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WATER REQUIREMENTS FOR THE FISHERIES RESOURCE OF THE NICOLA RIVER, B.C.

by

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ABSTRACT

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The hydrology of the Nicola River system is examined and low flows analysed. Data on the fisheries resource is summarized including distribution, timing, and escapements of salmon stocks utilizing the Nicola River and its principal tributaries, the Coldwater River and Spius Creek. Information on the economic value of the fisheries resource is also provided. Spawning and rearing habitat was studied in detail using 6 transects on the Coldwater River and 16 transects on the Nicola River. Useable habitat area versus discharge curves were prepared, from which Fisheries Resource Maintenance Flow (FRMF) requirements were determined for these systems. Tentative FRMF recommendations are also given for the Upper Nicola River, Spius, and Guichon Creeks. Temperature data were collected at 7 sites on the Coldwater and Nicola Rivers in the summer of 1981, and suggest that high water temperatures may be limiting salmonid production in the Nicola River between Nicola Lake and the Coldwater confluence, and in the lower reaches near its confluence with the Thompson River. Recommendations are made regarding regulation of storage on Nicola Lake for the benefit of the fisheries resource.

KEY WORDS: Hydrology, Low Flows, Pacific Salmon, Fisheries Flows

RESUME

KOSAKOSKI, G.T., and HAMILTON, Roy E. 1982 "La qualité de l'eau requise pour les ressources poissonnières de la rivière Nicola, Colombie Britannique". Canada. MS rep. Fish. Aquat. Sci. 1680.

Le présent rapport porte sur l'hydrologie de la rivière Nicola et sur ses faibles débits. Les données présentées au sujet des ressources poissonnières y sont résumées, et concernent la répartition, les particularités chronologiques et les remontées des populations de saumon dans la rivière Nicola et dans ses principaux affluents, dans la rivière Coldwater et dans le ruisseau Spuis. Des renseignements sur la valeur économique des ressources poissonnières y sont également fournis. Les frayères et les aires de croissance sont étudiées en détails dans six zones de la rivière Coldwater et seize de la rivière Nicola. Des courbes de l'habitat utilizable en fonction du débit ont été tracées, courbes à partir desquelles les conditions requises par le programme de débits pour la préservation des ressources poissonnières ont été déterminées pour les rivières Coldwater et Nicola. Le programme de débits pour la préservation des ressources poissonnières tente également de donner des conseils pour la rivière du Haut-Nicola, et les ruisseaux Spius et Guichon. Des renseignements concernant les températures ont été receuillis dans sept zones des rivières Coldwater et Nicola durant l'été 1981, et suggèrent qu'il serait possible que les hautes températures de l'eau limitent la production de saumons dans la rivière Nicola entre sa confluence avec la rivière Coldwater et le lac Nicola, et près de l'estuaire, près de sa confluence avec la rivière Thompson. Des conseils sont également donnés à propos des règlementations d'emmagasinnage sur la rivière Nicola pour le bénéfice des ressources poissonnières.

Mots-Clef: Hydrologie, faibles débits, saumon du Pacifique, débits pour la préservation des ressources poissonnières.

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1. INTRODUCTION

The Nicola River system (Figure 1), including its principal tributaries, the Coldwater River and Spius Creek, is an important producer of chinook (Oncorhynchus tshawytscha), coho (O. kisutch), and pink salmon (O. gorbuscha), as well as steelhead trout (Salmo gairdneri). Located in the interior drybelt of B.C., the system is subject to heavy irrigation demands during the late summer - early fall low flow period, when instream flow requirements for salmon spawning and rearing are particularly critical.

In 1977, in response to growing water use conflicts, a group of local ranchers formed a committee (the Nicola Valley Resource Management Working Committee) to represent their interests. The Working Committee was instrumental in promoting a major study by a consultant (Y. Bajard and Associates), with the objective of developing a comprehensive water management system for the basin. Responsibility for the project was subsequently assumed by the B.C. Ministry of Environment, culminating in 1980 in the M.O.E. Planning Branch's Nicola Basin Strategic Planning Study.

Basic information requirements for this study included flow requirements for fisheries in each sub-basin, and, for purposes of economic analysis, data on present and potential fisheries production.

In response to this initiative, cooperative fisheries studies were initiated on the Nicola River system in 1980 by the Department of Fisheries and Oceans, Habitat Management Division (instream flow requirements), Fraser River, Northern B.C. and Yukon Division (adult stock assessment), and by the M.O.E. Fish and Wildlife Branch, Fish Habitat Improvement Section, (enhancement opportunities).

This report documents the results of bio-engineering studies conducted by the Habitat Management Division in 1980 and 1981 to determine fisheries flow requirements for the Nicola and Coldwater Rivers.

2. WATERSHED DESCRIPTION AND HYDROLOGY

The Nicola River system, draining a watershed area of 7,280 square kilometres (above gage 8LG6), is located in the Thompson River basin in south-central British Columbia (Figure 1). Nicola Lake, with an area of 2,500 hectares, is the largest lake in the watershed, and has been regulated in an irregular way for power and irrigation purposes since construction of the present dam in 1927 (Smyth, 1967). Power is no longer being generated and at the present time very little regulation of the dam is done.

Streamflows are recorded for the Nicola River below Merritt at station 8LG7 and near the mouth at station 8LG6, and for the Coldwater River entering the Nicola at Merritt at station 8LG10. These stations have been operated continuously since 1957 although records date back to 1911. Streamflow for the Nicola River between Nicola Lake and Merritt has not been recorded. Historical flows in this section have to be estimated by subtraction of the Coldwater flows from the flows recorded at 8LG7. Average monthly flows obtained in this way are shown in Tables 1 to 4, column 3.

For the purposes of this study, the Nicola River was divided into several major reaches as shown in Figure 1. In 1980 and 1981 several representative study sites (Figure 1 and Figures 2 to 5) were chosen on the Nicola and Coldwater Rivers. Several transects were surveyed at each study site and the flows were metered several times. Figures 6 to 13 show schematically the position of the transects relative to the tributaries and hydrometric stations, the flows measured, and the dates. There was considerable variation between the meterings themselves and between the meterings and the flows as recorded at the hydrometric stations. This is illustrated in bar graph form in Figures 14 and 15.

Meterings on the Nicola above Merritt were usually less, with the exception of transect 6, than the difference between 8LG7 and 8LG10 indicated. The flow profiles in Figure 16 show transect 6 in the Nicola and transect C4 in the Coldwater always reading higher than adjacent transects. These various discrepancies in the Merritt area indicate variable interchange of flow between the channel and its gravel bed. This is a condition that seems to be favoured by spawning fish and may explain in part the existence of the chinook spawning area just below Merritt.

Table 5 is a summary of fisheries resource maintenance flows for the Nicola River and its tributaries. Details of the methods used to determine fisheries flow requirements are provided in Section 4.

Monthly hydrographs for a number of years of record for the Nicola (8LG7), Coldwater (8LG10), Guichon Creek, and Spius Creek are shown in Figures 17 to 22. Superimposed on the hydrographs are the fisheries resource maintenance flows. The shaded area represents the deficit, that is when monthly flows were less than the fisheries resource maintenance flows. It may be seen from these that the fisheries resource maintenance flows are sometimes greater than the monthly flows during very low months but still less than the average.

As monthly hydrographs do not always convey the correct low flow severity a number of daily hydrographs for the Nicola and Coldwater were prepared (Appendix A). Cross hatched areas represent the deficits between the basic fishery flows and the recorded flow during those periods when the recorded flow was less.

Low flows in the Coldwater, that is below 50 cfs, are rarely a problem until August. August 1 to September 30, or perhaps into October is a critical period because of irrigation demand. The average flow in August is 76 cfs and in September is 51 cfs. Low flows may however persist through the fall and winter and occasionally until April. See hydrographs in Appendix A.

2.1 Optimum Flow Management

Using the Nicola River hydrographs in Appendix A the deficits (resulting from flows less than the FRMF of 110 cfs below Merritt) were calculated and tabulated for seven years of records, Table 6. The extra storage that would have been required to maintain the 110 cfs is represented by the totals. On the average, only one extra foot of regulation would have been necessary. In dry years 2 feet would have been necessary.

It should be kept in mind that these calculations include present irrigation use and present dam regulation, such as it is. It is probable that with very little change to the operational rules of the reservoir the one or two feet of extra regulation could be easily achieved.

The present order issued in 1948 requires that the lake level be kept to not more than 3.0 feet between April 1 and July 31, and then reduced to 2.0 feet and kept at that level until September 30th (Appendix B). A more beneficial reservoir management schedule using the existing structure but providing a low outlet is given in Appendix B.

For the period October to April no regulation is required for irrigation. During this time of year the reservoir could be controlled for fisheries use. Inflows during this period could be beneficially controlled.

Tables 1 to 4 show, in column 4, the releases from the dam which would have been required to maintain 110 cfs in the river below Merritt for the period 1970 - 1978. In addition to this requirement there is a further requirement that flows below the dam are not less than 40 cfs December to July, and 60 cfs August to November. Column 5 shows the release required to satisfy both these requirements. In general the release over and above the

40/60 requirement to satisfy the downstream requirement of 110 cfs is not great.

Offsetting this release is the inflow to the reservoir. Assuming the reservoir is full at the end of July, which should be the case, releases out of storage are needed until the following freshet (May-July). Offsetting the release from storage is the net inflow to storage. The table shows an example for the average year. Net release from storage worked out to 3,661 cfs days or approximately 1.2 feet of storage between July 31 and the following April 30th.

A high flow is needed once a year in June or July to clean the gravels in the river. This occurs naturally in the Coldwater and these high Coldwater flows will probably suffice for the Nicola below Merritt. If a new dam is built there will be some control of the runoff but it may be desirable to release the high flows at a certain time to be most beneficial for flushing and perhaps to better phase in with the Coldwater high flows.

It is believed that the flow requirement in the lower Nicola can in general be met with the present irrigation use. A number of tributaries and irrigation return flows contribute to this. Historically, the gage at the mouth (8LG6) has recorded flows approximately double those at the gage near Merritt (8LG7).

3. FISHERIES RESOURCE

The Nicola River system supports populations of chinook, coho, and pink salmon, in addition to steelhead trout. Annual salmon escapement data for the Nicola River, Coldwater River, and Spius Creek are shown in Figures 23, 24, and 25, respectively. Average escapement data, including maximum recorded escapements, for the periods 1951-1960, 1961-1970, and 1971-1980 are provided in Table 7. Although comparable data is not available for steelhead, the spawning population for the Nicola River system is estimated to be about 1,000 fish.

It is evident that chinook and coho stocks have declined significantly from historical levels. Although this decline can be largely attributed to excessive exploitation rates, it is likely that habitat problems related to water diversions for irrigation, channelization, municipal waste discharges, logging, and pipeline construction, have also contributed to a reduction in system productivity.

The current economic value of the fisheries resource of the Nicola River system has been conservatively estimated at approximately $600,000 annually ($1982). This estimate does not include economic benefits associated with the popular Thompson River steelhead fishery, to which Nicola River stocks are thought to contribute significantly. The total steelhead catch (fish killed plus released) reported for the Thompson in 1980-81 was 2,645 (Ford 1982). A summary of current and potential salmon catch and values is provided in Appendix C. Potential production figures are based on historical escapement data, and preliminary estimates of system carrying capacity (Sebastian, 1982). Best estimates of current and optimum catch/escapement ratios for Nicola stocks were provided by P. Starr (pers. comm.).

3.1 SPAWNING DISTRIBUTION

The salmon spawning distributions shown in Figure 26, and discussed briefly below, are based largely on reports by Starr (1976), and Elvidge (1971), and on surveys carried out by Fraser River, Northern B.C. and Yukon Division staff in 1980 and 1981.

NICOLA RIVER

Chinook

It has been estimated that up to 75% of chinook spawning in the Nicola River occurs in the 21 Km section between the Coldwater River and Spius Creek junctions (Reach N2, Figure 1). The remaining 25% is generally distributed equally between the section downstream of Spius Creek (Reach N1), and the section between the Coldwater confluence and Nicola Lake (Reach N3). Although the upper Nicola River, above Nicola Lake (Reaches N4 and N5), appears to have considerable fisheries potential, recent escapements to this part of the system have been very low.

Coho

Although escapement records indicate coho spawning in the Nicola River, it is likely that the majority of coho spawn in the Coldwater River and Spius Creek (particularly Maka Creek). Elvidge (1971) reported a few coho spawners in the Nicola mainstem above and below the Coldwater confluence.

Pink

A significant population of odd-year pink salmon spawn in the lower reaches of the Nicola River. With the exception of the area immediately upstream of the Thompson River junction, utilization of this section appears to be limited by the availability of suitable spawning gravel.

COLDWATER RIVER

Chinook

Spawning is scattered, largely between Brodie and Merritt, although a significant number of chinook spawn upstream of this section.

Coho

Coho spawn throughout the Coldwater system with the area upstream of Brodie being the most heavily utilized.

SPIUS CREEK

Chinook

Spawning is sparsely distributed throughout, with the vicinity of the bedrock canyon located approximately 10 Km from the mouth being the most heavily utilized area. Suitable spawning habitat appears to be limited, with substrates consisting primarily of large cobble and boulders.

Coho

The best coho spawning habitat in the Spius Creek system occurs in Maka Creek.

3.2 FRESHWATER TIMING

Chinook

Upstream migration of chinook in the Nicola River normally begins in August, with the peak of spawning occurring in mid-September. In some years, however, an early July run, spawning in August, has been reported. Fry emerge from the gravel in April, and based on adult scale analysis, 98% overwinter in fresh water (Starr 1976). Scale data collected in 1981 (Kalnin 1981) indicates that approximately 90% of Nicola River chinook return at age 4_2.

Coho

Coho first appear in the system in September with migration peaking in early October. Spawning occurs in late October and November. Fry emerge in April and May, and spend one or two years rearing in fresh water before migrating seaward in late spring as smolts. Adult scale data collected in 1981 (Kalnin 1982) indicates the following age composition for Nicola system coho:

70% - 3_2

30% - 4_3

Pink

In odd years pink salmon arrive in September and spawn in late September and October. Fry begin their seaward migration shortly after emergence from March to early May.

Steelhead

Adult steelhead appear to hold in the Thompson River until ready to spawn in the Nicola River and various tributaries from April to June. Juveniles normally spend 2 years rearing in fresh water.

The freshwater timing of salmon in the Nicola River system is summarized in Figure 27.

3.3 REARING DISTRIBUTION

The following brief summary is based largely on Starr (1976) and Sebastian (1982). See Figure 28.

NICOLA RIVER

Chinook

The highest densities of juvenile chinook are found in Reach 2 (Spius Creek to Coldwater River), contributing an estimated 40% of total Nicola River smolt carrying capacity. Reach N1 (Thompson River to Spius Creek) contributes another 40%, with the remaining 20% being distributed more or less equally between Reaches N3 (Coldwater River to Nicola Lake), N4 (Nicola Lake to Douglas Lake) and N5 (upstream of Douglas Lake). The rearing potential of Reach N3, and the lower section of Reach N1, may be limited by high summer water temperatures, particularly in August. Present production in Reaches N4 and N5 is limited primarily by underseeding.

Coho

There seems to be very little mainstem rearing of coho in the Nicola River, although this may be partly a function of low fry recruitment, rather than an absence of suitable rearing habitat. Coho pre-smolts were captured in side pools and side channels in Reaches N1 and N2 in April, 1981.

Steelhead

Reaches N1 and N2 are the most important section of the mainstem for juvenile steelhead production.

COLDWATER RIVER

Populations of juvenile coho, chinook, and steelhead are widely distributed throughout the Coldwater system, with average densities for each species generally reflecting the spawning distribution. Considerable underutilized rearing habitat exists in the upper reaches.

SPIUS CREEK

The highest rearing densities of chinook and steelhead occur in the lower 8-10 Km, although inadequate fry recruitment may limit utilization of the upper reaches. Maka Creek appears to contribute the majority of juvenile coho production for the Spius system.

OTHER TRIBUTARIES

Small tributaries such as Nuaitch, Shakan, Skuhun, and Guichon Creeks are thought to contribute significantly to steelhead production in the Nicola River system. In some cases, where the available rearing habitat is limited, it is assumed that fry move downstream to rear in the mainstem Nicola or Thompson Rivers.

4. FISHERIES FLOW REQUIREMENTS

4.1 TRANSECT ANALYSIS

Bio-engineering studies were conducted on the Nicola River (downstream of Nicola Lake), and the Coldwater River in 1980 and 1981.

On the Nicola River in 1980, three transects were established in Reach N3, and four in Reach N2. In addition, two transects were located on the Coldwater River near Merritt, and two more upstream of Kingsvale. In 1980, all study sites were selected primarily to represent chinook or coho spawning habitat.

In 1981 several additional transects were established to more adequately represent all habitat types (i.e. pools, riffles and runs). Some of the transects used in 1980 were deleted due to changes in channel morphology which occurred during high flows in December, 1980. In total, data from 16 transects on the Nicola River and 6 transects on the Coldwater River have been used in the present analysis. Transect locations are shown in Figure 1 and Figures 2 - 5.

Transects were established normal to the flow and permanently marked at each end. Depths and velocities (at .6 the depth from the surface) were measured at intervals ranging from 4 to 8 ft. depending on the width of the transect. Using a modified Wentworth particle size scale (see Appendix D), dominant (>50% of area) and sub-dominant (if >25% of area) substrate types were recorded over a one square metre area at each vertical. Data was collected at each transect at several river discharge levels.

Using habitat suitability criteria for each species (see Section 4.2), the useable width at each transect was calculated for a range of flows (see Appendix E for examples). For each flow, the average useable width for each habitat type in a reach (ie. pools, riffles, runs) was weighted according to the proportional length of stream consisting of similar habitat, using biophysical inventory data provided by Starr (1976). The resulting useable areas for each habitat type were then summed to give a composite curve of total useable area per unit length of stream, versus discharge, for each species and life history stage in the reach, as shown in Figures 29 to 35.

Composite curves were not developed for Reach N1 of the Nicola River because the four transects selected in this 49 Km section were not considered to be an adequate sample, or sufficiently representative of certain habitat types (i.e. deep pools and runs). The individual curves for transects 14-17, however, (Appendix E) were used as indices of habitat availability at different flows.

4.2 HABITAT SUITABILITY CRITERIA

The habitat suitability criteria used in the present analysis are provided in Table 8, and discussed below.

Spawning

Depth and velocity criteria for chinook spawning were taken from Thompson (1972). Since depth and velocity preferences for coho are generally similar, it is assumed that the suitability criteria used for chinook apply also to coho.

Since steelhead spawning occurs during the normal freshet period, adequate spawning flows were not considered to be a problem, and habitat requirements were therefore not analyzed.

Chinook, Coho, and Steelhead Rearing

The criteria used for rearing are based on the probability-of-use curves developed by the Cooperative Instream Flow Group (IFG) of the U.S. Fish and Wildlife Service (Bovee 1978). A typical example is shown in Figure 36. In the IFG methodology, specific depths, velocities, and substrates which occur over a given stream area at a particular flow, are weighted according to their probability-of-use (ie. suitability), in order to calculate the weighted useable area at that flow (Bovee and Milhaus, 1978).

In view of the generalized nature of the probabilty-of-use curves, and in the absence of race and size specific micro-habitat preference data for Nicola system salmonids, we have selected optimum ranges of depth and velocity within the limits defined by the curves for each species, rather than attemtping to weight specific values of each parameter.

The 0.5 level of probability, as shown in Figure 36, was used to set the upper and lower limits for velocity, and the lower limit for depth. With the exception of steelhead fry, it was assumed that there is no maximum depth limit for rearing.

Specific substrate or cover criteria were not used for rearing. Observations indicate that juvenile chinook in the Nicola River utilized a variety of substrate types ranging from very fine material in pools to large cobble and boulders in runs. Substrate preferences by rearing fish may be largely velocity related, reflecting the relationship between substrate size and cover value. For this reason, the data presented for juvenile steelhead and chinook may tend to underestimate the useable habitat area at higher discharges as average velocities apparently become limiting. In reality, the curves may not drop off as steeply as indicated where the bed material of sufficient size to provide low velocity refugia.

4.3 FISHERIES RESOURCE MAINTENANCE FLOWS

The Fisheries Resource Maintenance Flow is defined here as the discharge reqime required to maintain the fisheries production potential of a stream. Determination of the Fisheries Maintenance Flow requires a consideration of the various habitat requirements for each species and life history stage, in the context of the hydrology of the system.

No attempt has been made to relate streamflow directly to specific fish production levels. However, it is assumed that the useable habitat area, which is related to streamflow, determines production capability or potential.

Fisheries Resource Maintenance Flows have been specified for the August to November salmon spawning and rearing period, and for the December to April incubation and juvenile overwintering period (Table 5). Although specific incubation and overwintering requirements were not investigated, it was assumed that flows from December-April shold be similar to the flows recommended for the August to November period, reflecting the natural hydrograph. In addition, flushing flows which normally occur during the May-July freshet period are required to maintain system productivity.

Nicola River

Reach N1 (Thompson R. to Spius Cr.)

Based on the useable width data for transects 14-17 (Appendix E), a minimum flow of 200 cfs (8LG006) is recommended from August to November in Reach N1 to satisfy the requirements for chinook spawning in the upper section (Skuhun Cr. to Spius Cr.), and for chinook and steelhead rearing throughout the reach.

Reach N2 (Spius Cr. to Coldwater R.)

We have assumed that Reach N2, comprising less than 25% by length of the river downstream of Nicola Lake, yet supporting 75% of the chinook spawning, and 40% of chinook rearing populations, is the most critical section in terms of flow requirements. Flow requirements for Reach N2, therefore, dictate to some extent upstream flows in Reach N3 and downstream flows in N1.

Since flows in the Nicola River downstream of Nicola Lake are partially regulated (and may become increasingly so in future), our objective was to define a minimum guaranteed discharge for Reach N2 each month which was equivalent in terms of useable habitat area and fish production capability to the existing flow regime.

As shown in Figure 29, the optimum flow for chinook spawning in Reach N2 is approximately 150 cfs. The optimum for both steelhead fry and parr is 100 cfs. For chinook rearing the useable habitat area curve peaks at 50 cfs (or less), and decreases fairly rapidly above 150 cfs.

Since chinook spawning peaks in September, the lowest flow month, and has the highest flow requirements, it was assumed to be the most critical life history stage. It was also assumed that if chinook spawning requirements were met, requirements for chinook and steelhead rearing would also be satisfied.

