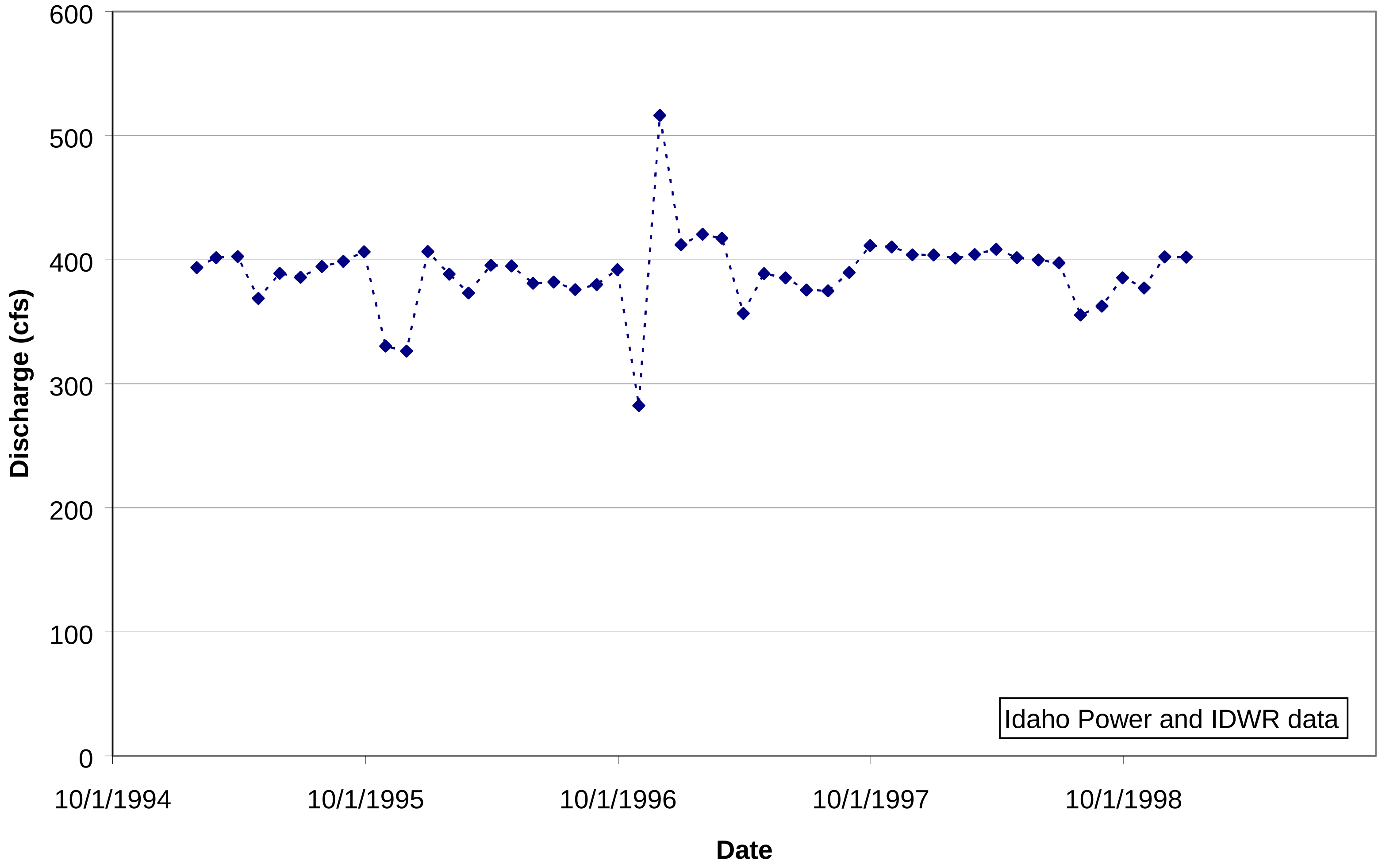

Figure 24. Thousand Springs historic discharge.