In order to determine the discharge required for the maintenance of chinook spawning habitat it is necessary to consider the natural variation in streamflow, and, therefore, the amount of spawning habitat that is available from year to year.

Using Figure 29 and historical streamflow data (WSC 8LG007) the useble spawning area was determined for each year of record based on the mean monthly discharge in September (Figure 30).

The average useable area for the period of record was then calculated, and the corresponding discharge determined from Figure 29, ie. 110 cfs. A discharge of 110 cfs, guaranteed every year during the spawning period, therefore, would be equivalent to the historical streamflow regime in terms of chinook spawning potential. From Figure 29, it can be seen that 110 cfs also provides near optimum rearing conditions for chinook and steelhead.

Accordingly, a minimum discharge of 110 cfs (measured at 8LG007) has been specified from August to November in Reach N2. At times, the actual discharge might have to be higher than this depending on downstream inflow (i.e. Spius Creek and other tributaries), in order to meet the requirement of 200 cfs in N1.

A minimum discharge of 110 cfs is also recommended from December to April in N2. This would generally be attainable in most years, based on average runoff during this period.

Reach N3 (Coldwater R. to Nicola Lake)

Section A - Nicola Lake outlet to silt boils (2.9 Km)

This section of Reach N3 is a productive chinook spawning area. Although suitable rearing habitat exists (Figure 28), utilization appears to be limited by high water temperatures in summer. As shown in Figure 31, optimum spawning conditions for chinook occur at 60 cfs.

<u>Section B</u> - Silt Boils to
Coldwater R. (13.8 Km)

Although much of this section consists of slow runs with fine substrates, chinook spawning occurs in suitable riffle areas. Rearing potential, however, is limited by sedimentation and high water temperatures in summer. As shown in Figure 32, the useable chinook spawning area does not change significantly over a fairly wide range of flows until about 80 cfs, at which point the spawnable area appears to increase. This is due to velocities increasing in the runs to a point (1-2 ft./sec.) where they become useable (if substrates are suitable). At normal flows in September, however, these areas are generally unsuitable for chinook spawning,

In summary, for Reach N3, a minimum discharge of 60 cfs is recommended from August to November (a gauge would have to be established in this section of the river). When the Coldwater River discharge was less than 50 cfs, flows in N3 would have to be greater than 60 cfs in order to meet the fisheries requirements of 110 cfs in N2.

A minimum flow of 40 cfs is recommended from December to April for incubation. (Flows in this section are normally lower in winter than in the fall.)

Coldwater River

The relationship between useable area and discharge is shown for the Coldwater River near Kingsvale, and near Merritt, in Figures 33 and 34, respectively.

Using the data for the Coldwater at Merritt and historical streamflow records (WSC 8LG010), the average area of chinook spawning habitat available in September was calculated as shown in Figure 35.

The corresponding Fisheries Resource Maintenance Flow was then determined from Figure 34, i.e. approximately 50 cfs. In addition to maintaining adequate spawning conditions, a discharge of 50 cfs in the Coldwater River at Merritt also provides good rearing conditions for all species. Below about 30 cfs, chinook spawning habitat is limited in the lower Coldwater. Optimum spawning conditions would occur at approximately 120 cfs.

At the present time, the Fisheries Resource Maintenance Flow is not always attained. In a dry year, flows in August or September may drop well below 50 cfs. Since flows are often critically low during this period, further diversions from the Coldwater River should not be permitted unless fully supported by storage.

Upper Nicola, Spius Creek and Guichon Creek

The Fisheries Resource Maintenance Flows determined for the Coldwater River and for the Nicola River downstream of Nicola Lake represent from 16-22% of the mean annual discharge. Using an average value of 20% of the mean annual discharge, fisheries flow requirements were estimated for the upper Nicola River (Reach N4), Spius Creek, and Guichon Creek (Table 5). Since field studies were not conducted in these sub-basins, these estimates must be considered provisional, but may be useful for preliminary resource planning purposes.

5. TEMPERATURE STUDIES

Water temperatures were measured near the outlet of Nicola Lake from August to October in 1977 (Figure 37). The warmest day was August 14 with maximum and minimum temperatures of 83° and 80°F. There was a relatively small spread, not more than about 4°F between maximum and minimum daily temperatures during this period of record, which shows the moderating influence of the lake on water tempertures. On August the 25th (at 1400 hrs.) a spot temperture of 66°F taken in the Nicola River just above Merritt shows that the river temperature increased only one degree between the lake (at 65°F) and Merritt, a river distance of about 15 miles.

Between June 22nd and the 24th 1981, seven thermographs were installed on the river at locations shown in Figures 2 to 5. Water temperatures recorded for the period June to December are shown in Figure 38. As in 1977, maximum temperatures occurred in the middle of August. Comparison of the Chutter and Jurett thermograph records shows, as in 1977, that very little change took place in water temperature between the lake and Merritt.

The average Coldwater temperature was generally colder than the Nicola River above Merritt (Figure 39). However, the flow in the Coldwater during the summer was much less so its influence on reducing the temperature in the Nicola mainstem was slight, only one or two degrees cooler at Hannas than at Juretts (Figures 3 and 39). Below Merritt, the water continues to cool slightly as it travels downriver.

Both the 1977 and 1981 data show that average water temperatures in the critical month of August are high at the outlet of Nicola Lake. They tend to decrease slightly downstream of Merritt, being generally cooled by the Coldwater (the amount of cooling being governed by the ratio of Coldwater to Nicola flows). Below Spius Creek temperatures increased again down to the Curnow thermograph. There, temperatures exceeded those in the Nicola at Merritt.

Although the temperature regime in the Nicola will vary from year to year depending on the weather and the relative flows in the tributaries (in 1981 the August flow in the Nicola was higher than average), it appears that increased flows out of Nicola Lake during periods of hot weather (August) would not reduce river temperature downstream and furthermore, whenever the Coldwater was colder, as it usually is, it would dilute the cooling effect at the Coldwater confluence. Due to the configuration of the Nicola Lake outlet, releasing cooler water from depth does not appear to be practical.

Presently, high water temperatures appear to limit the salmonid rearing potential of the Nicola River between Nicola Lake and the Coldwater confluence, and possibly in the lower reaches near its confluence with the Thompson River, with mean daily temperatures in August 1981 exceeding 74°F (23°C) in both cases.

SUMMARY AND RECOMMENDATIONS

The current economic value of the fisheries resource of the Nicola River system is approximately $600,000 annually, not including the contribution, believed to be significant, to the popular Thompson River steelhead fishery.

Hydrological records and data collected during field studies in 1980-81 were used to determine Fisheries Resource Maintenance Flows (flows required to maintain the production potential) for the Nicola and Coldwater Rivers. The results are shown in table 5. The values given for the upper Nicola (above Nicola Lake) Spius and Guichon Creeks are based on 20% of the mean annual flow.

Superposition of these flow requirements on the historic hydrographs (Appendix A) shows that the critical low flow periods are in the late summer - fall, and winter. The extra storage (over that presently maintained in Nicola Lake) that would have been required for the years listed is shown in table 6. For an average year this would have amounted to about one extra foot of storage; for a dry year, about two feet. Calculations included the effects of present water withdrawals from the system. Extra storage could effectively be obtained by better regulation of the present Nicola Lake dam.

Release of more water from the Nicola Lake reservoir may not be beneficial because of high lake water temperatures particularly during low flow periods in very hot weather (usually August). It is known that temperatures in the Nicola between the lake and Merritt become critical in July - August and may be limiting juvenile survival in that reach.

In order to ensure that the salmonid production potential of the Nicola River system is maintained, it is recommended that:

1. There be no increase in water diversion from the Nicola mainstem, Spius Creek, and Coldwater River during low flow periods, and no new water diversion licences unless they are supported by storage.

2. Nicola Lake be better regulated to ensure optimum use of storage potential. This would be facilitated by upgrading the Nicola Lake Dam.

3. The Fisheries Resource Maintenance Flows as given in table 5 be provided.

4. The fishway at the Nicola Lake dam be improved or replaced.

5. An hydrometric station be established just downstream of Nicola Lake for monitoring flow releases out of the lake.

6. The storage potential of Douglas Lake be assessed, as increased flows in the Upper Nicola River would provide considerable fisheries benefits.

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TABLES
1 -- 8

TABLE 1

NICOLA RIVER
Monthly Flows and Deficits
1970, 1971

1970	(1) Nicola Below Merritt	(2) Coldwater	(3) Nicola above Merritt (1)-(2)	(4) Deficit* above Merritt 40/60 -(3)	(5) Deficit* below Merritt 110 -(1)
JAN	105	40	65	-	5
FEB	110	43	67	-	-
MAR	138	93	45	-	-
APR	207	185	22	18	-
MAY	1240	930	310	-	-
JUN	1530	1000	530	-	-
JUL	301	78	223	-	-
AUG	128	15	113	-	-
SEP	95	21	74	-	15
OCT	90	38	52	8	20
NOV	57	40	17	43	53
DEC	47	29	18	22	63
1971					
JAN	93	70	23	17	17
FEB	285	184	101	-	-
MAR	144	102	42	-	-
APR	358	320	38	2	-
MAY	3090	2040	1050	-	-
JUN	3200	1230	1970	-	-
JUL	1180	509	671	-	-
AUG	187	79	108	-	-
SEP	98	40	58	2	12
OCT	105	68	37	23	5
NOV	122	78	44	16	-
DEC	104	20	84	-	6

*The Deficit is that additional release that would have been required to maintain the following Fisheries Maintenance Flow schedule:
110 cfs below Merritt
60 cfs above Merritt- Aug. to Nov.
40 cfs above Merritt- Dec. to Apr.

TABLE 2

NICOLA RIVER
Monthly Flows and Deficits
1972, 1974

	(1)	(2)	(3)	(4)	(5)
1972	Nicola Below Merritt	Coldwater	Nicola above Merritt (1)-(2)	Deficit* above Merritt 40/60 -(3)	Deficit* below Merritt 110 -(1)
JAN	82	26	56	-	28
FEB	91	71	20	20	19
MAR	529	404	125	-	-
APR	813	470	343	-	-
MAY	3090	2130	960	-	-
JUN	3380	1950	1430	-	-
JUL	1660	861	799	-	-
AUG	464	158	306	-	-
SEP	188	52	136	-	-
OCT	103	54	50	10	7
NOV	30	35	0	60	80
DEC	67	14	53	-	43
1974					
JAN	150	90	60	-	-
FEB	171	107	64	-	-
MAR	224	177	47	-	-
APR	689	658	31	9	-
MAY	2190	1310	880	-	-
JUN	3210	1970	1240	-	-
JUL	1470	814	656	-	-
AUG	368	154	214	-	-
SEP	146	34	112	-	-
OCT	114	34	80	-	-
NOV	127	53	74	-	-
DEC	126	58	68	-	-

*The Deficit is that additional release that would have been required to maint‹in the following Fisheries Maintenance Flow schedule:
110 cfs below Merritt
60 cfs above Merritt- Aug. to Nov.
40 cfs above Merritt- Dec. to Apr.

TABLE 3

NICOLA RIVER
Monthly Flows and Deficits
1975, 1976

	(1)	(2)	(3)	(4)	(5)
1975	Nicola Below Merritt	Coldwater	Nicola above Merritt (1)-(2)	Deficit* above Merritt 40/60 -(3)	Deficit* below Merritt 110 -(1)
JAN	101	43	58	-	9
FEB	115	43	72	-	-
MAR	157	49	108	-	-
APR	307	179	128	-	-
MAY	1430	1180	250	-	-
JUN	2270	1620	650	-	-
JUL	807	570	237	-	-
AUG	212	69	143	-	-
SEP	117	40	77	-	-
OCT	151	87	64	-	-
NOV	426	341	85	-	-
DEC	343	331	12	28	-
1976					
JAN	230	197	33	7	-
FEB	197	146	51	-	-
MAR	154	87	67	-	-
APR	300	247	53	-	-
MAY	1460	1230	230	-	-
JUN	1630	1120	510	-	-
JUL	863	788	105	-	-
AUG	473	244	229	-	-
SEP	435	90	345	-	-
OCT	199	37	162	-	-
NOV	185	66	119	-	-
DEC	133	59	74	-	-

*The Deficit is that additional release that would have been required to maintain the following Fisheries Maintenance Flow schedule:
110 cfs below Merritt
60 cfs above Merritt- Aug. to Nov.
40 cfs above Merritt- Dec. to Apr.

TABLE 4

NICOLA RIVER
Monthly Flows and Deficits
1977, 1978

	(1)	(2)	(3)	(4)	(5)
1977	Nicola Below Merritt	Coldwater	Nicola above Merritt (1)-(2)	Deficit* above Merritt 40/60 -(3)	Deficit* below Merritt 110 -(1)
JAN	125	66	59	-	-
FEB	190	115	75	-	-
MAR	142	73	69	-	-
APR	327	280	47	-	-
MAY	819	513	306	-	-
JUN	705	497	208	-	-
JUL	185	68	117	-	-
AUG	77	15	62	-	33
SEP	72	23	49	11	38
OCT	88	39	48	12	22
NOV	166	141	25	35	-
DEC	137	125	12	28	-
1978					
JAN	91	61	30	10	19
FEB	86	59	27	13	24
MAR	221	162	59	-	-
APR	529	469	60	-	-
MAY	1630	961	669	-	-
JUN	1780	1010	770	-	-
JUL	436	216	220	-	-
AUG	138	41	97	-	-
SEP	181	83	98	-	-
OCT	169	76	93	-	-
NOV	265	176	89	-	-
DEC	124	55	69	-	-

*The Deficit is that additional release that would have been required to maintain the following Fisheries Maintenance Flow schedule:
110 cfs below Merritt
60 cfs above Merritt- Aug. to Nov.
40 cfs above Merritt- Dec. to Apr.

TABLE 5

FISHERIES RESOURCE MAINTENANCE FLOW REQUIREMENTS
FOR THE NICOLA RIVER AND MAJOR TRIBUTARIES

Stream/Reach	Fisheries Resource Maintenance Flows Aug-Nov cfs	Aug-Nov (M^3/s)	Dec-Apr cfs	Dec-Apr (M^3/s)	Gage or Point of Measurement
Nicola R					
N1 Thompson R. to Spius Cr.	200[1]	(5.66)	200[1]	(5.66)	8LG006
N2 Spius Cr. to Coldwater River	110[1]	(3.12)	110[1]	(3.12)	8LG007
N3 Coldwater R. to Nicola Lake	60[1]	(1.69)	40[1]	(1.13)	Dam
N4 Nicola L. to Douglas L.	28[2]	(.78)	28[2]	(.78)	8LG049
Coldwater R. (Brodie-Merritt)	50[1]	(1.42)	50	(1.42)	8LG010
Spius Creek	78[2]	(2.22)	78[2]	(2.22)	8LG008
Guichon Creek	7[2]	(.2)	7[2]	(.2)	8LG004

[1] Minimum flows
[2] Estimates based on 20% of mean annual flow

TABLE 6

NICOLA RIVER
Deficits in CFS Days
(Short of 110 cfs flow requirement)

	1970-71	1971-72	1972-75*	1975-76	1976-77	1977-78
JUL						
AUG						930
SEP	400	450				1200
OCT	750	125	720	0	0	1000
NOV	1500	0	2400	0	0	300
DEC	1860	360	1300	0	0	520
JAN	1250	910	230	0	170	610
FEB		540				880
MAR						210
APR						
MAY						
JUN						
	5,760	2,385	4,650	000	170	5,650

Average = (5760+2385+4650+0+170+5650)/6=3102 cfs days
= 6,204 acre feet

*Data for 1973 - 1974 missing
Combining data for 1972 and 1975 was assumed valid

TABLE 7

NICOLA RIVER SYSTEM - AVERAGE AND MAXIMUM RECORDED ESCAPEMENTS

	Average Escapements			Maximum Escapement
	1951-1960	1961-1970	1971-1980	
Nicola				
Chinook	6,567	2,950	2,950	7,500
Coho	1,230	1,108	367	3,500
Pink	2,140	820	1,625	4,000
Coldwater				
Chinook	780	251	611	1,500
Coho	2,400	1,461	518	7,500
Spius				
Chinook	528	118	343	1,500
Coho	964	222	364	3,500

TABLE 8

HABITAT SUITABILITY CRITERIA

	Depth (ft.)	Velocity (ft./sec.)	Dominant Substrate Type
Chinook spawning	0.8+	1.0 - 3.0	4, 5
Chinook juvenile	1.0+	.25 - 1.25	
Coho juvenile	1.2+	0.2 - .75	
Steelhead fry	0.2 - 1.4	.25 - 1.5	
Steelhead parr	0.5+	.25 - 2.25	

FIGURES

1 - 39

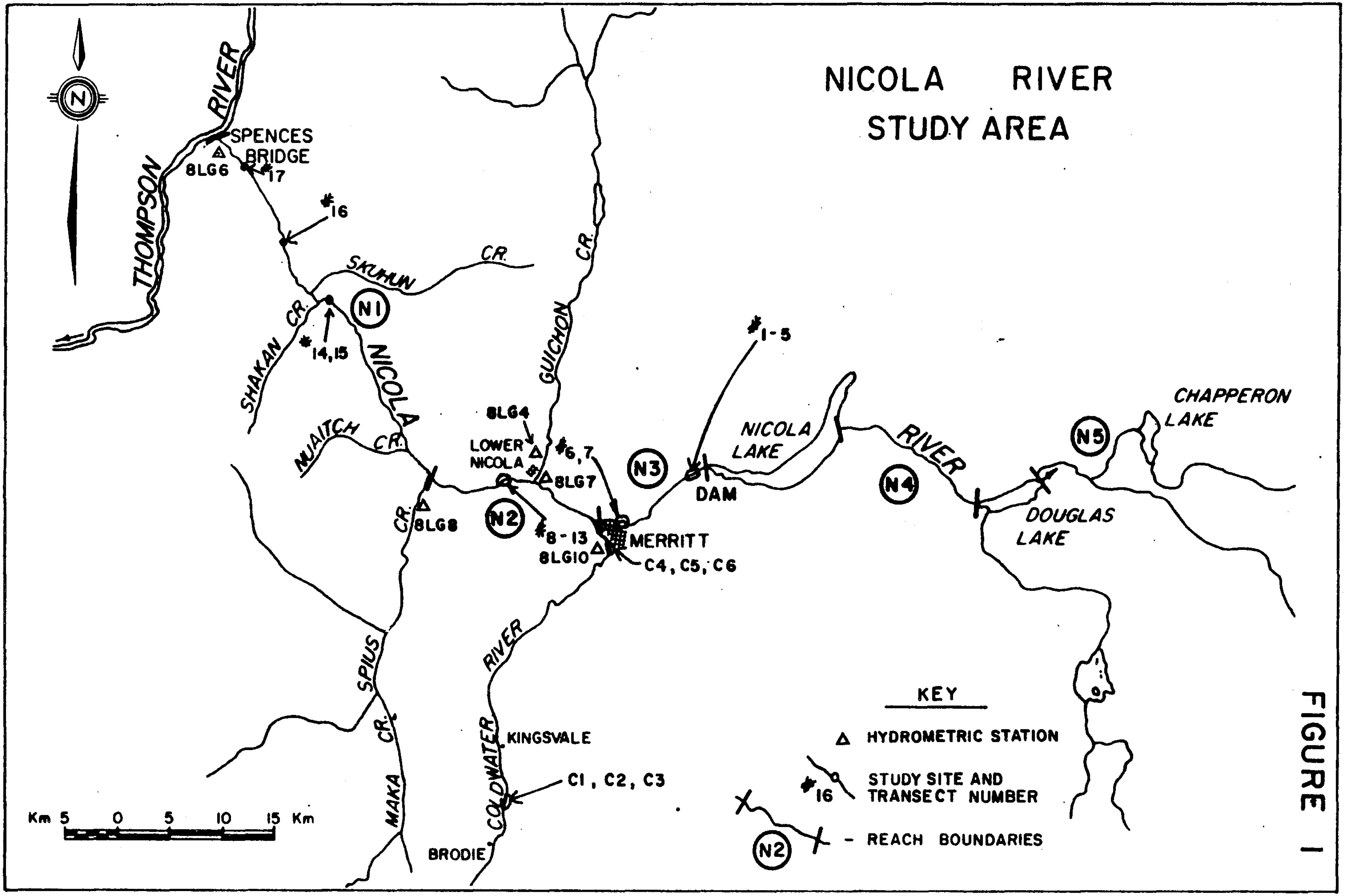


FIGURE 1

NICOLA RIVER STUDY AREA

FIGURE 2

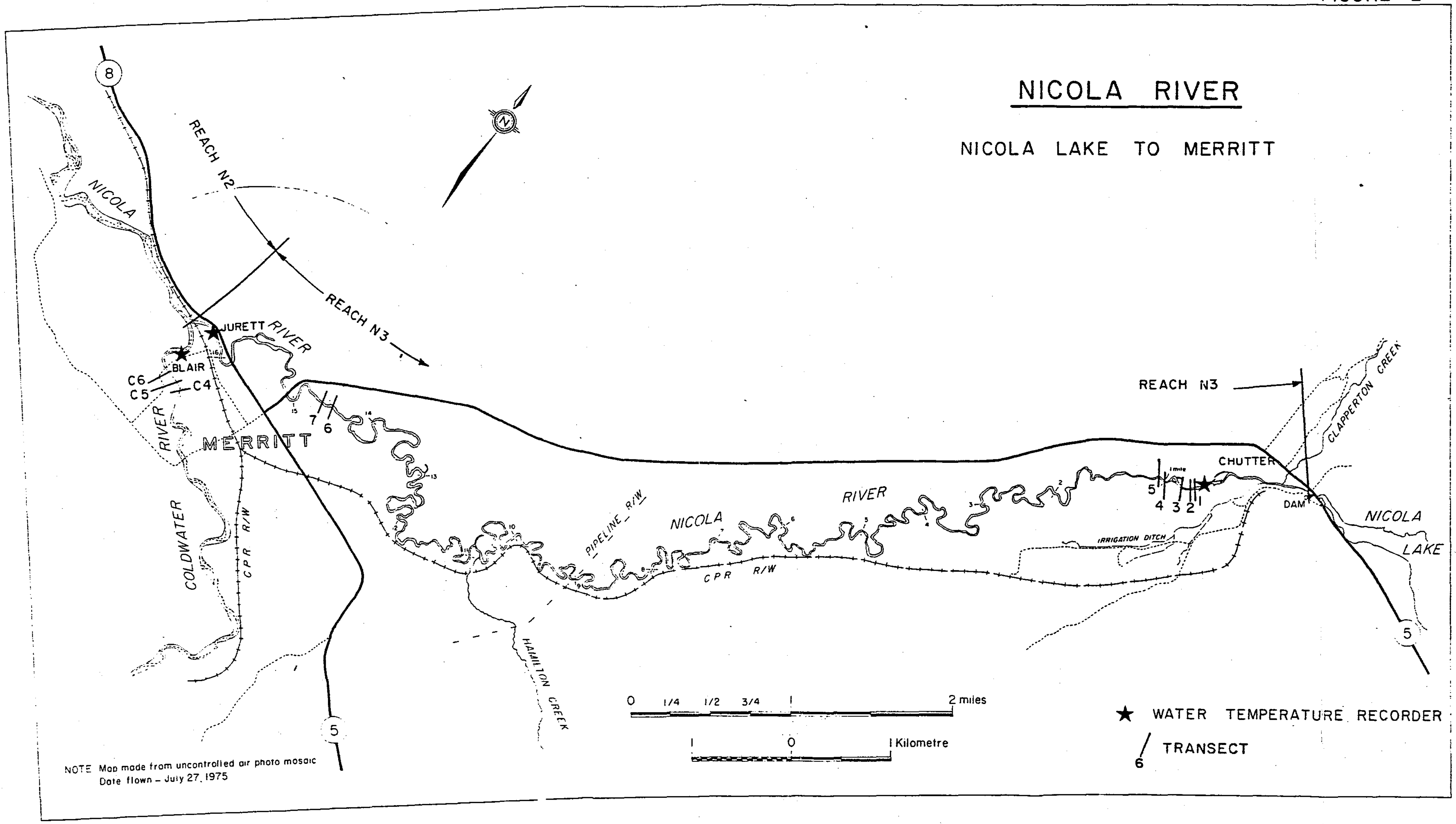

NICOLA RIVER
NICOLA LAKE TO MERRITT
REACH N2
REACH N3
REACH N3
NICOLA
RIVER
JURETT
BLAIR
C6
C5
C4
7
6
MERRITT
RIVER
COLDWATER
CPR R/W
PIPELINE R/W
NICOLA
RIVER
CPR R/W
HAMILTON CREEK
CHUTTER
CLAPPERTON CREEK
DAM
NICOLA
LAKE
IRRIGATION DITCH
5
4
3
2
1
8
5
5
0
1/4
1/2
3/4
1
2 miles
1
0
1 Kilometre
WATER TEMPERATURE RECORDER
TRANSECT
6
NOTE Map made from uncontrolled air photo mosaic
Date flown – July 27, 1975

FIGURE 3

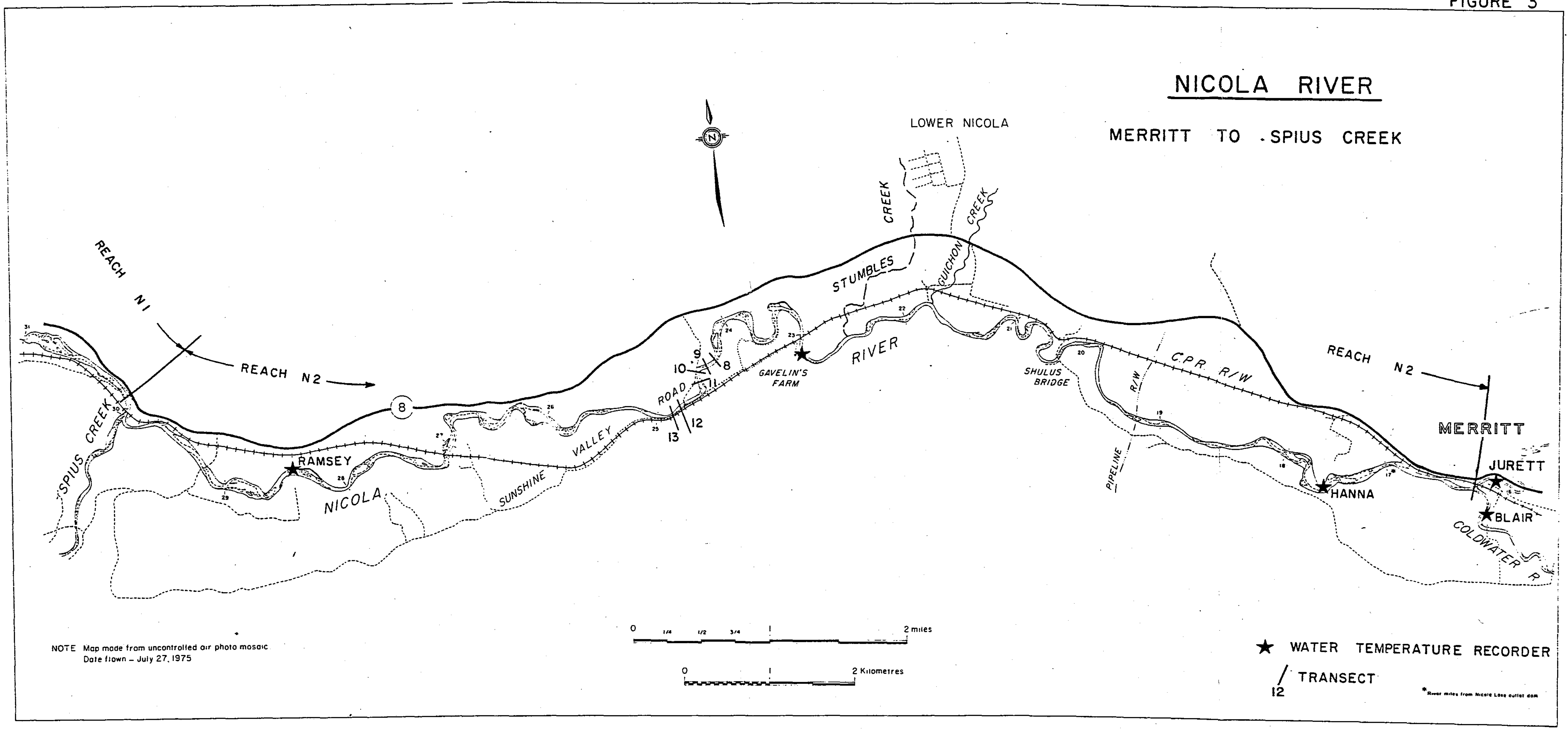

NICOLA RIVER
MERRITT TO SPIUS CREEK
LOWER NICOLA
CREEK
STUMBLES
GUICHON
CREEK
REACH N1
REACH N2
REACH N2
SPIUS CREEK
RAMSEY
NICOLA
SUNSHINE
VALLEY
ROAD
GAVELIN'S FARM
RIVER
SHULUS BRIDGE
C.P.R. R/W
R/W
PIPELINE
MERRITT
JURETT
HANNA
BLAIR
COLDWATER R.
8
10
9
8
12
13
0
1/4
1/2
3/4
1
2 miles
2 Kilometres
NOTE Map made from uncontrolled air photo mosaic
Date flown – July 27, 1975
WATER TEMPERATURE RECORDER
TRANSECT
12
* River miles from Nicola Lake outlet dam

FIGURE 4

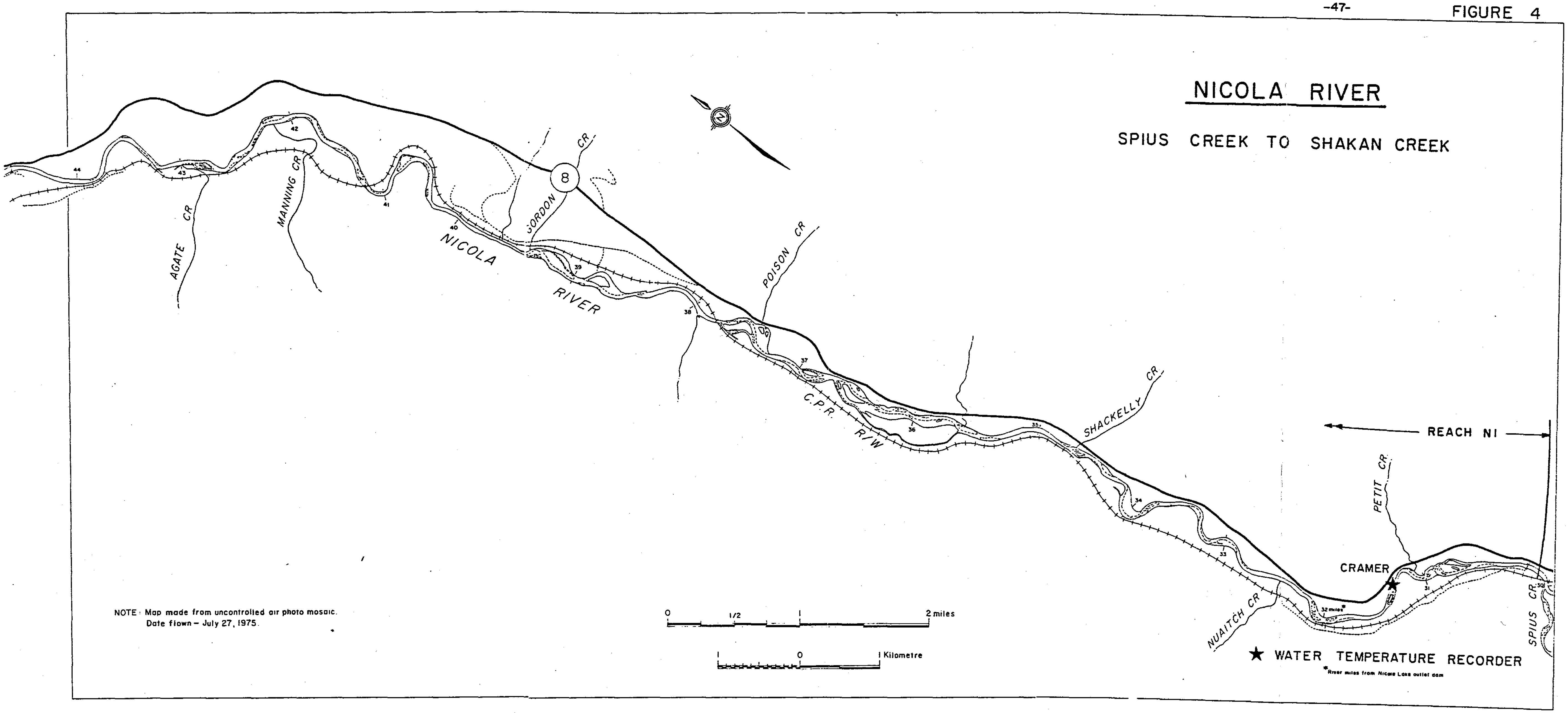
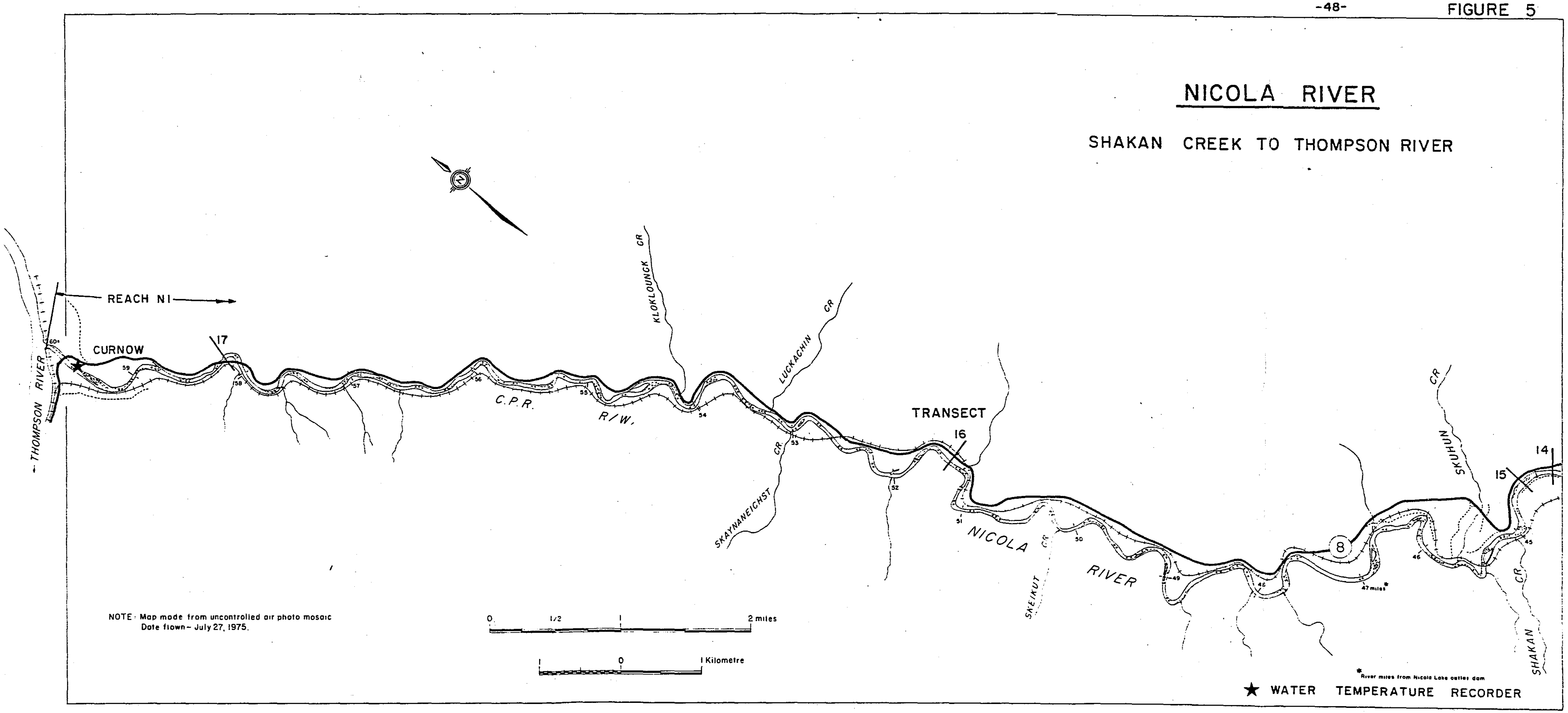

NICOLA RIVER
SPIUS CREEK TO SHAKAN CREEK
NICOLA RIVER
C.P.R. R/W
AGATE CR
MANNING CR
GORDON CR
POISON CR
SHACKELLY CR
PETIT CR
NUAITCH CR
SPIUS CR
CRAMER
REACH N1
8
44
43
42
41
40
39
38
37
36
35
34
33
32 miles
31
30
0
1/2
1
2 miles
1
0
1 Kilometre
NOTE: Map made from uncontrolled air photo mosaic.
Date flown – July 27, 1975.
WATER TEMPERATURE RECORDER
River miles from Nicola Lake outlet dam

FIGURE 5


NICOLA RIVER
SHAKAN CREEK TO THOMPSON RIVER
REACH N1
CURNOW
THOMPSON RIVER
17
KLOKLOUNCK CR
LUCKACHIN CR
C.P.R. R/W.
SKAYNANEIGHST CR
TRANSECT
16
NICOLA RIVER
SKEIKUT CR
8
SKUHUN CR
SHAKAN CR
14
15
NOTE: Map made from uncontrolled air photo mosaic
Date flown – July 27, 1975.
0 1/2 1 2 miles
1 0 1 Kilometre
* River miles from Nicola Lake outlet dam
★ WATER TEMPERATURE RECORDER

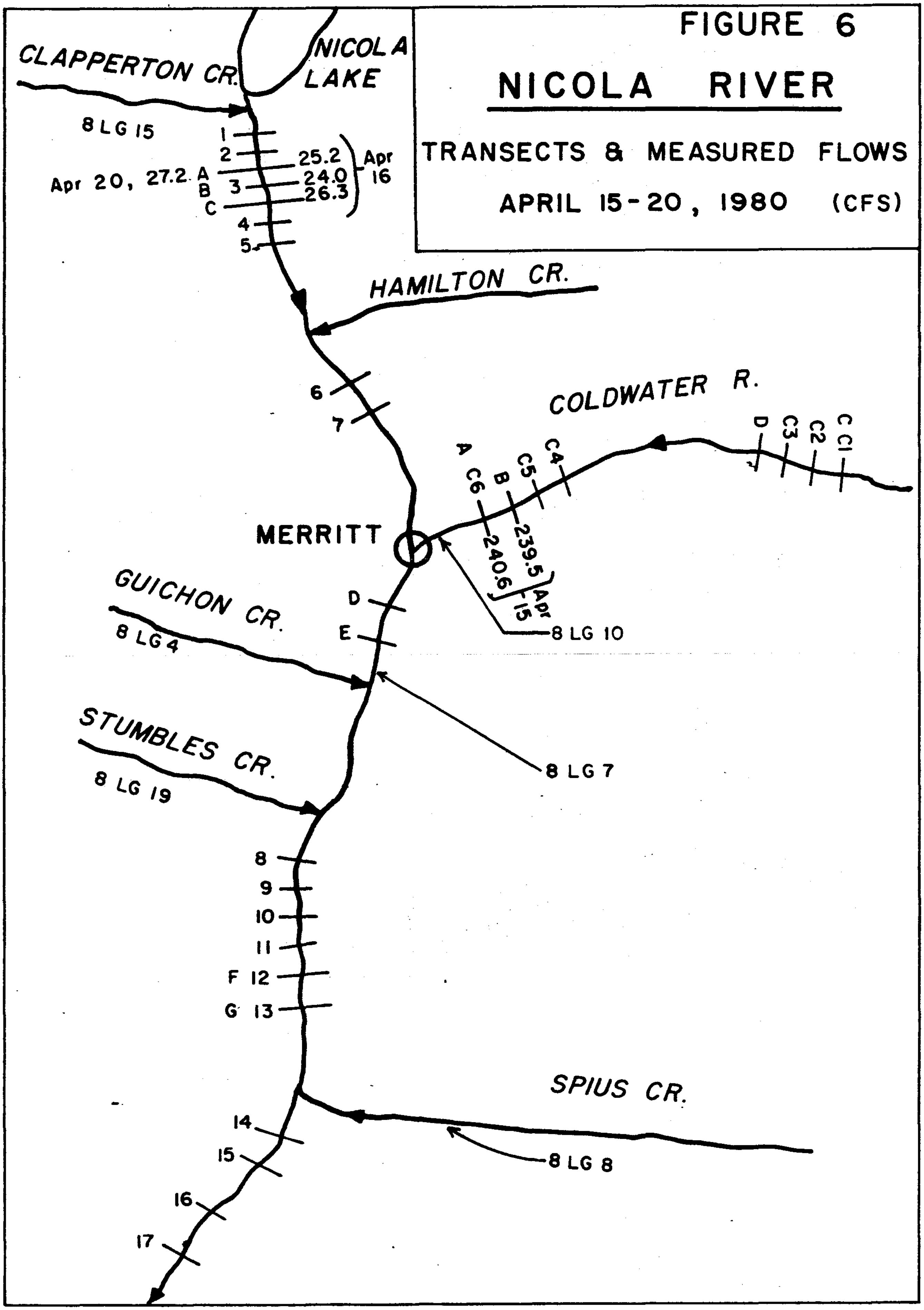


FIGURE 6
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
APRIL 15-20, 1980 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
1
2
25.2
Apr 16
Apr 20, 27.2 A
24.0
B 3
26.3
C
4
5
HAMILTON CR.
6
7
COLDWATER R.
C C1
C2
C3
D
C4
C5
B
A C6
239.5
240.6
Apr 15
MERRITT
8 LG 10
GUICHON CR.
8 LG 4
D
E
8 LG 7
STUMBLES CR.
8 LG 19
8
9
10
11
F 12
G 13
SPIUS CR.
8 LG 8
14
15
16
17

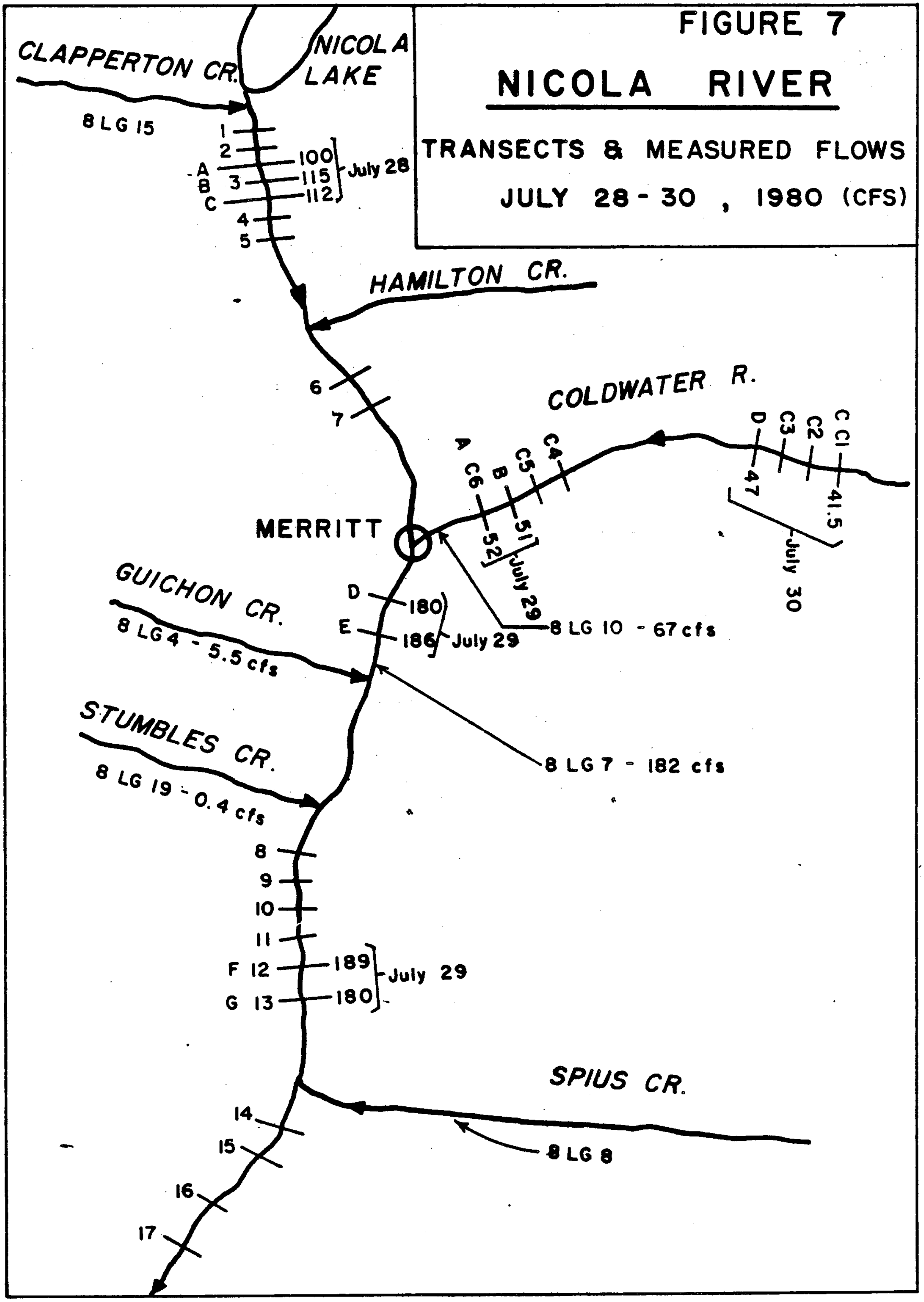


FIGURE 7
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
JULY 28 - 30 , 1980 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
1
2
A
B 3
C
100
115
112
July 28
4
5
HAMILTON CR.
6
7
COLDWATER R.
A C6
B C5
C4
52
51
July 29
D
C3
C2
C C1
47
41.5
July 30
MERRITT
GUICHON CR.
8 LG 4 - 5.5 cfs
D
E
180
186
July 29
8 LG 10 - 67 cfs
8 LG 7 - 182 cfs
STUMBLES CR.
8 LG 19 - 0.4 cfs
8
9
10
11
F 12
G 13
189
180
July 29
SPIUS CR.
8 LG 8
14
15
16
17