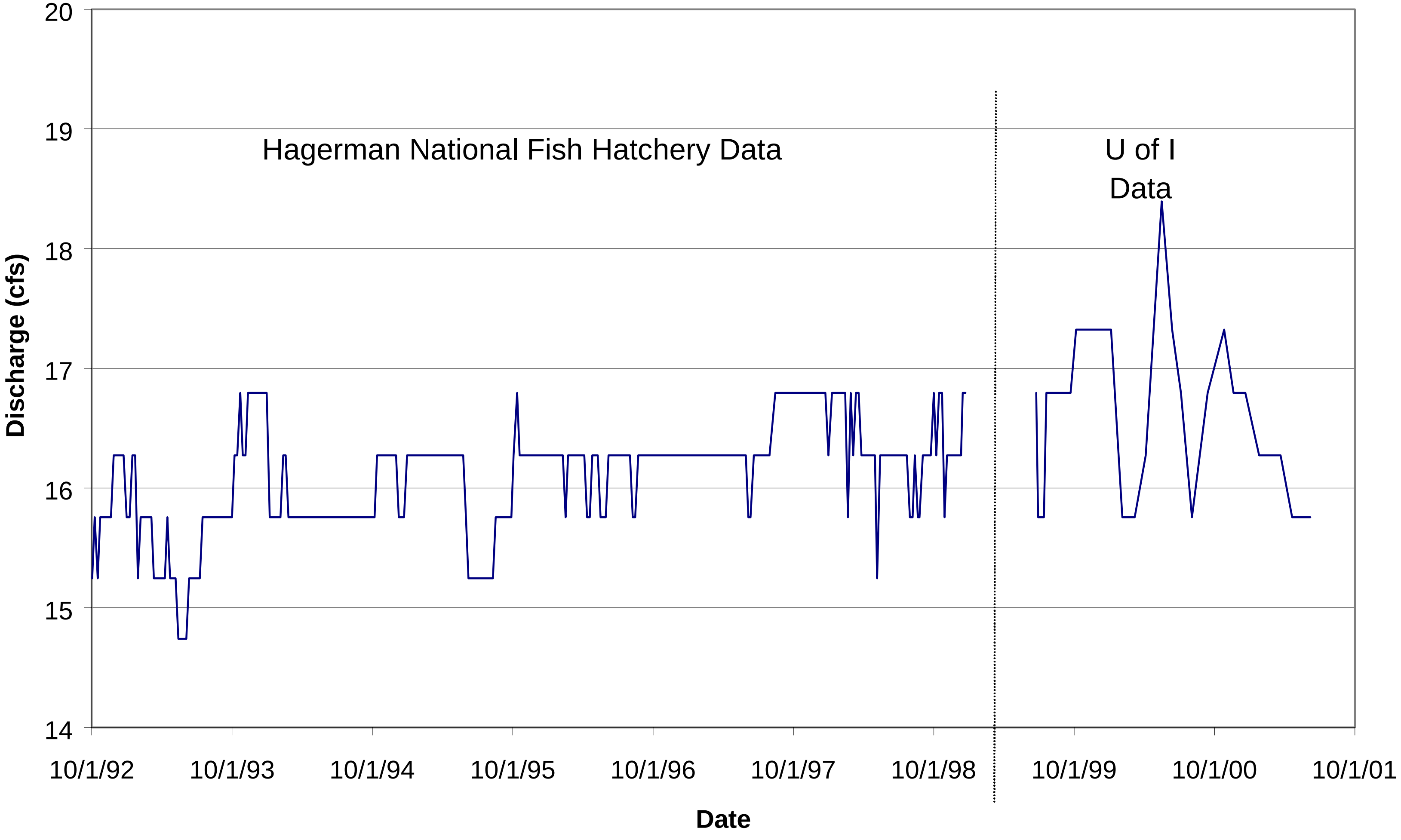

Figure 25. Bickel Lake historic data.