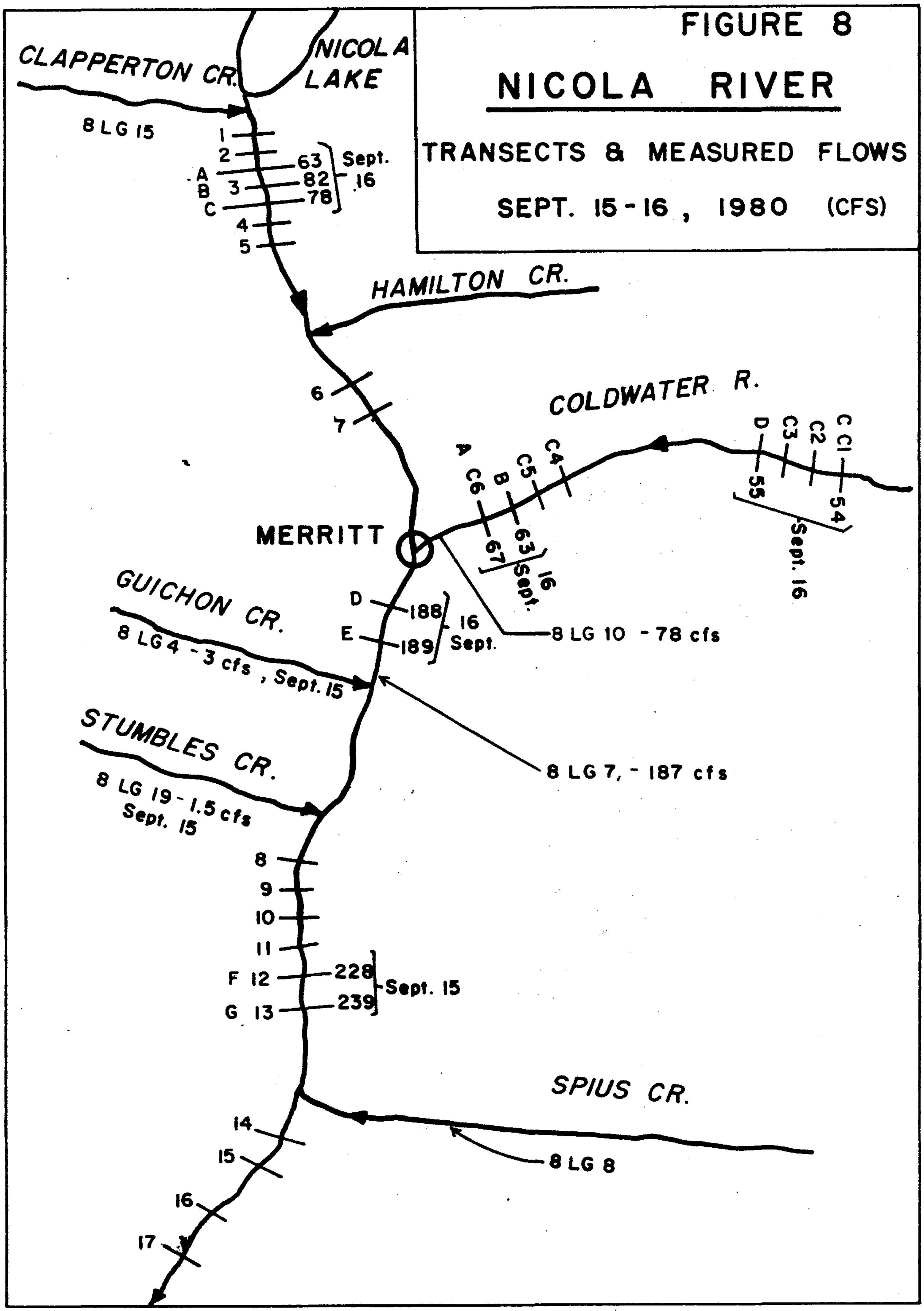


FIGURE 8
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
SEPT. 15-16, 1980 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
1
2
A
3
B
C
4
5
63
82
78
Sept. 16
HAMILTON CR.
6
7
COLDWATER R.
MERRITT
A C6
B
C5
C4
67
63
Sept. 16
D
55
C3
C2
C C1
54
Sept. 16
8 LG 10 - 78 cfs
GUICHON CR.
8 LG 4 - 3 cfs, Sept. 15
D
E
188
189
16 Sept.
8 LG 7, - 187 cfs
STUMBLES CR.
8 LG 19 - 1.5 cfs Sept. 15
8
9
10
11
F 12
G 13
228
239
Sept. 15
SPIUS CR.
8 LG 8
14
15
16
17

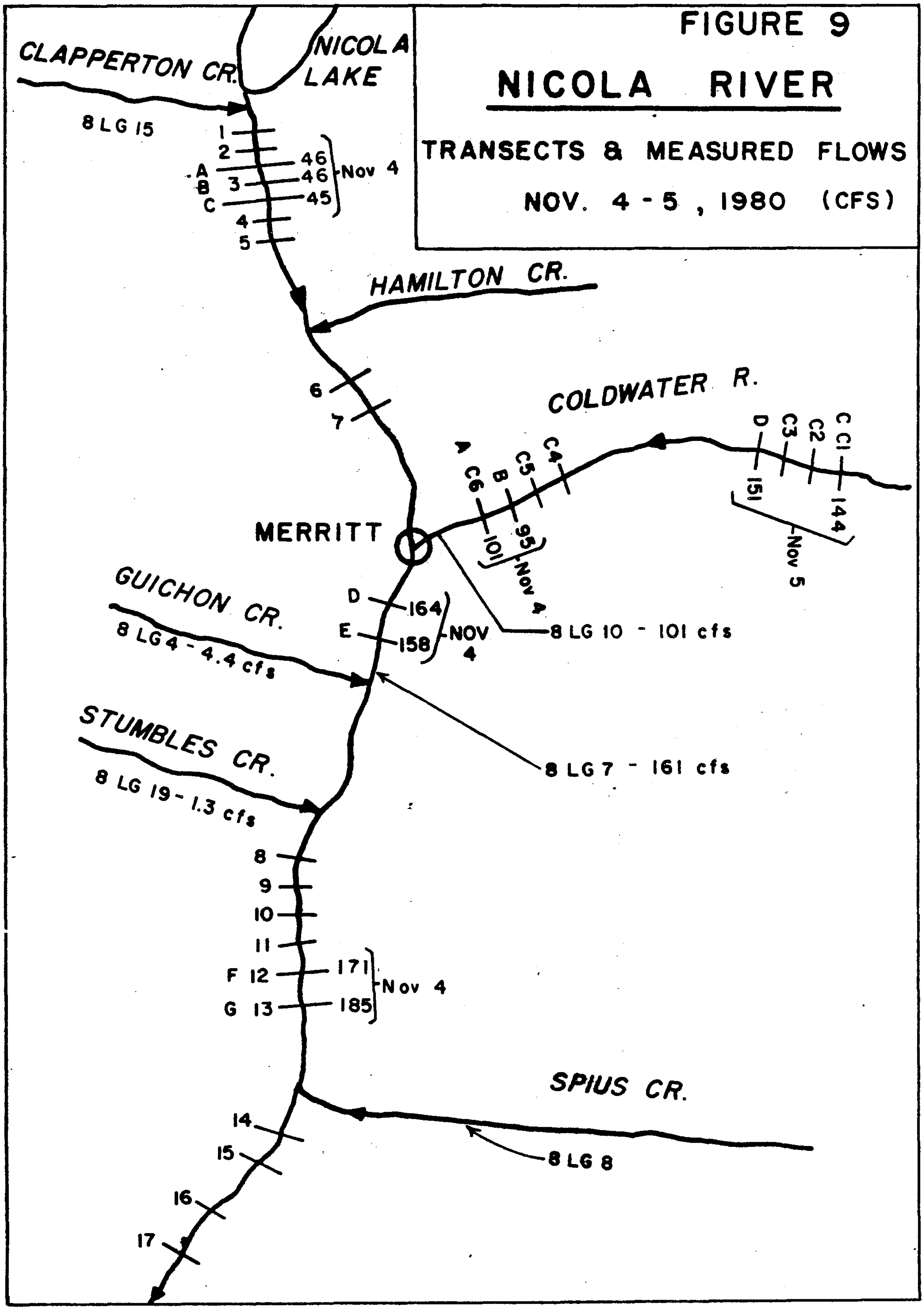


FIGURE 9
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
NOV. 4 - 5 , 1980 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
1
2
A 46
B 3 46
C 45
Nov 4
4
5
HAMILTON CR.
6
7
COLDWATER R.
C C1
C2
C3
D
151
144
Nov 5
C4
C5
B
A C6
95
101
Nov 4
MERRITT
D 164
E 158
NOV 4
8 LG 10 - 101 cfs
GUICHON CR.
8 LG 4 - 4.4 cfs
8 LG 7 - 161 cfs
STUMBLES CR.
8 LG 19 - 1.3 cfs
8
9
10
11
F 12 171
G 13 185
Nov 4
SPIUS CR.
8 LG 8
14
15
16
17

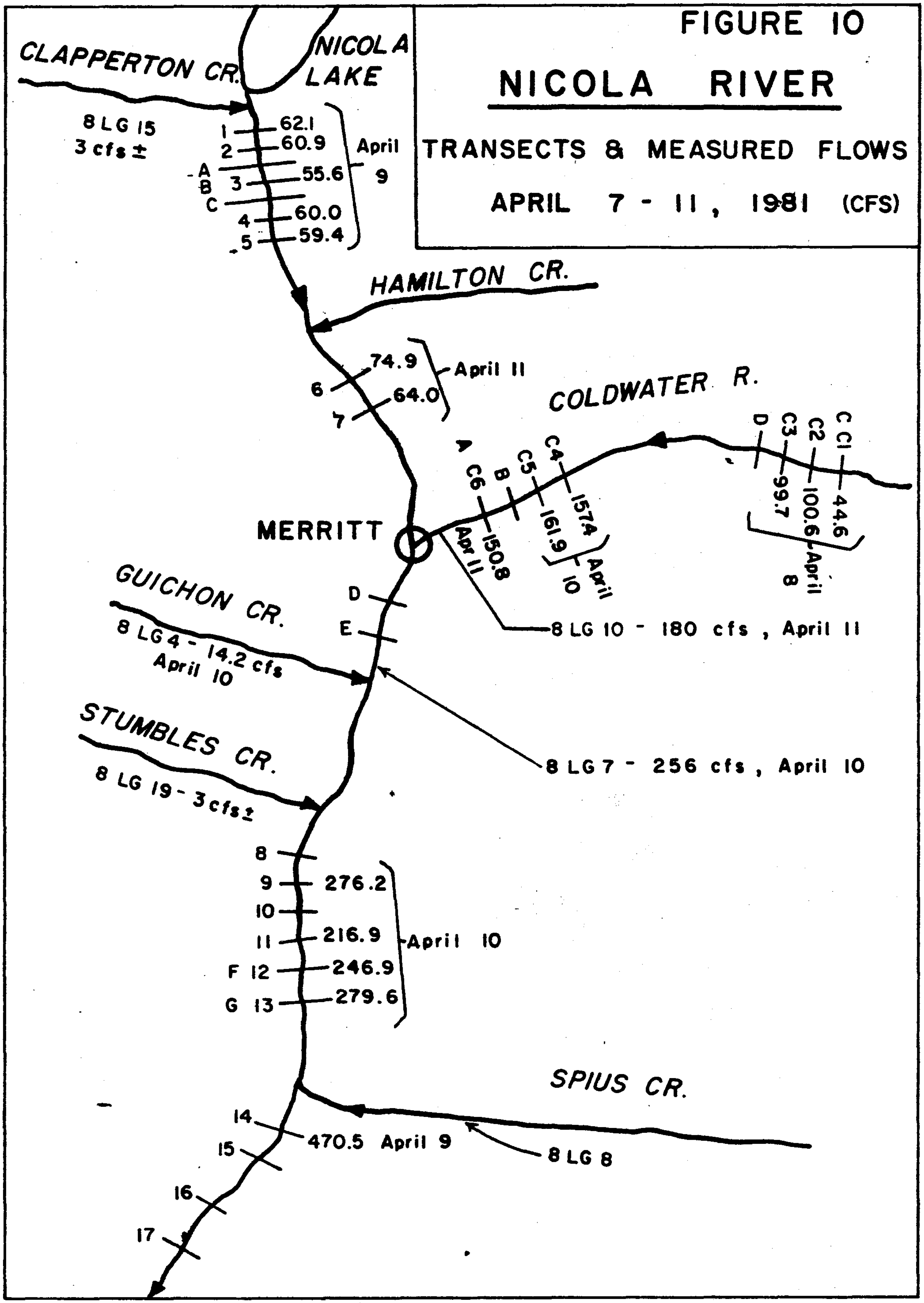


FIGURE 10
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
APRIL 7 - 11, 1981 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
3 cfs ±
1 62.1
2 60.9
A
B 3 55.6
C
4 60.0
5 59.4
April 9
HAMILTON CR.
6 74.9
7 64.0
April 11
COLDWATER R.
C C1 44.6
C2 100.6
C3 99.7
D
April 8
C4 157.4
C5 161.9
April 10
B
A C6 150.8
Apr 11
MERRITT
8 LG 10 - 180 cfs, April 11
GUICHON CR.
8 LG 4 - 14.2 cfs
April 10
D
E
8 LG 7 - 256 cfs, April 10
STUMBLES CR.
8 LG 19 - 3 cfs ±
8
9 276.2
10
11 216.9
F 12 246.9
G 13 279.6
April 10
SPIUS CR.
14 470.5 April 9
15
16
17
8 LG 8

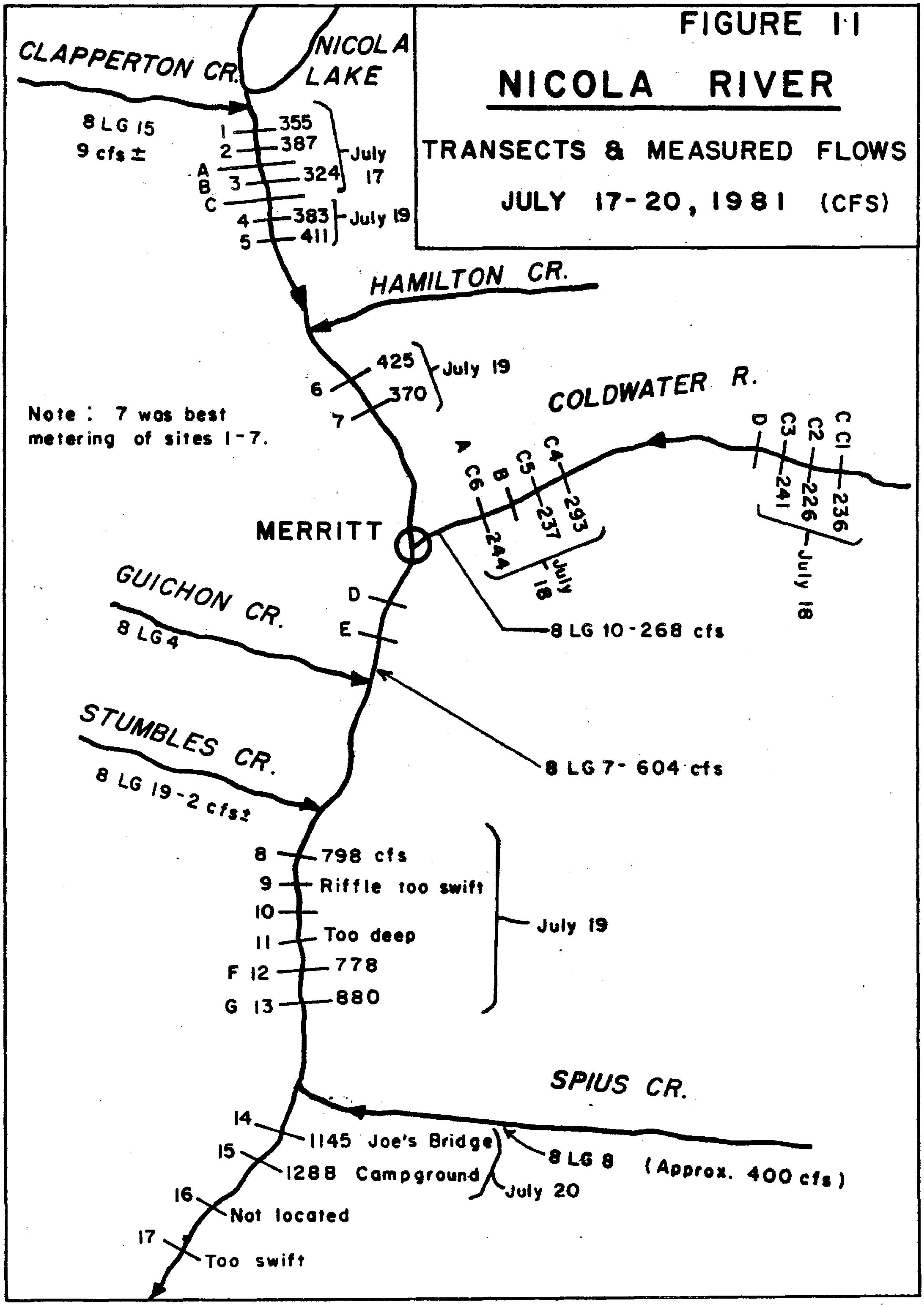


FIGURE 1·1
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
JULY 17-20, 1981 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
9 cfs ±
1 355
2 387
A
B 3 324
C
July 17
4 383
5 411
July 19
HAMILTON CR.
6 425
7 370
July 19
Note: 7 was best metering of sites 1-7.
COLDWATER R.
A C6 244
B C5 237
C4 293
July 18
D C3 241
C2 226
C C1 236
July 18
MERRITT
8 LG 10-268 cfs
GUICHON CR.
8 LG 4
D
E
8 LG 7- 604 cfs
STUMBLES CR.
8 LG 19-2 cfs±
8 798 cfs
9 Riffle too swift
10
11 Too deep
F 12 778
G 13 880
July 19
SPIUS CR.
14 1145 Joe's Bridge
15 1288 Campground
July 20
8 LG 8 (Approx. 400 cfs)
16 Not located
17 Too swift

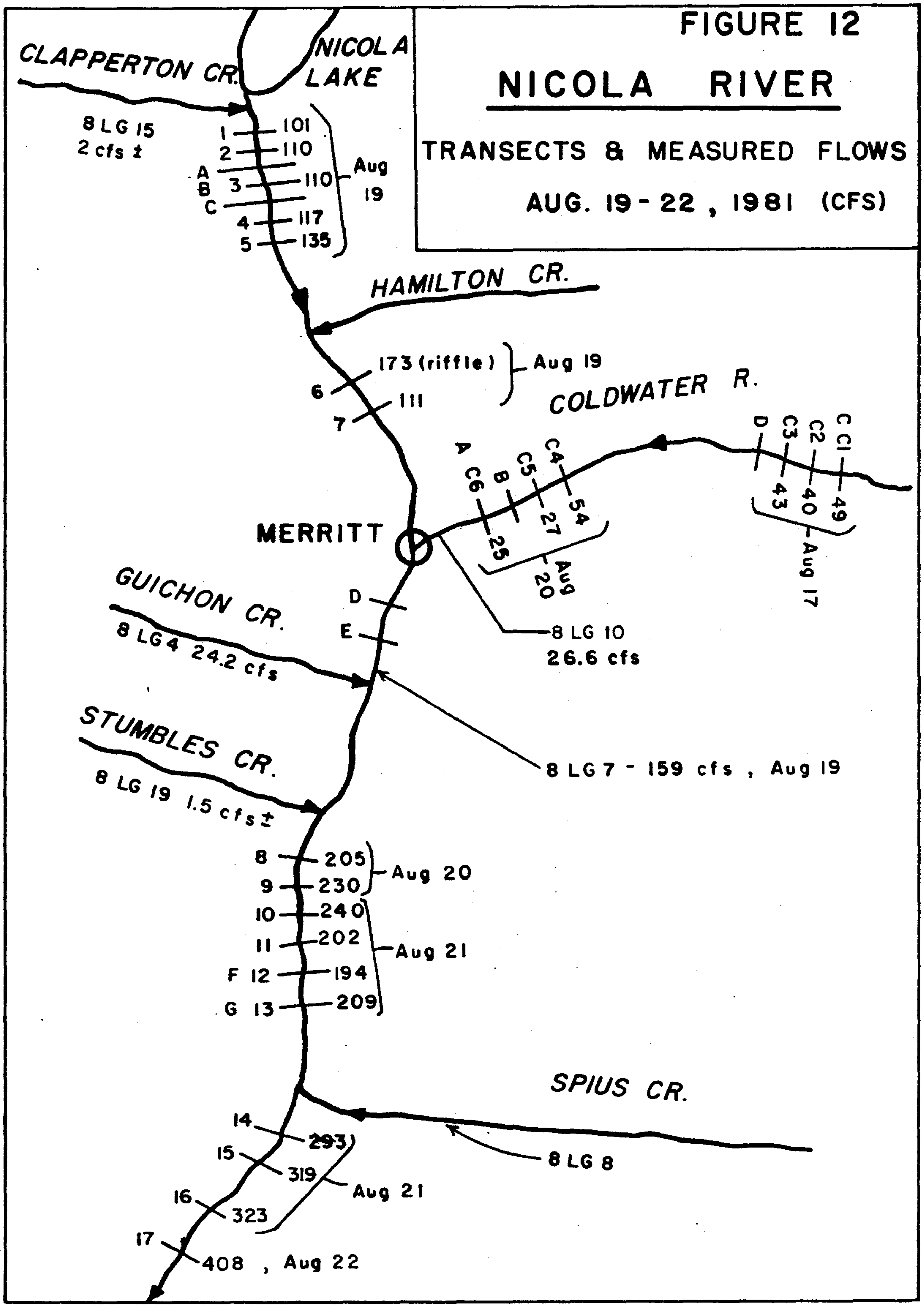


FIGURE 12
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
AUG. 19 - 22, 1981 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
2 cfs ±
1 101
2 110
A
B 3 110
C
4 117
5 135
Aug 19
HAMILTON CR.
173 (riffle)
6
7 111
Aug 19
COLDWATER R.
C C1 49
C2 40
C3 43
D
Aug 17
C4 54
C5 27
B
A C6 25
Aug 20
MERRITT
8 LG 10
26.6 cfs
GUICHON CR.
8 LG 4 24.2 cfs
D
E
8 LG 7 - 159 cfs, Aug 19
STUMBLES CR.
8 LG 19 1.5 cfs ±
8 205
9 230
Aug 20
10 240
11 202
F 12 194
G 13 209
Aug 21
SPIUS CR.
8 LG 8
14 293
15 319
16 323
Aug 21
17 408, Aug 22

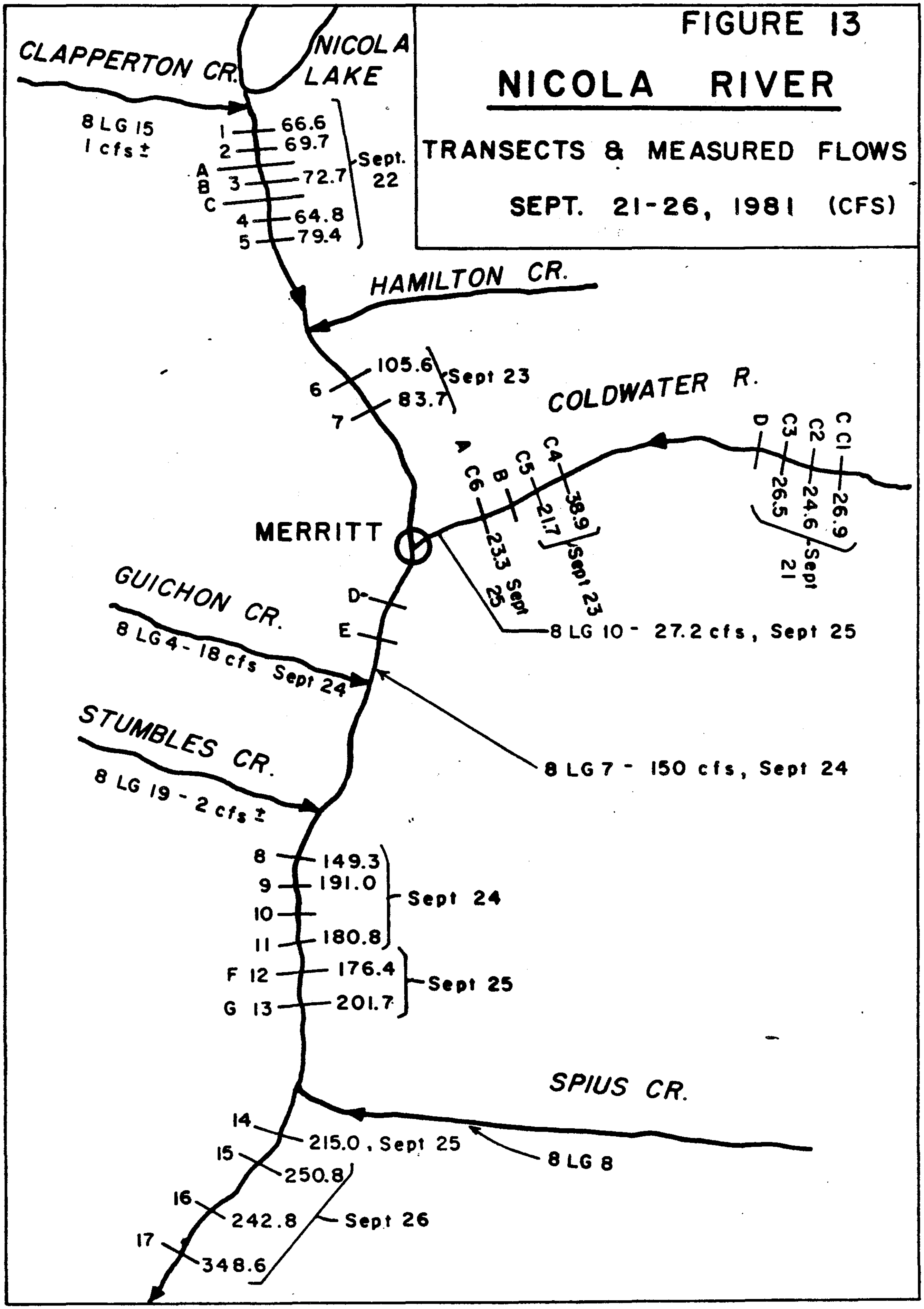
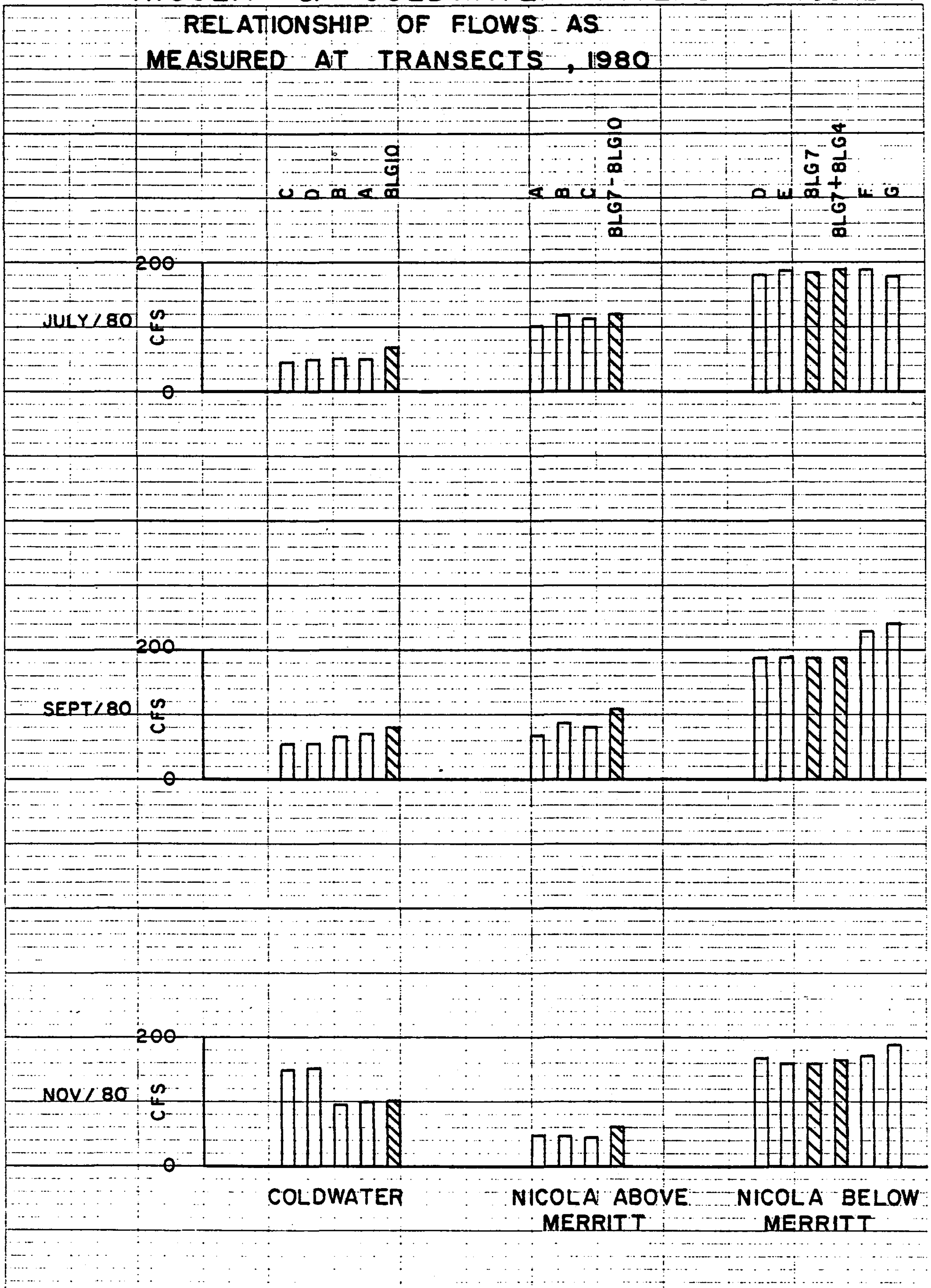


FIGURE 13
NICOLA RIVER
TRANSECTS & MEASURED FLOWS
SEPT. 21-26, 1981 (CFS)
CLAPPERTON CR.
NICOLA LAKE
8 LG 15
1 cfs ±
1 66.6
2 69.7
A
B 3 72.7
C
4 64.8
5 79.4
Sept. 22
HAMILTON CR.
6 105.6
7 83.7
Sept 23
COLDWATER R.
C C1 26.9
C2 24.6
C3 26.5
D
Sept 21
C4 38.9
C5 21.7
B
Sept 23
A C6 23.3 Sept 25
MERRITT
8 LG 10 - 27.2 cfs, Sept 25
GUICHON CR.
8 LG 4 - 18 cfs Sept 24
D
E
8 LG 7 - 150 cfs, Sept 24
STUMBLES CR.
8 LG 19 - 2 cfs ±
8 149.3
9 191.0
10
11 180.8
Sept 24
F 12 176.4
G 13 201.7
Sept 25
SPIUS CR.
8 LG 8
14 215.0, Sept 25
15 250.8
16 242.8
17 348.6
Sept 26