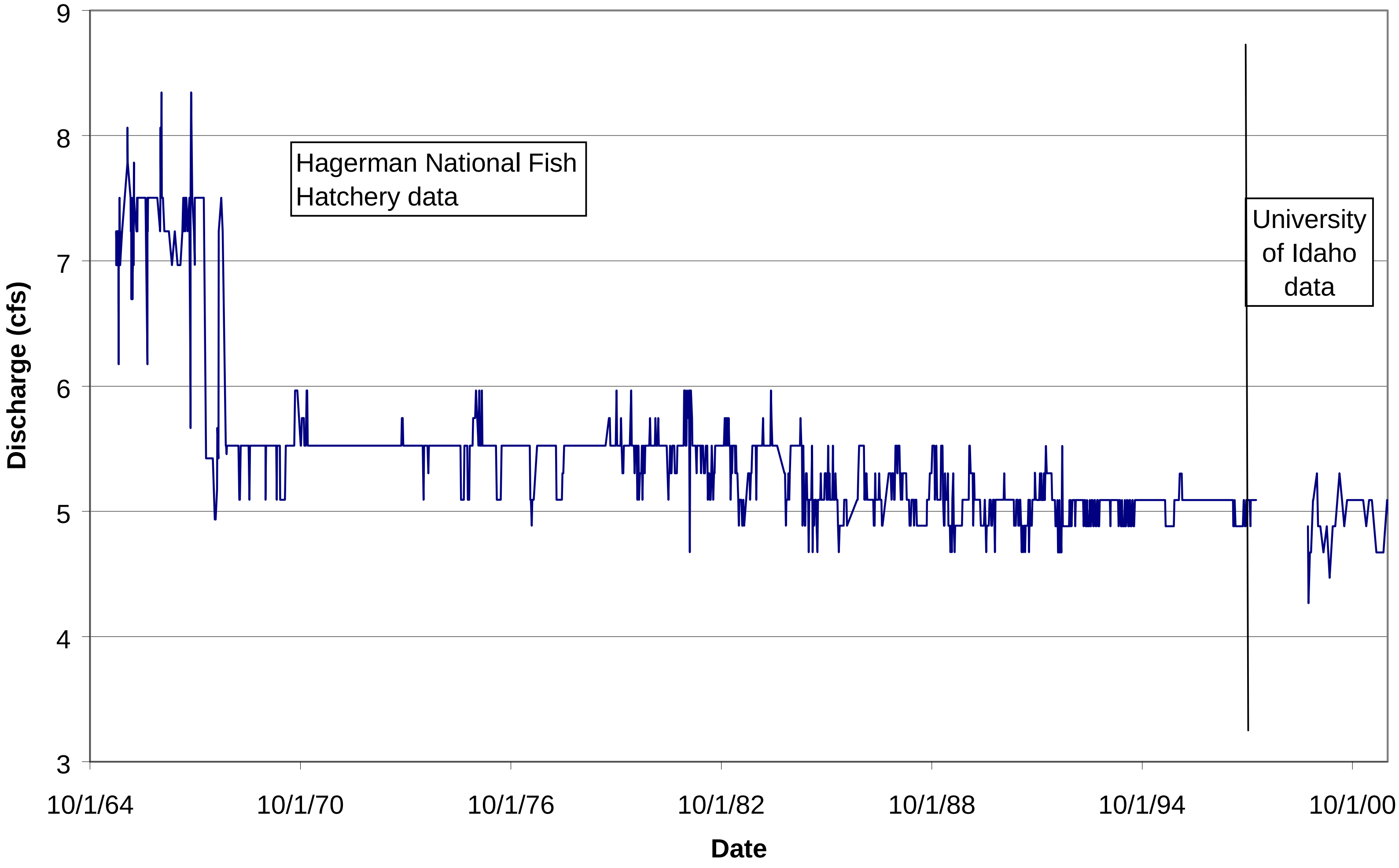

Figure 26. Riley Lake historic data.