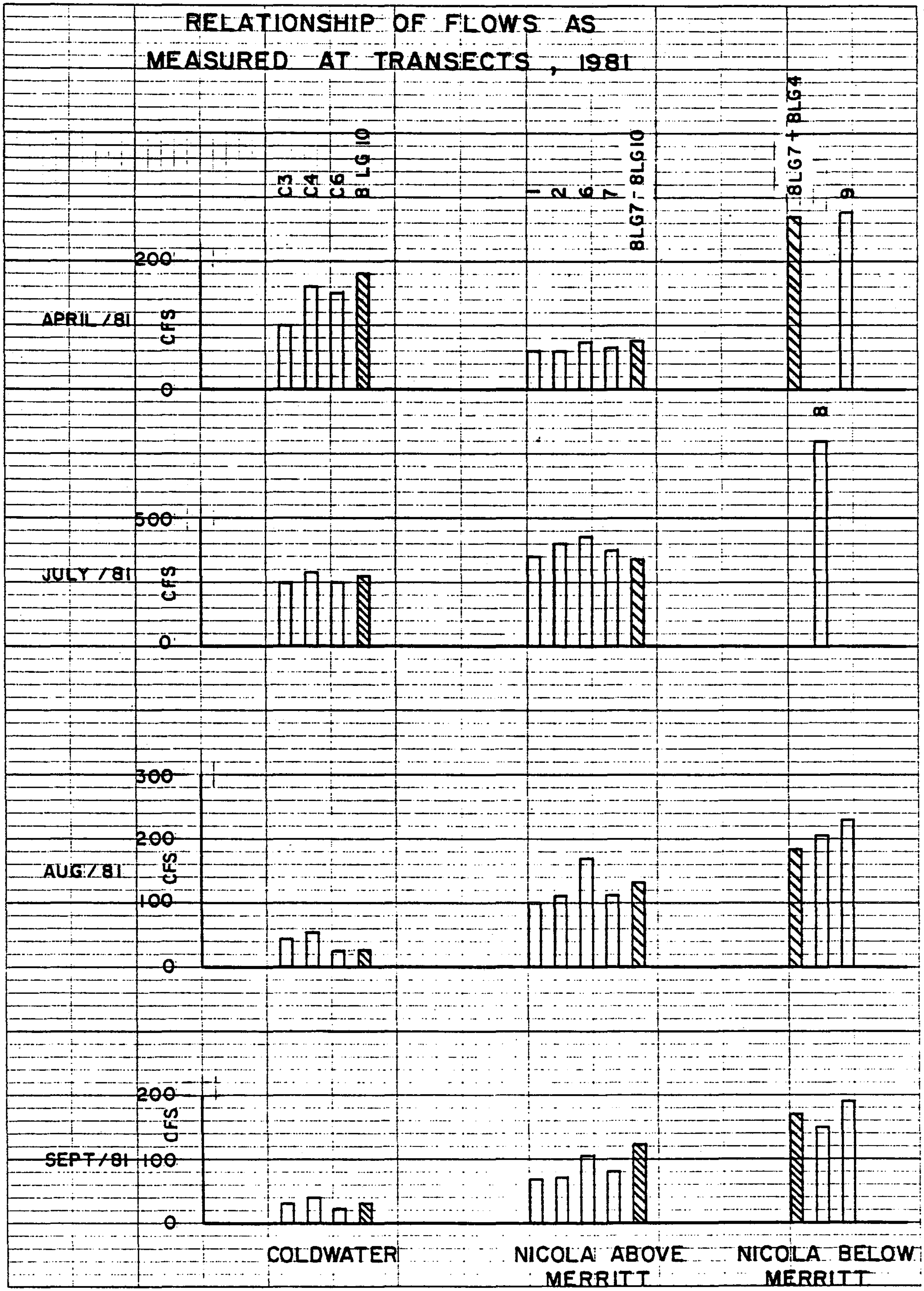
NICOLA & COLDWATER RIVERS

FIGURE 14



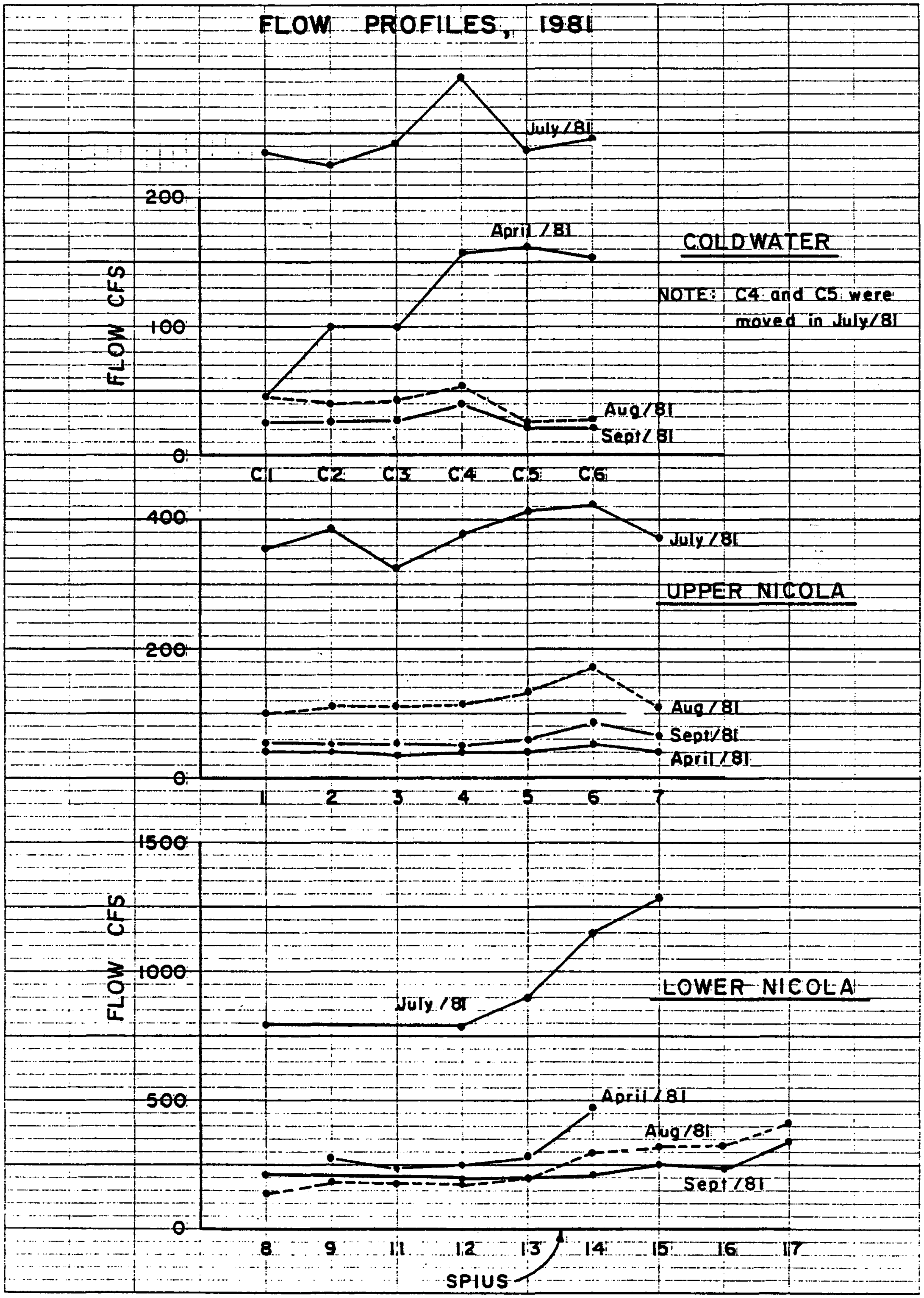
NICOLA & COLDWATER RIVERS

FIGURE 15



NICOLA & COLDWATER RIVERS

FIGURE 16



NICOLA RIVER

FIGURE 17

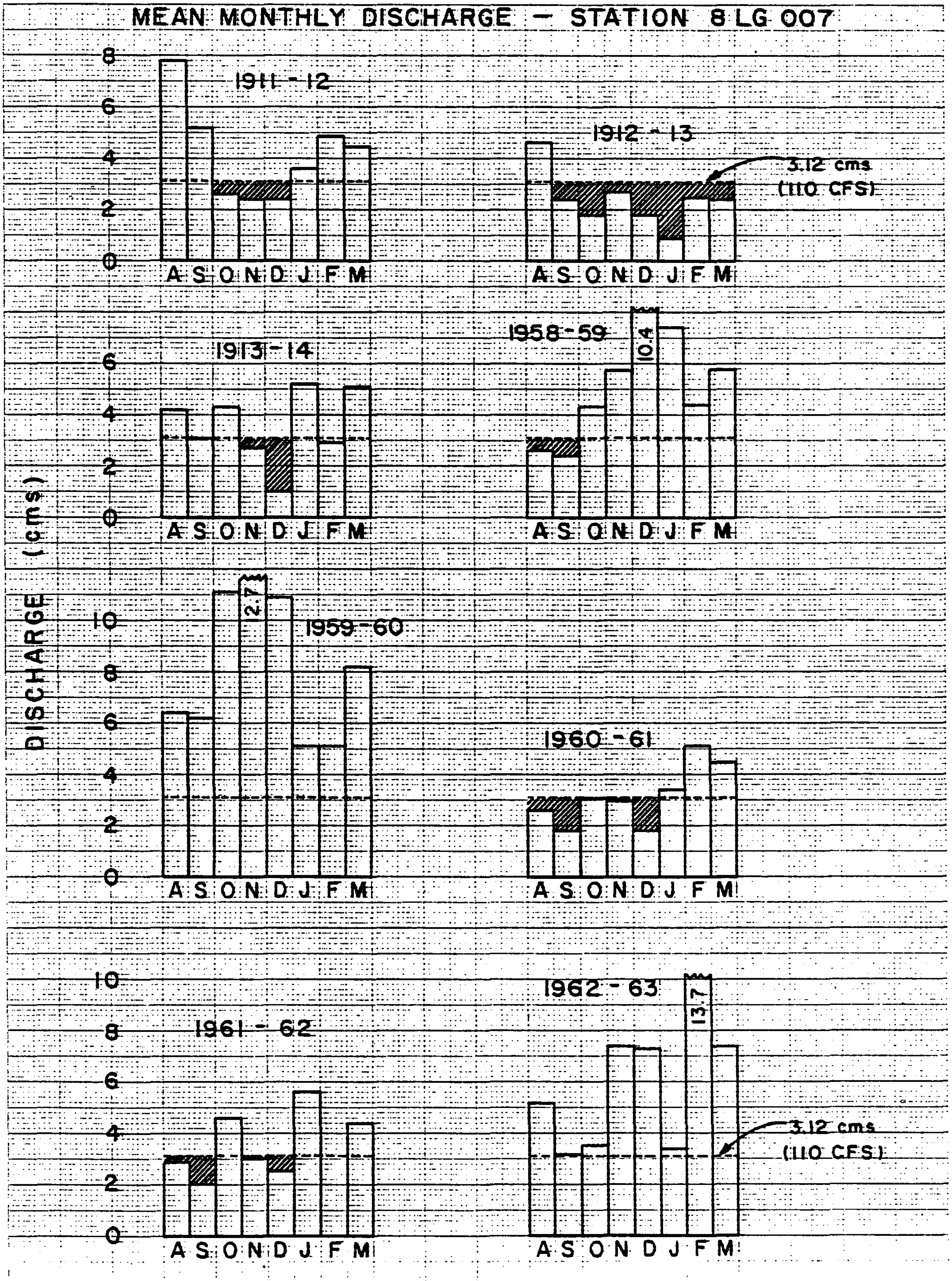
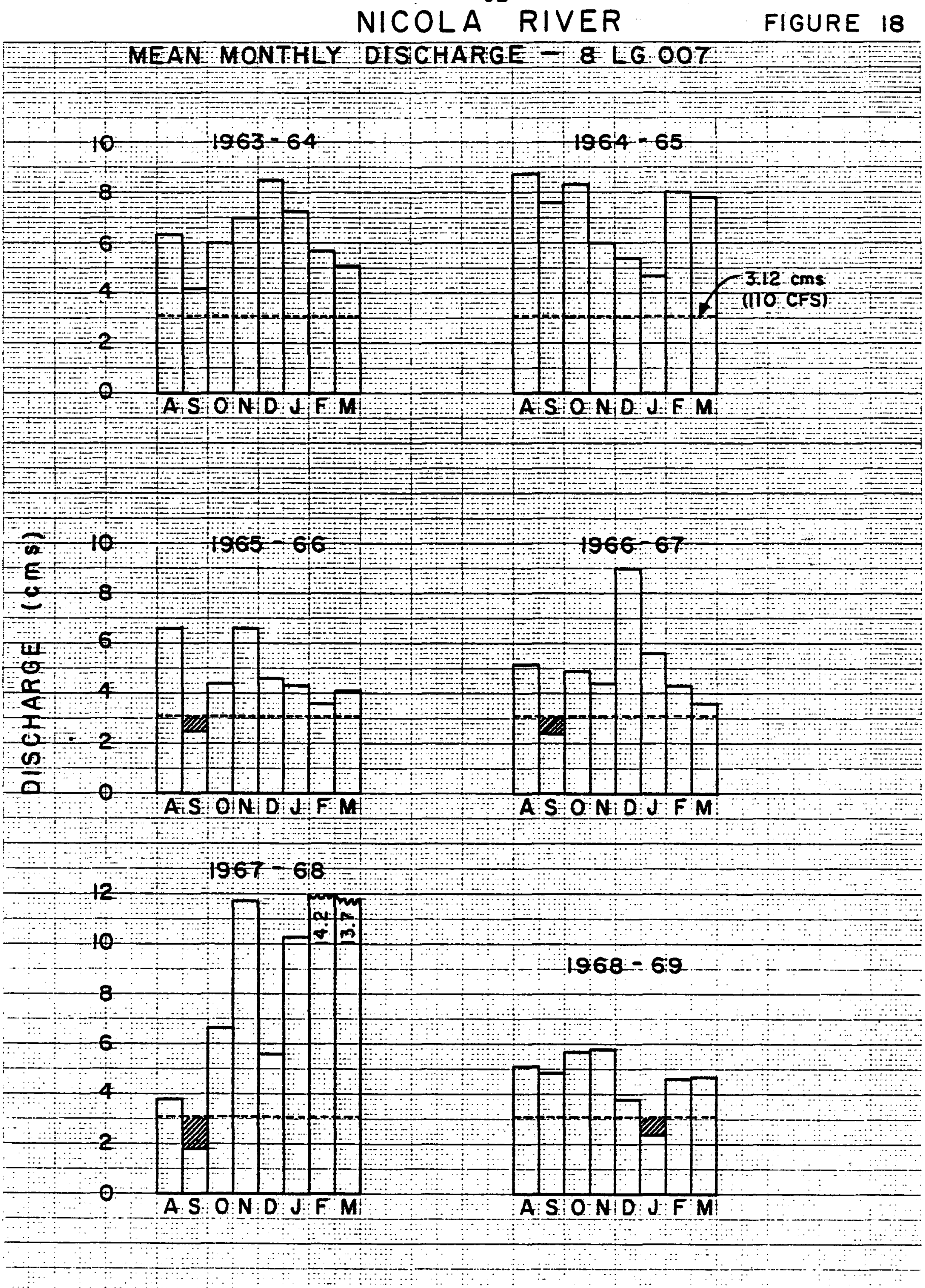
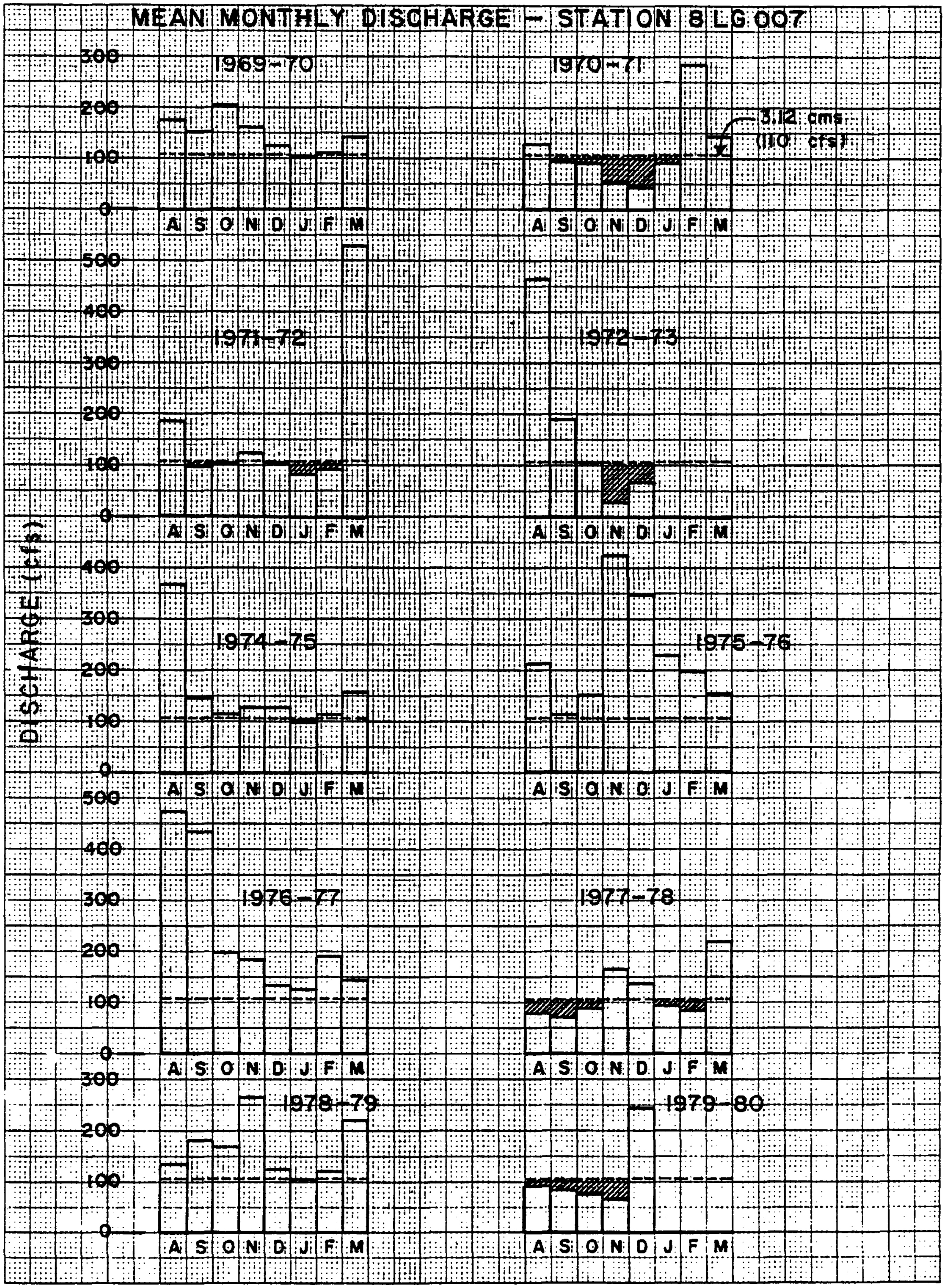


FIGURE 18


NICOLA RIVER
MEAN MONTHLY DISCHARGE — 8 LG 007
DISCHARGE (cms)
1963 - 64
1964 - 65
1965 - 66
1966 - 67
1967 - 68
1968 - 69
3.12 cms
(110 CFS)
14.2
13.7
A S O N D J F M
0
2
4
6
8
10
12

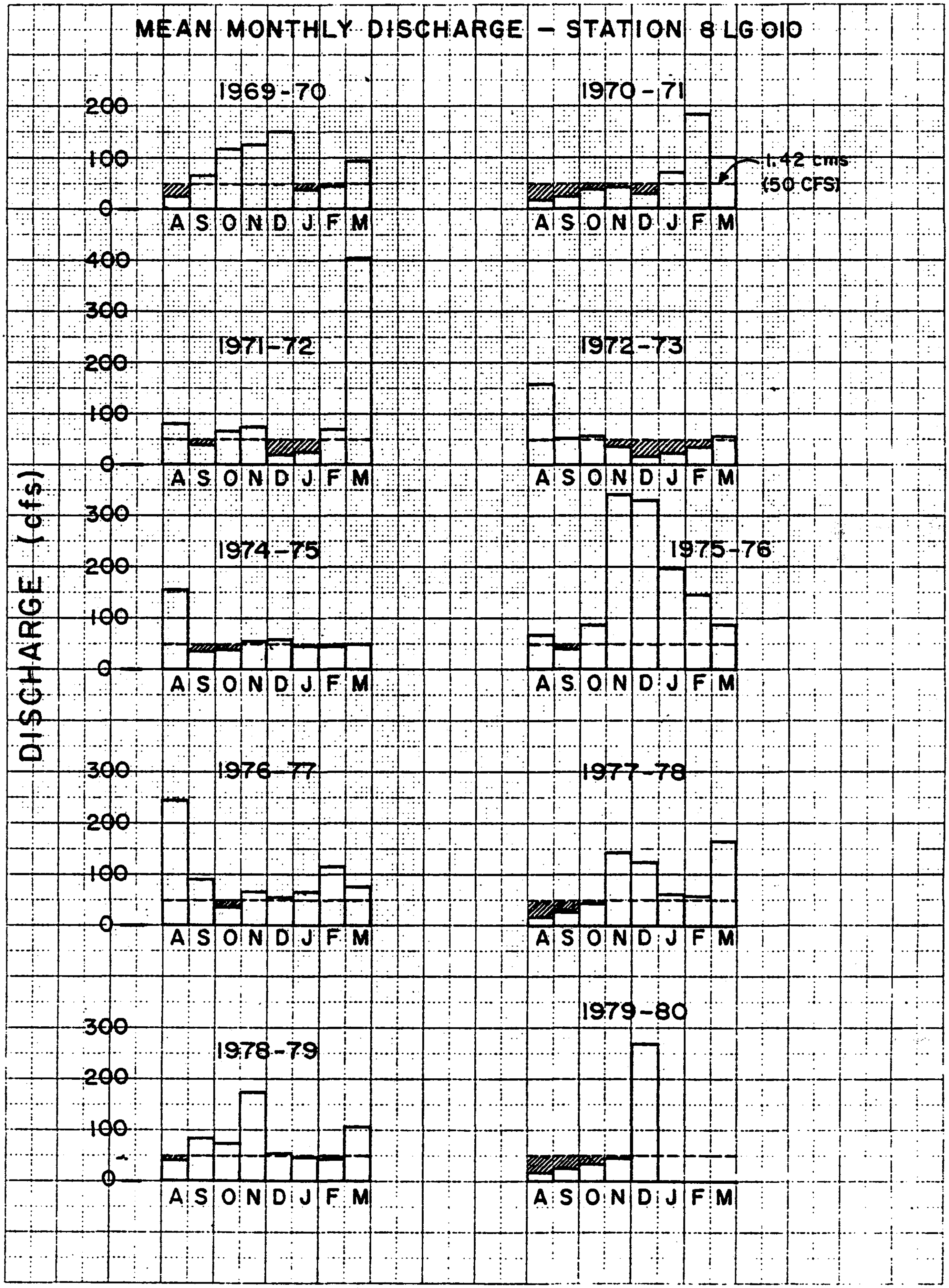
NICOLA RIVER

FIGURE 19



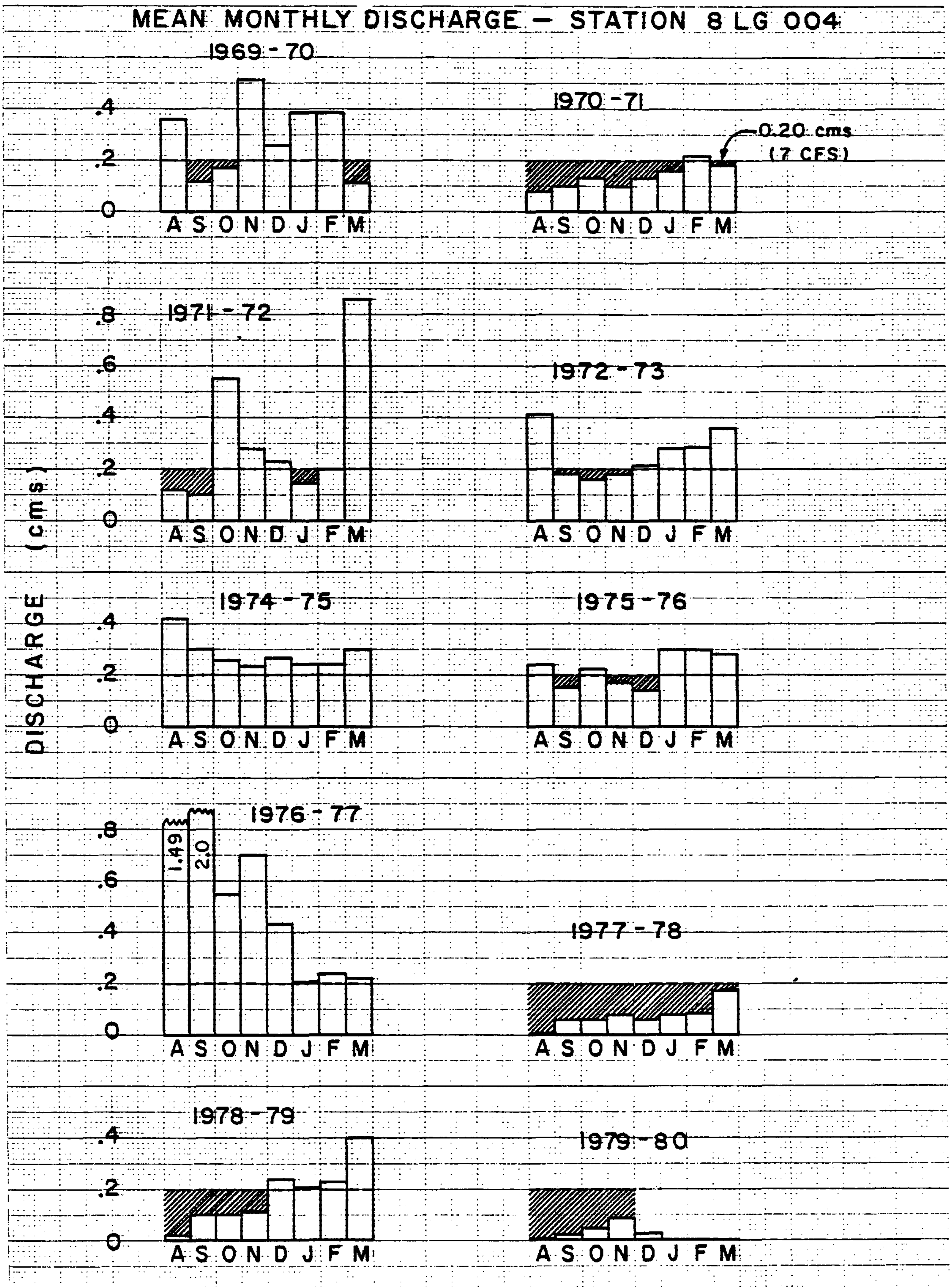
COLDWATER RIVER

FIGURE 20



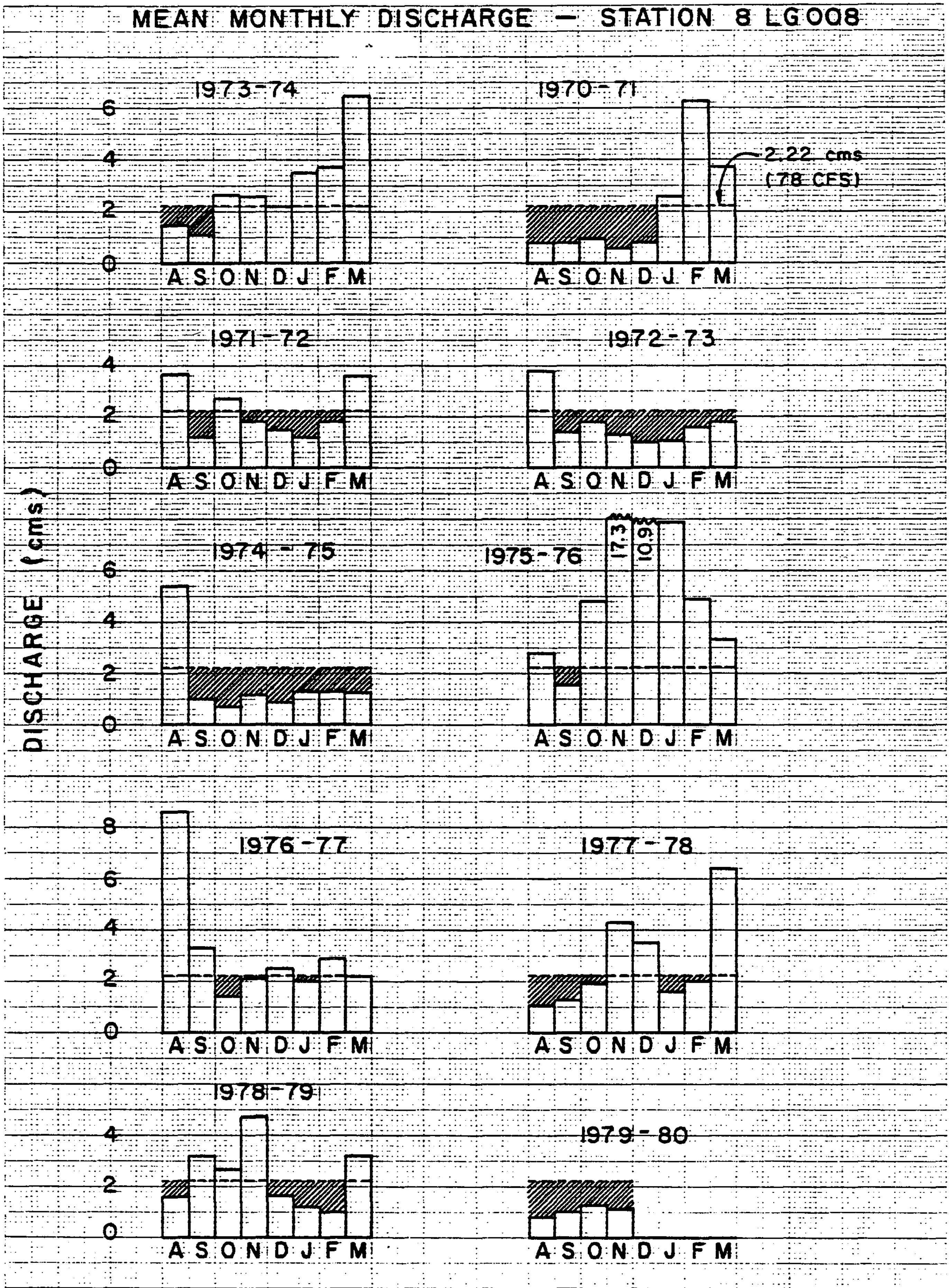
GUICHON CREEK

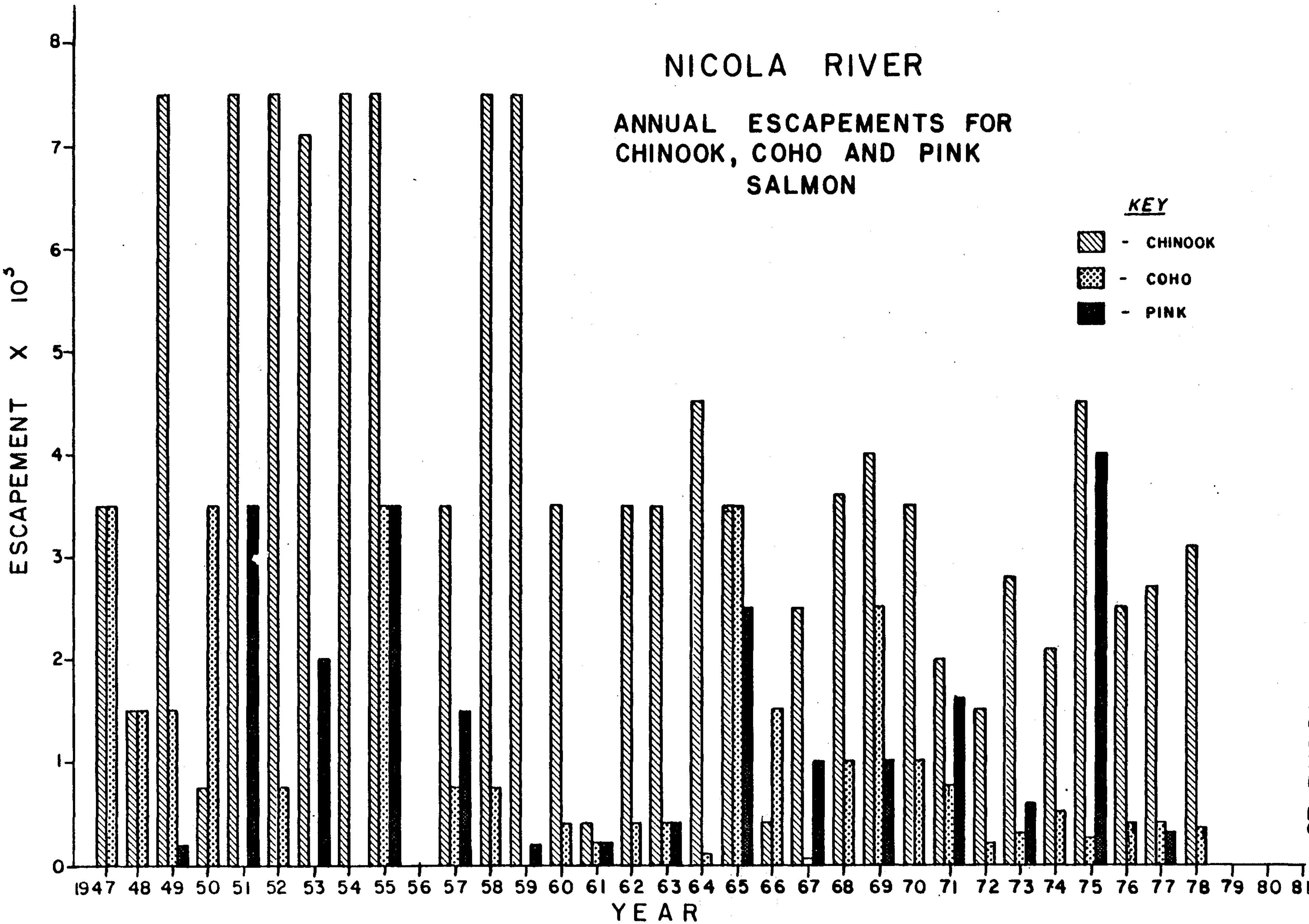
FIGURE 21



SPIUS CREEK

FIGURE 22





NICOLA RIVER
ANNUAL ESCAPEMENTS FOR CHINOOK, COHO AND PINK SALMON
KEY
- CHINOOK
- COHO
- PINK
ESCAPEMENT X 10³
0
1
2
3
4
5
6
7
8
1947 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81
YEAR