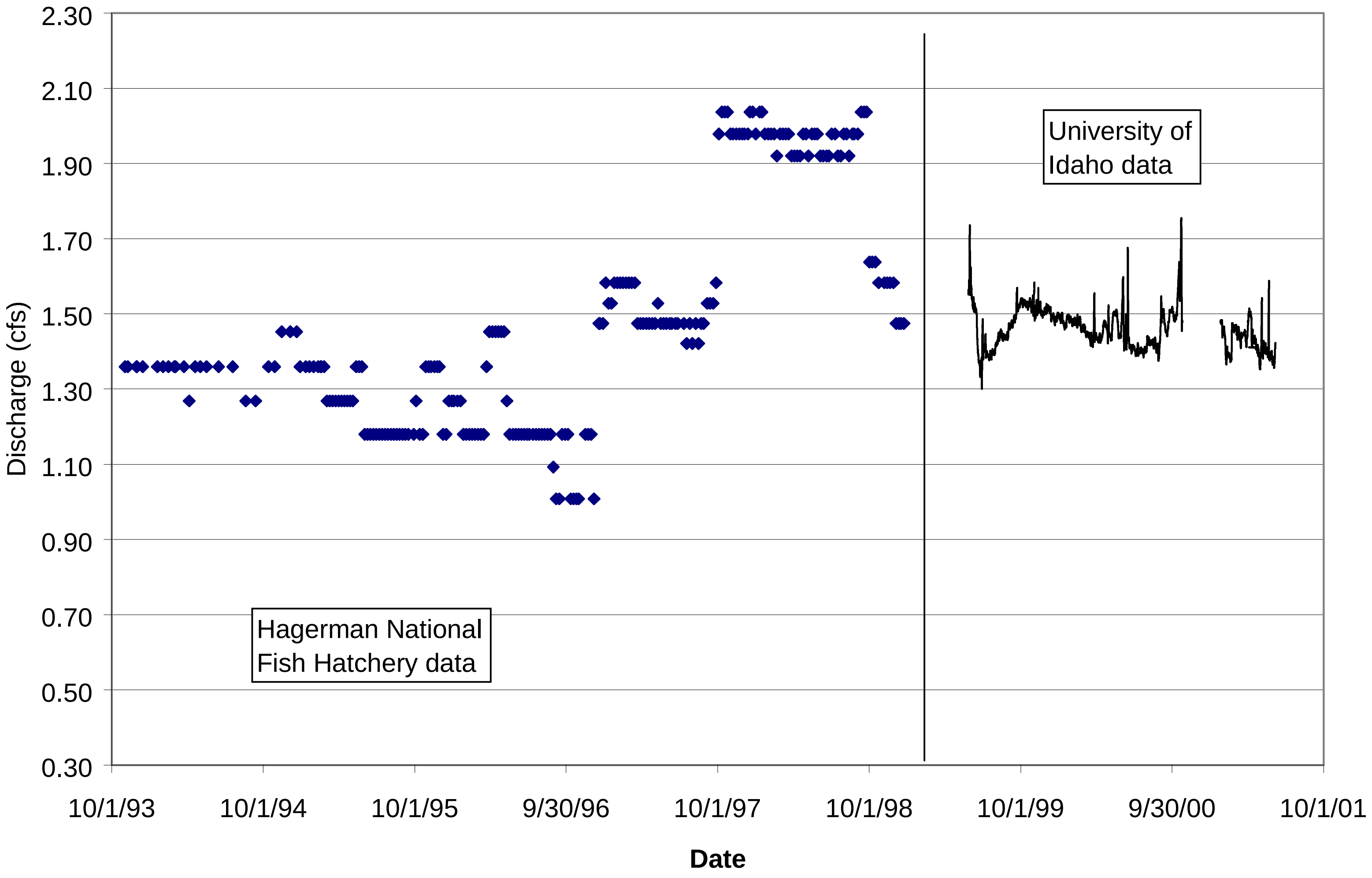

Figure 27. Discharge of Spring 10 at the Hagerman National Fish Hatchery.

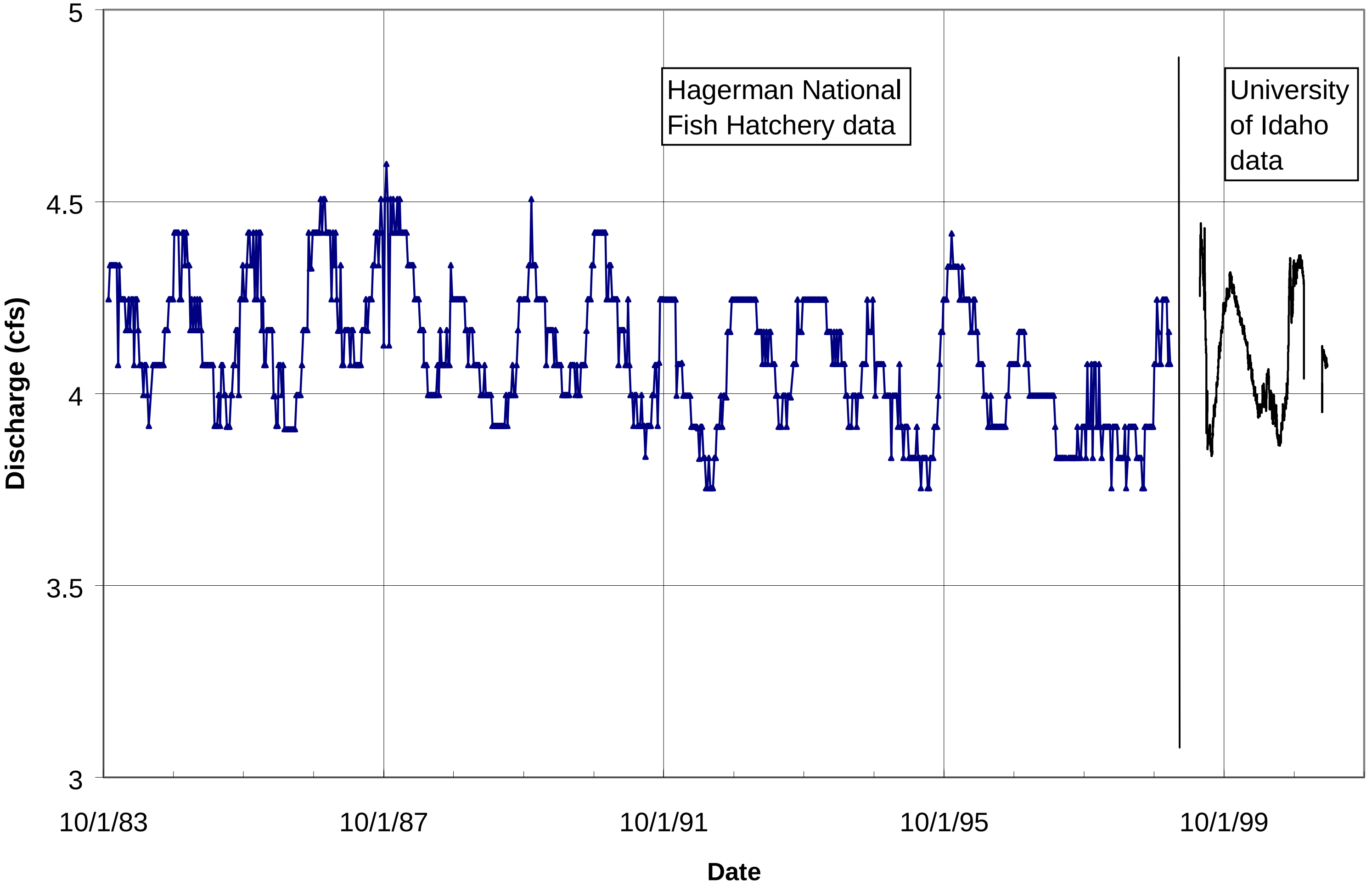

Figure 28. Discharge of Spring 15 at the Hagerman National Fish Hatchery.