FIGURE 23

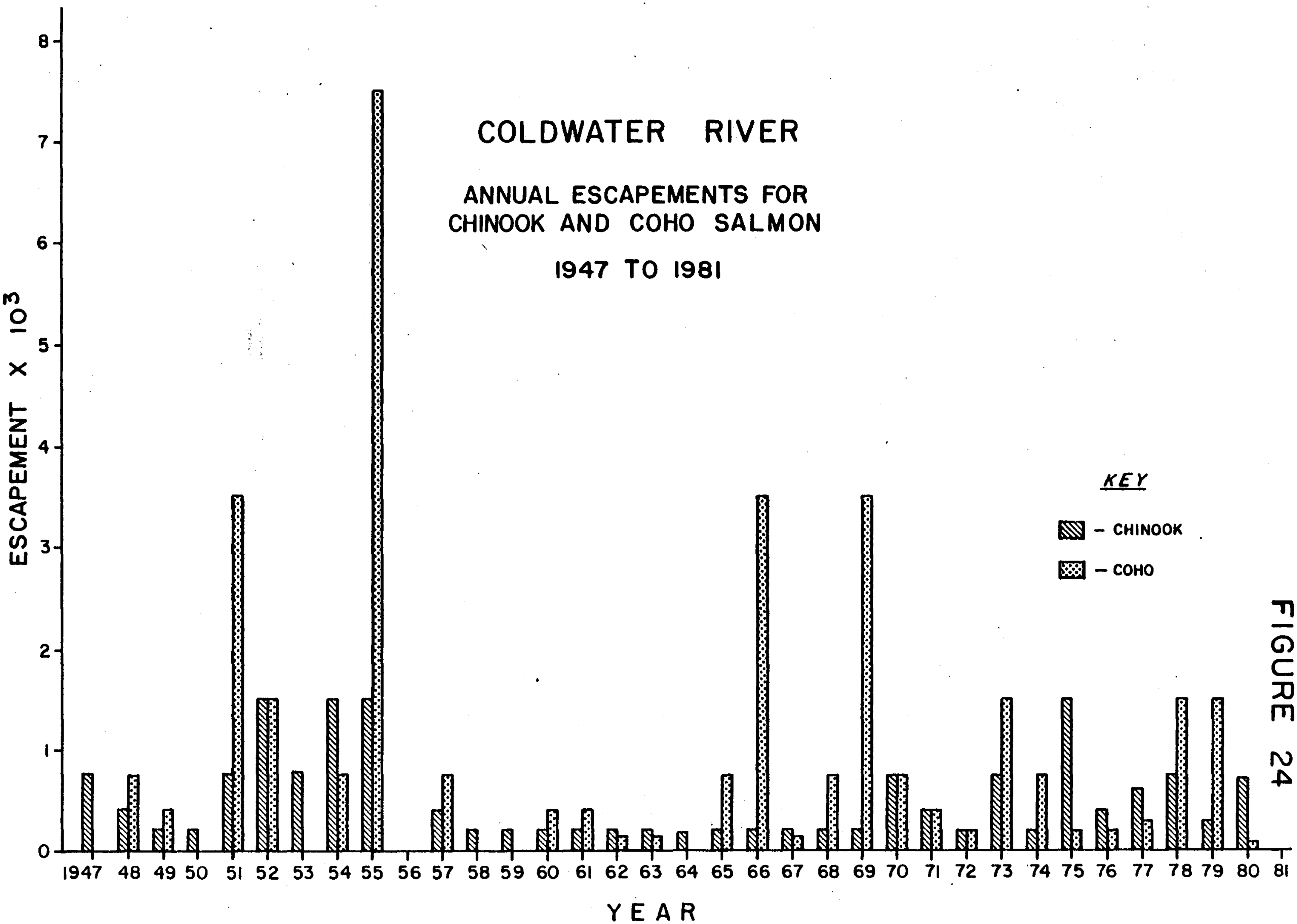

COLDWATER RIVER
ANNUAL ESCAPEMENTS FOR CHINOOK AND COHO SALMON
1947 TO 1981
ESCAPEMENT X 10^3
0
1
2
3
4
5
6
7
8
KEY
– CHINOOK
– COHO
1947
48
49
50
51
52
53
54
55
56
57
58
59
60
61
62
63
64
65
66
67
68
69
70
71
72
73
74
75
76
77
78
79
80
81
YEAR

FIGURE 24

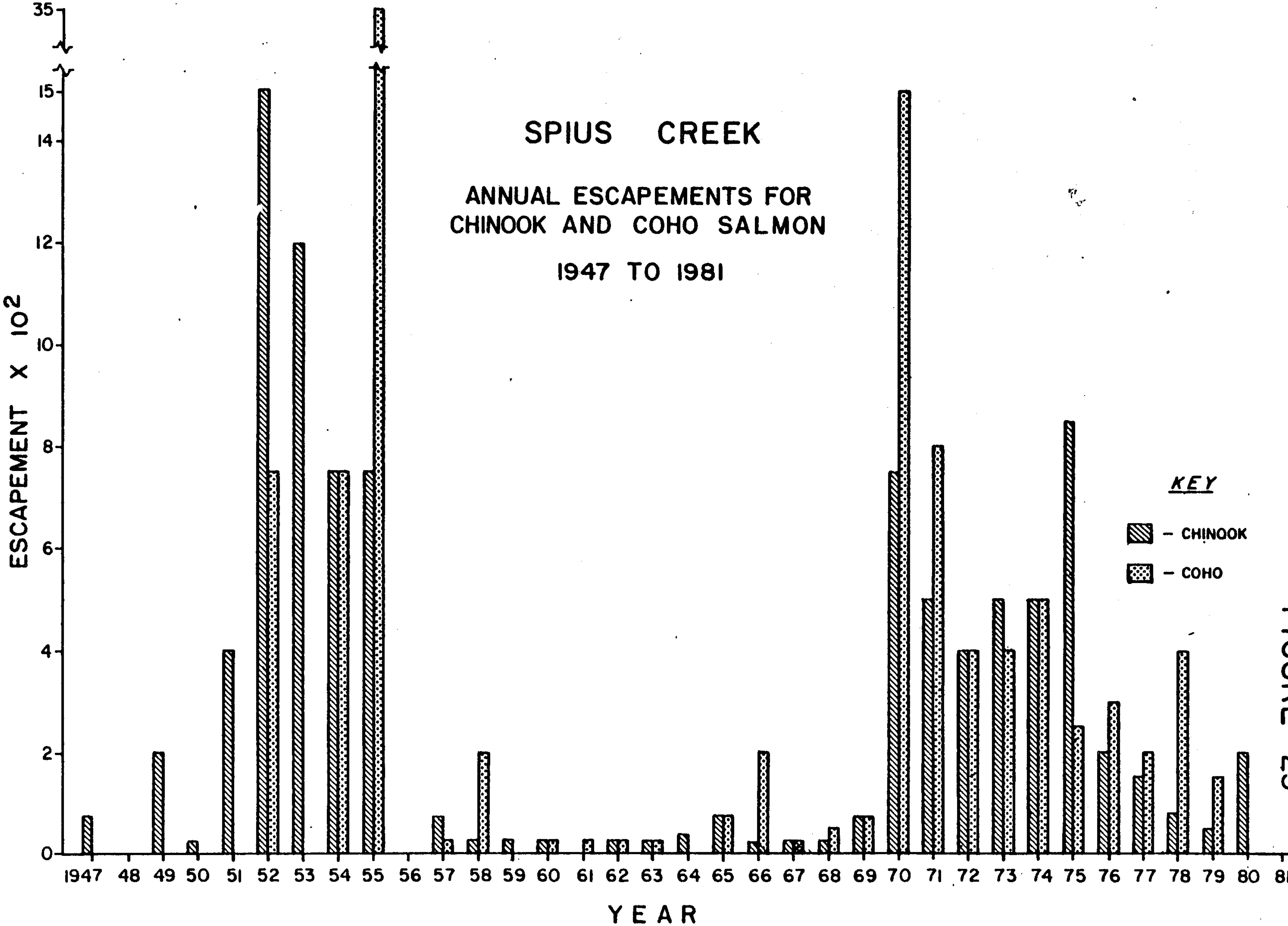

SPIUS CREEK
ANNUAL ESCAPEMENTS FOR
CHINOOK AND COHO SALMON
1947 TO 1981
ESCAPEMENT X 10^2
YEAR
KEY
- CHINOOK
- COHO
0
2
4
6
8
10
12
14
15
35
1947 48 49 50 51 52 53 54 55 56 57 58 59 60 61 62 63 64 65 66 67 68 69 70 71 72 73 74 75 76 77 78 79 80 81

FIGURE 25

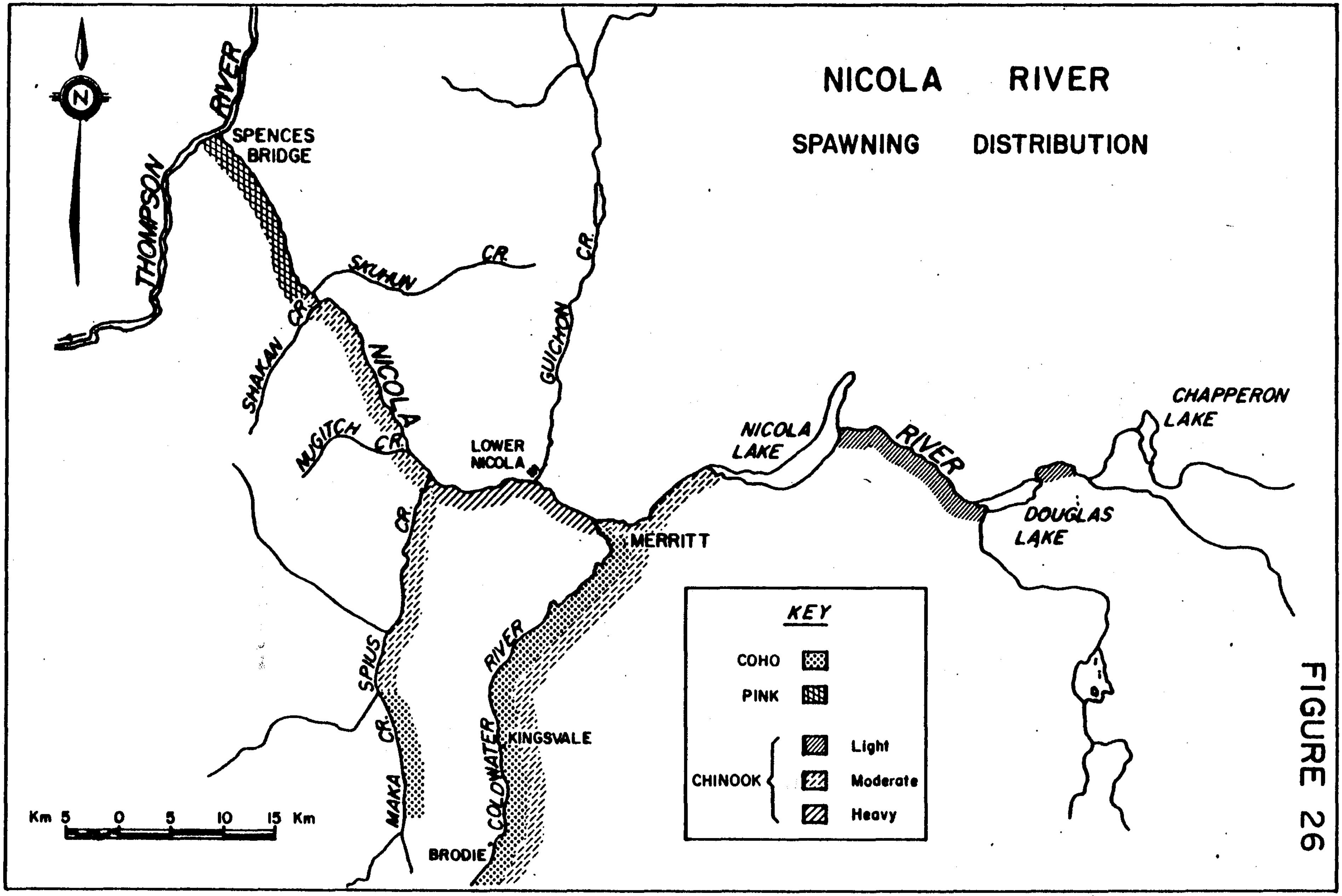

NICOLA RIVER
SPAWNING DISTRIBUTION
N
THOMPSON RIVER
SPENCES BRIDGE
SKUHUN CR.
GUICHON CR.
SHAKAN CR.
NICOLA
NUGITCH CR.
LOWER NICOLA
SPIUS CR.
MERRITT
NICOLA LAKE
RIVER
CHAPPERON LAKE
DOUGLAS LAKE
COLDWATER RIVER
KINGSVALE
MAKA CR.
BRODIE
Km 5 0 5 10 15 Km
KEY
COHO
PINK
CHINOOK
Light
Moderate
Heavy

FIGURE 26

NICOLA RIVER

FRESHWATER TIMING FOR NICOLA RIVER SALMON

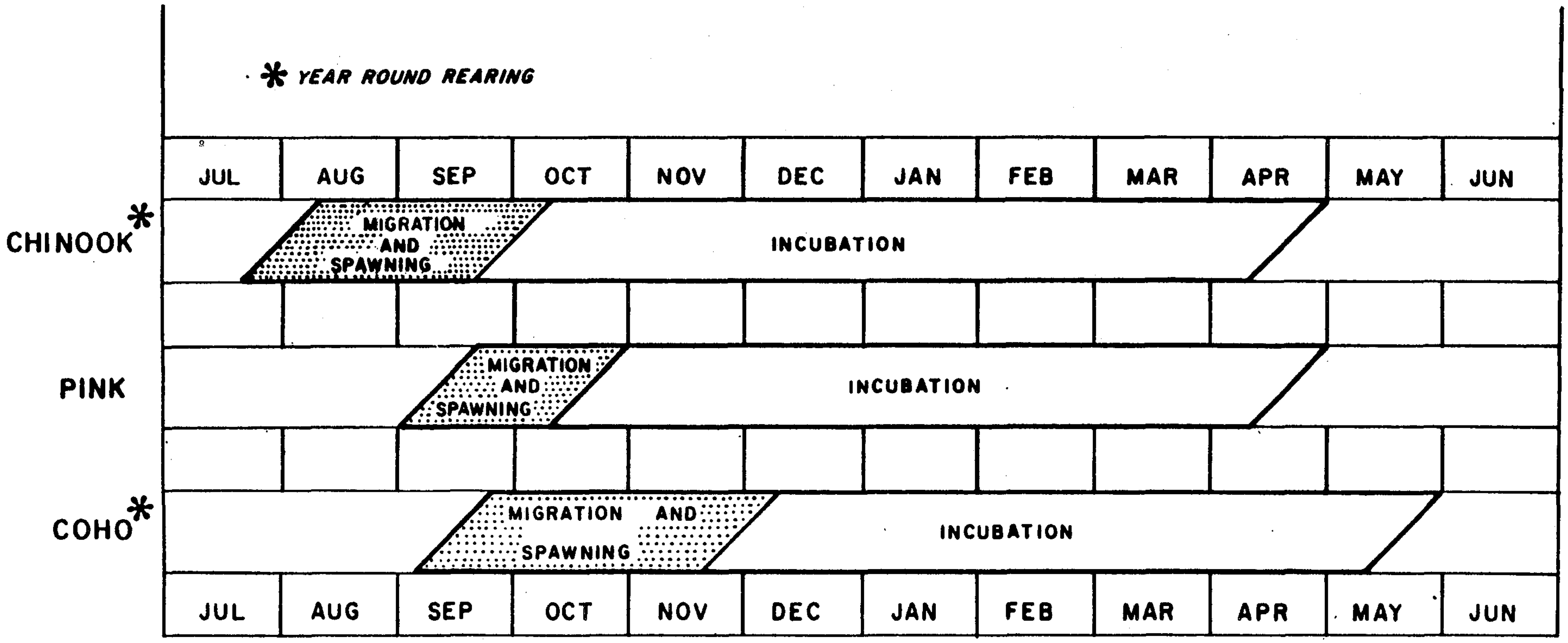


FIGURE 27

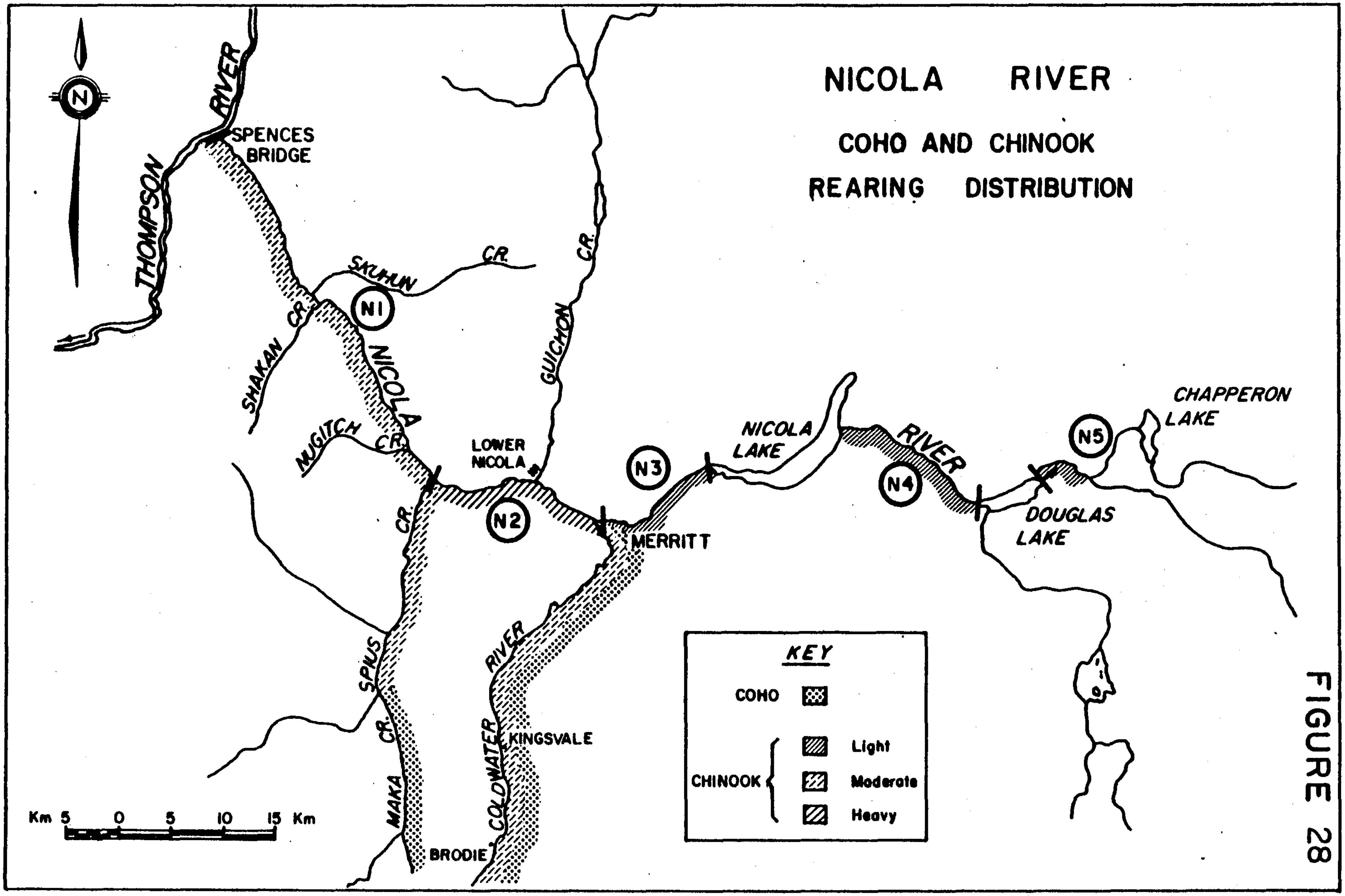
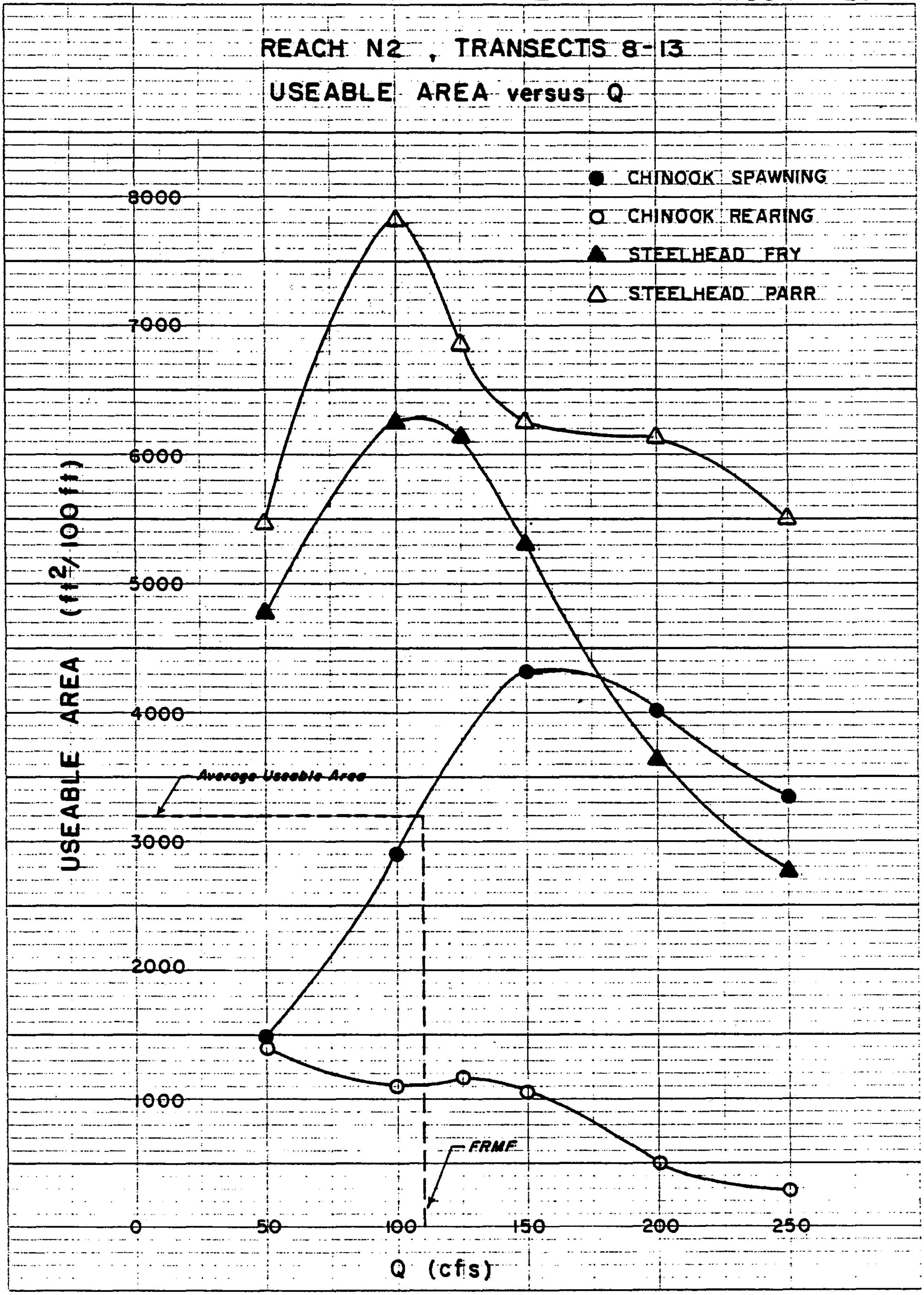