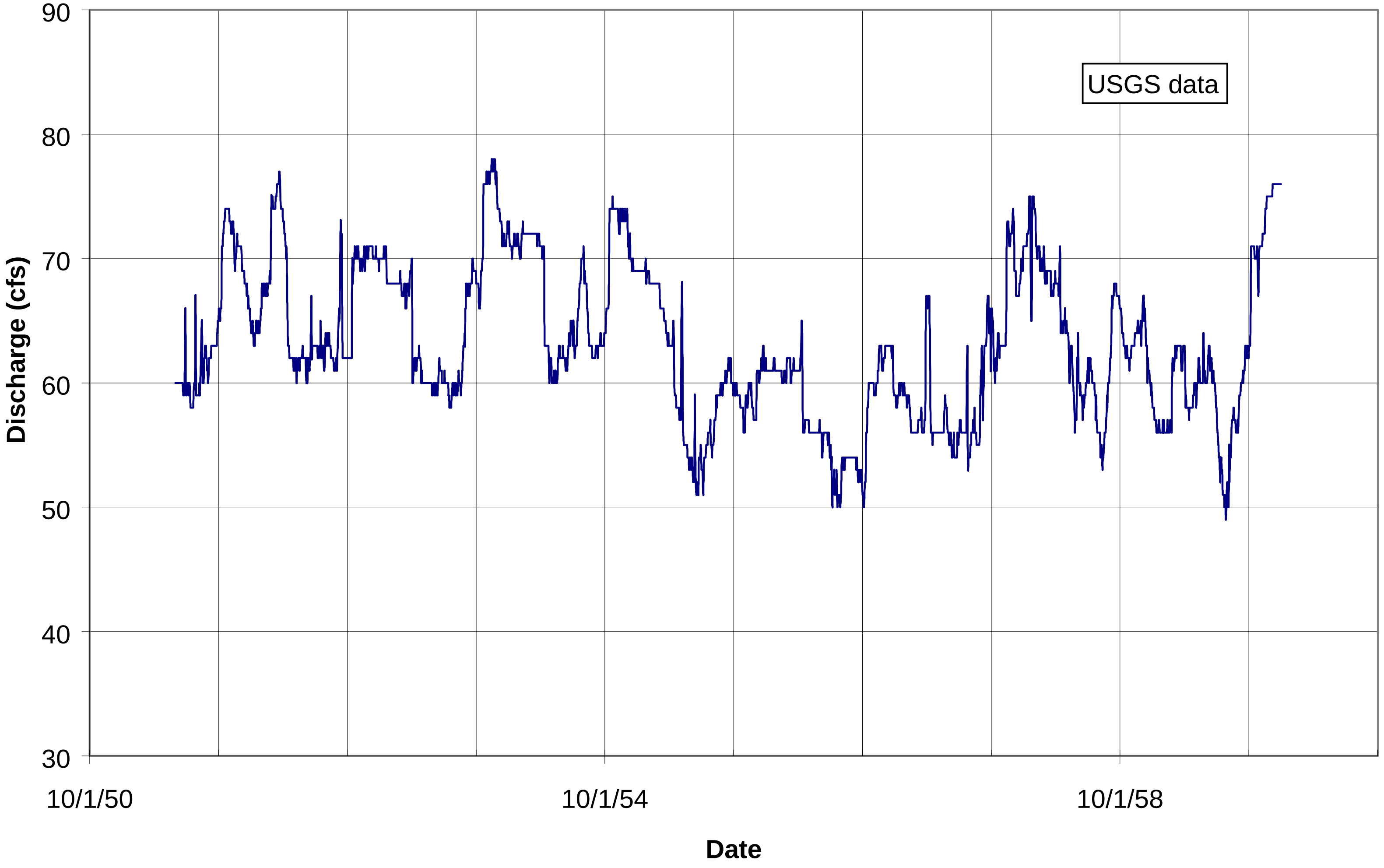

Figure 29. Riley Creek below Lewis Spring historic discharge.

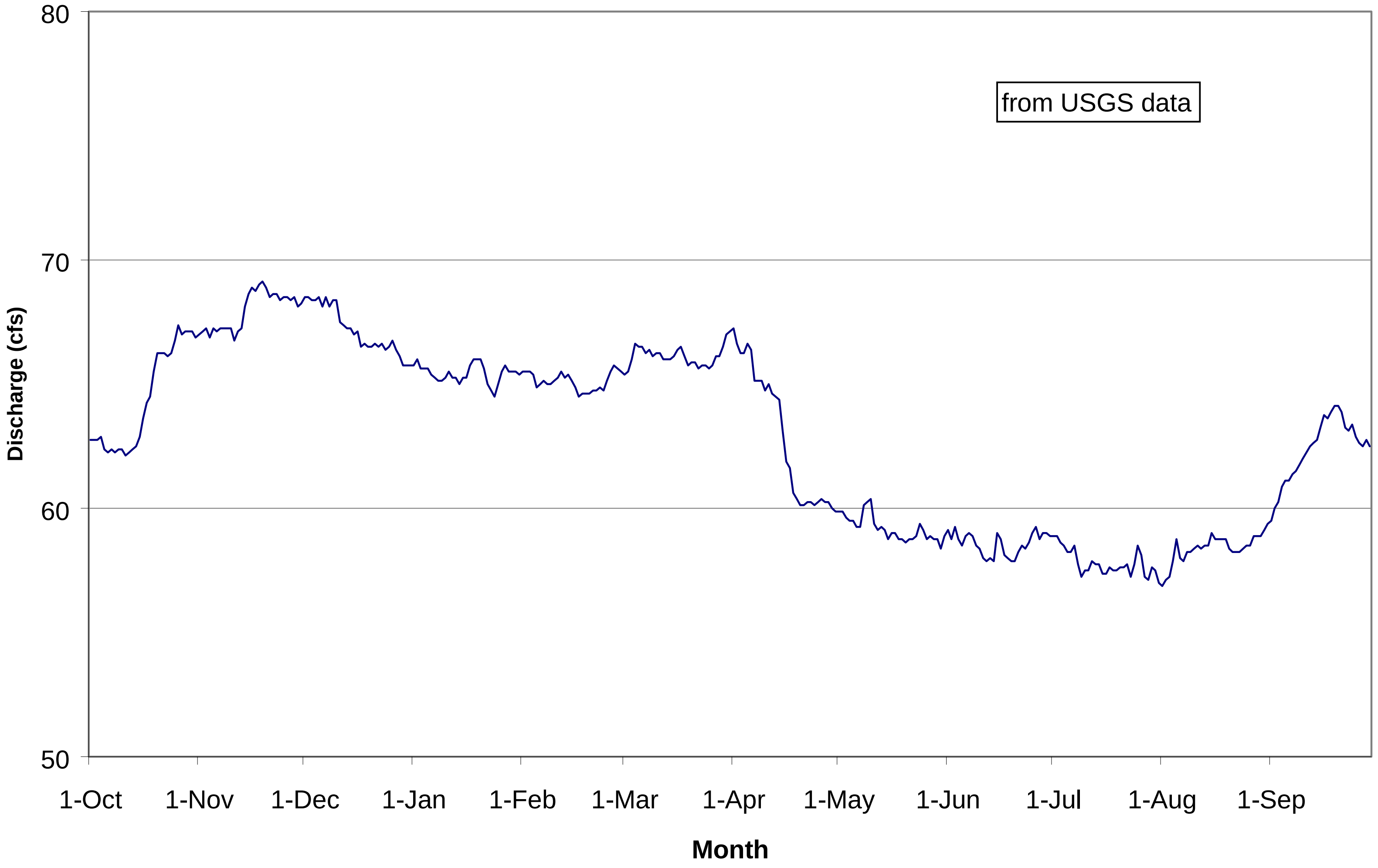

Figure 30. Riley Creek below Lewis Spring average seasonal variation, 1951 through 1958.

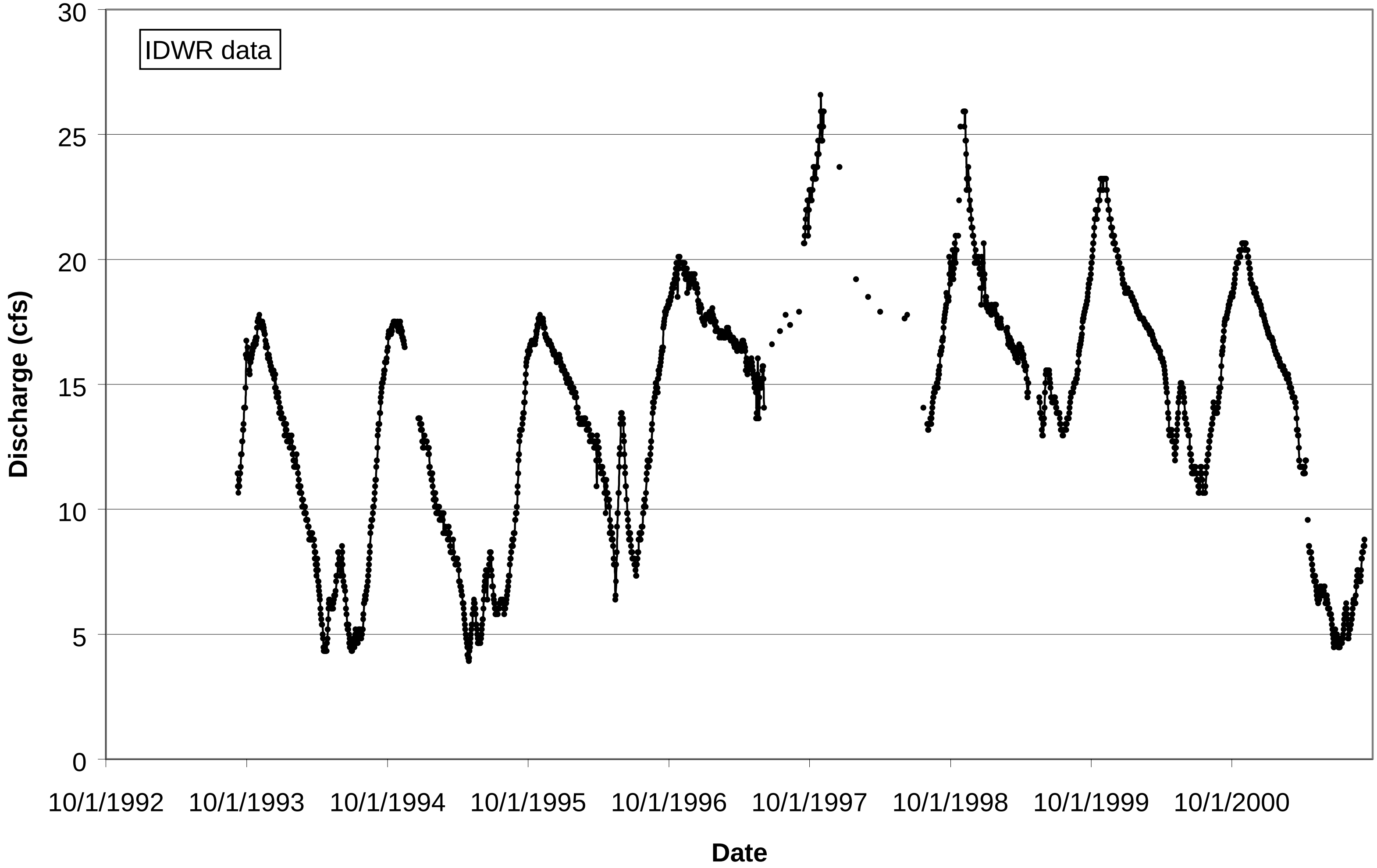

Figure 31. Curren Tunnel historic discharge.

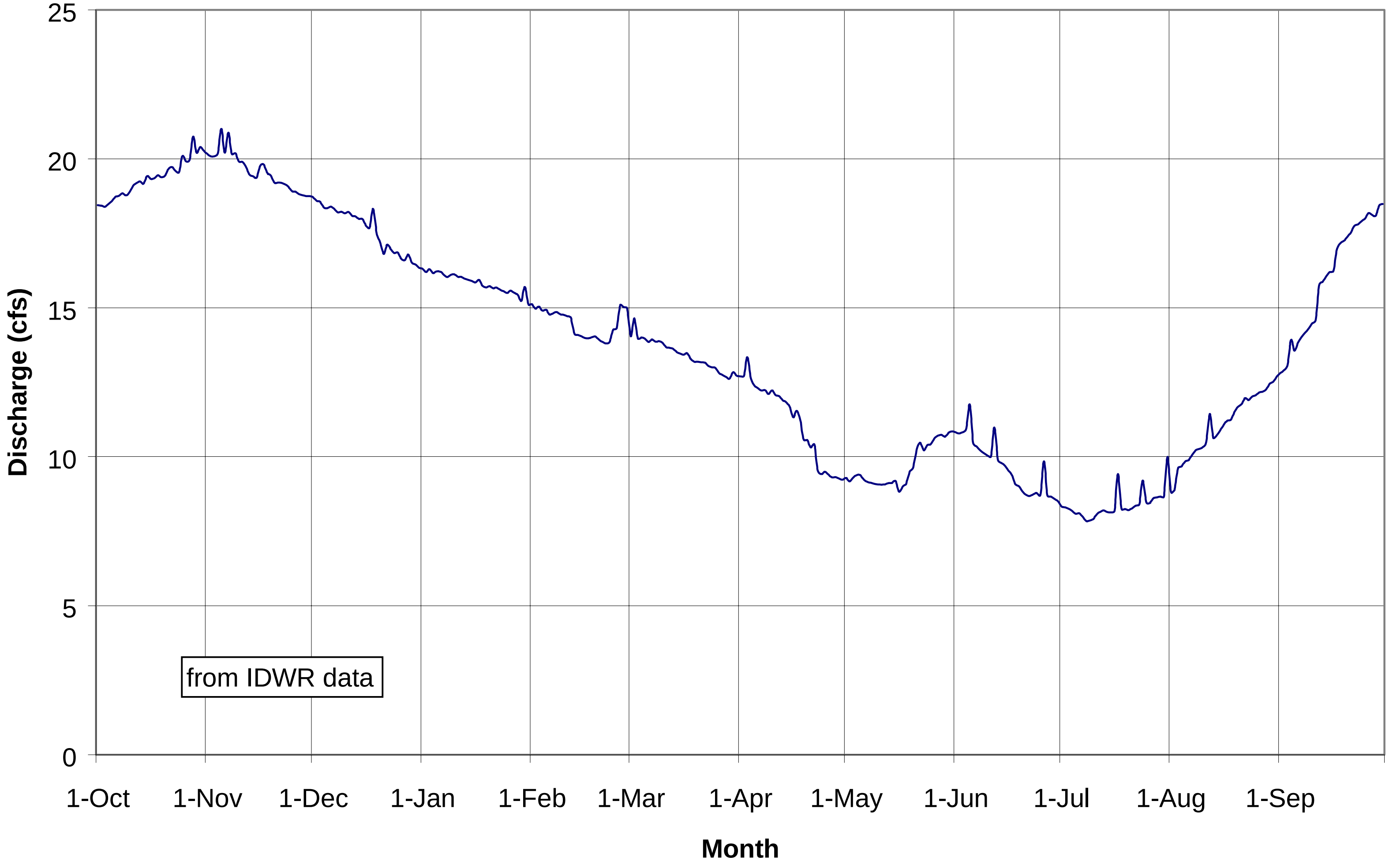

Figure 32. Average daily discharge for Curren Tunnel, 1994-2001 water years.