NICOLA RIVER
COHO AND CHINOOK
REARING DISTRIBUTION
N
THOMPSON
RIVER
SPENCES
BRIDGE
SKUHUN
CR.
GUICHON
CR.
N1
SHAKAN
CR.
NICOLA
NUGITCH
CR.
LOWER
NICOLA
N2
N3
MERRITT
NICOLA
LAKE
RIVER
N4
N5
CHAPPERON
LAKE
DOUGLAS
LAKE
CR.
SPIUS
CR.
MAKA
COLDWATER
RIVER
KINGSVALE
BRODIE
KEY
COHO
CHINOOK
Light
Moderate
Heavy
Km 5 0 5 10 15 Km

FIGURE 28

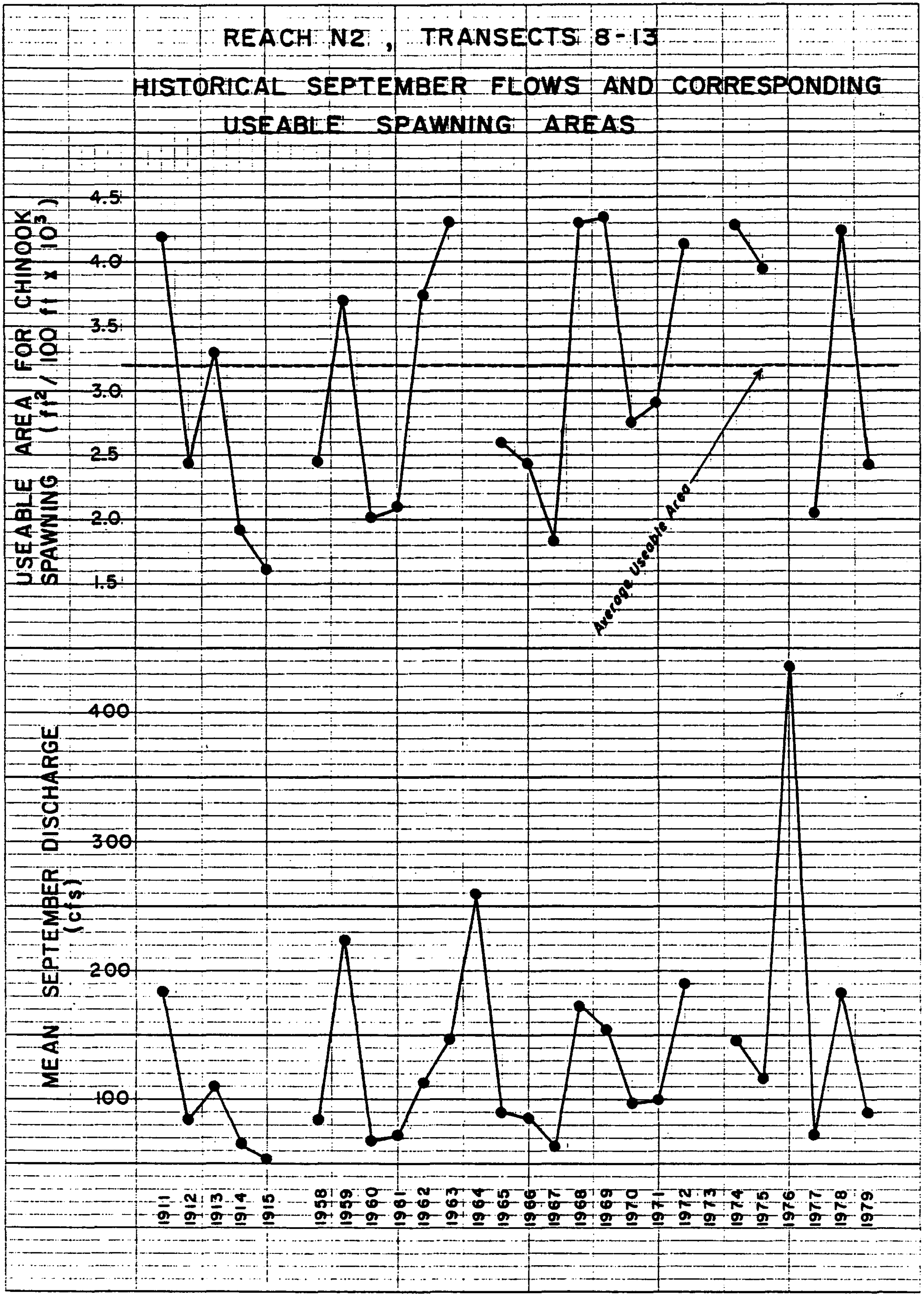
NICOLA RIVER

FIGURE 29



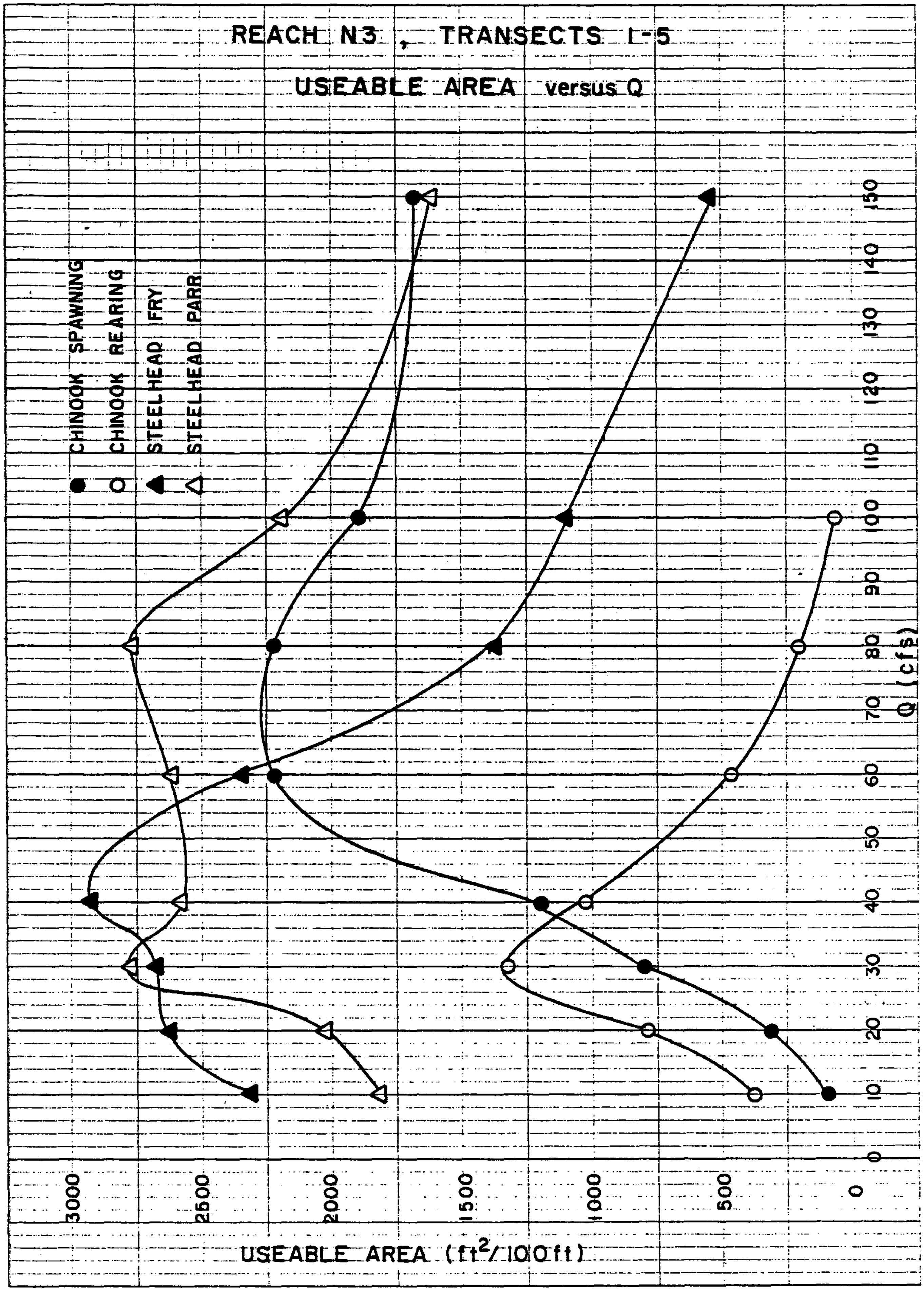
NICOLA RIVER

FIGURE 30



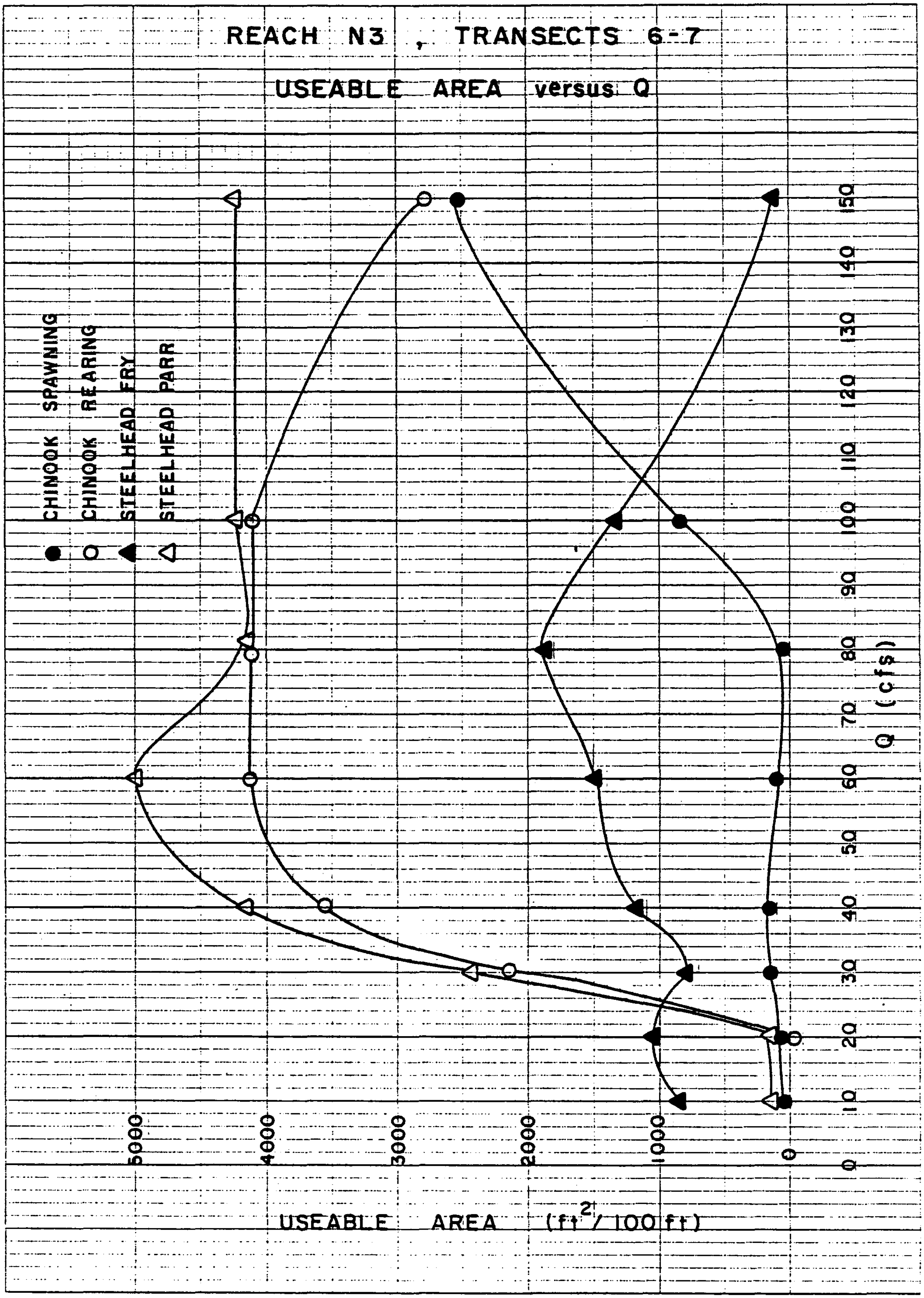
NICOLA RIVER

FIGURE 31



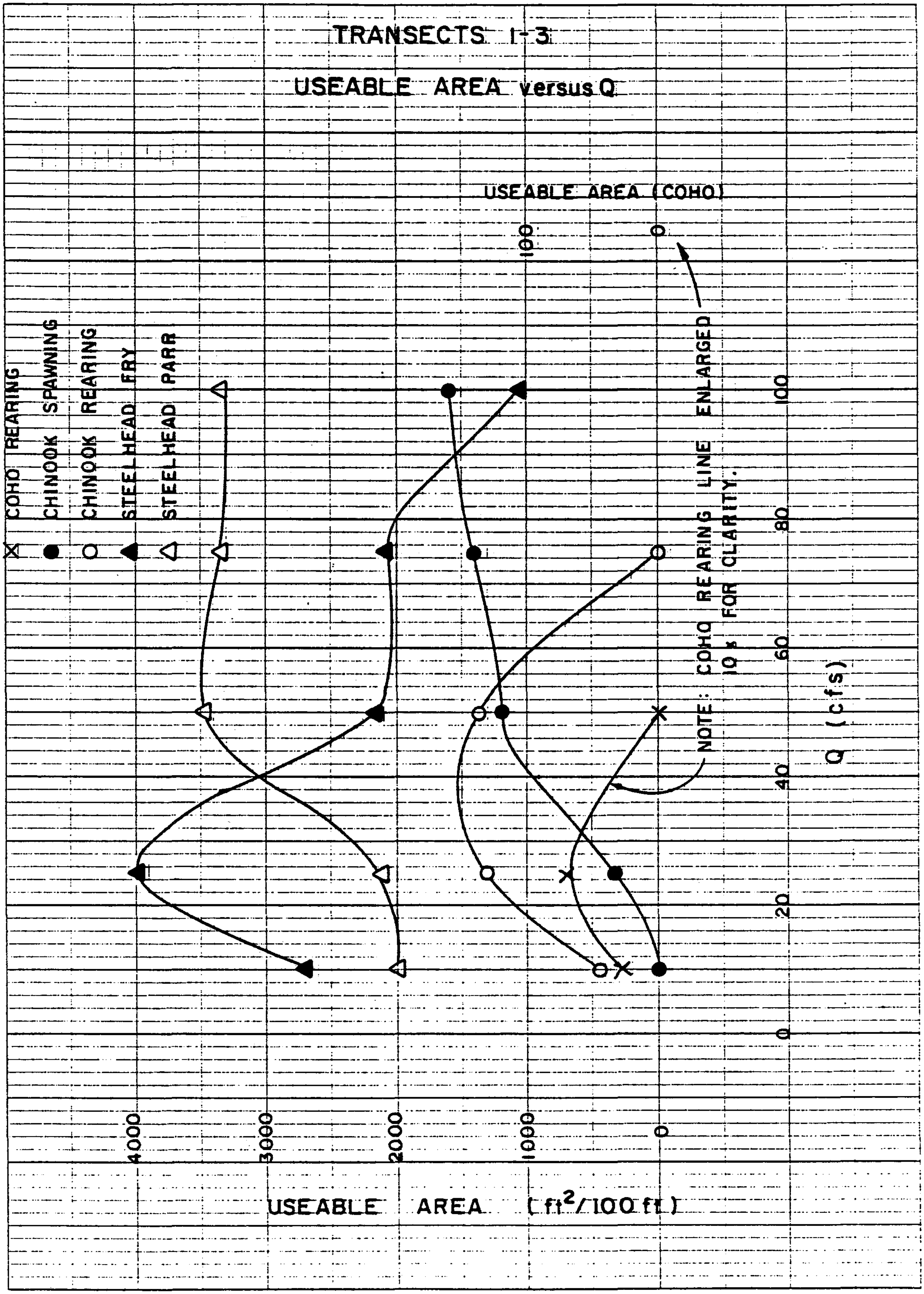
NICOLA RIVER

FIGURE 32



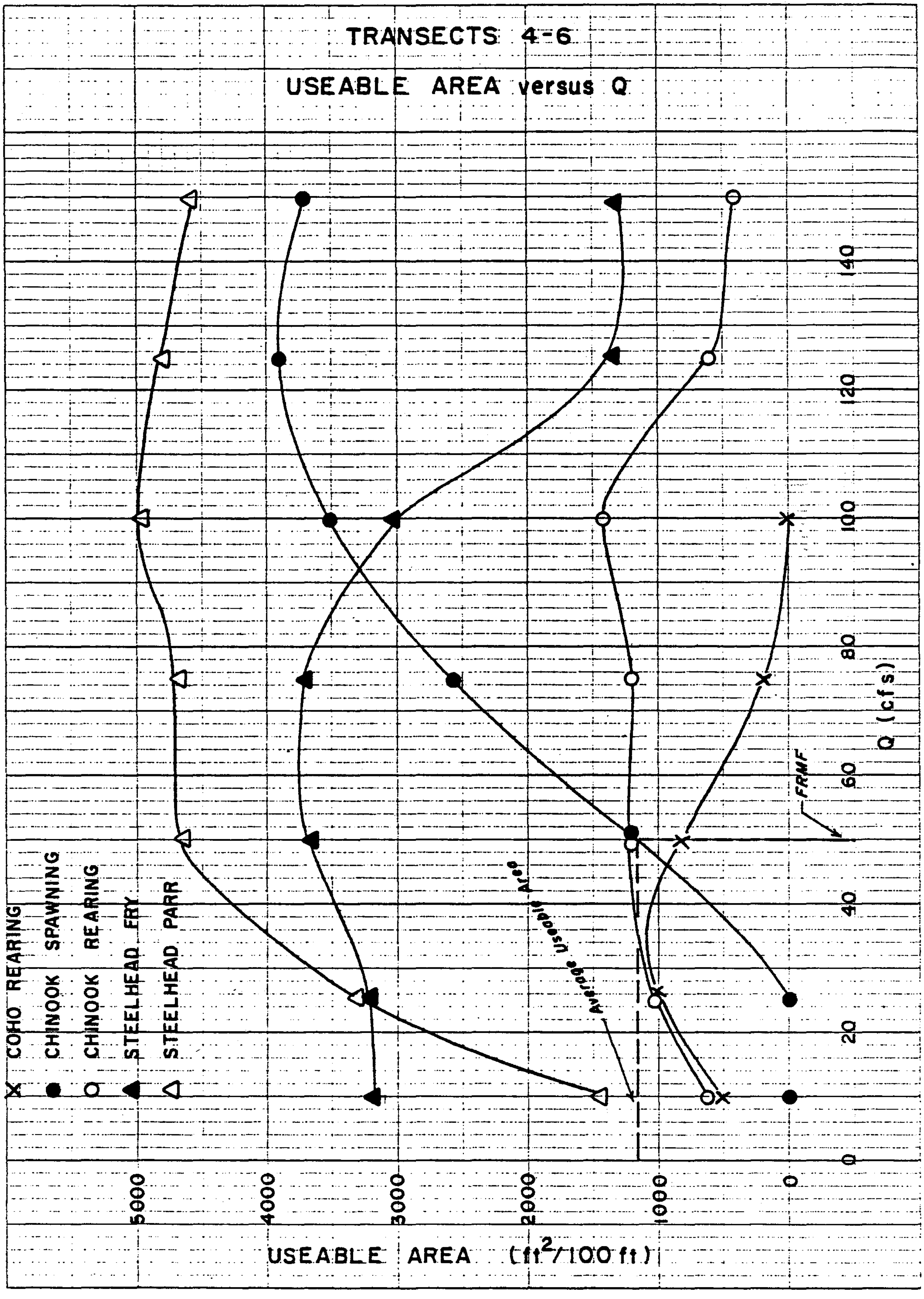
COLDWATER RIVER

FIGURE 33

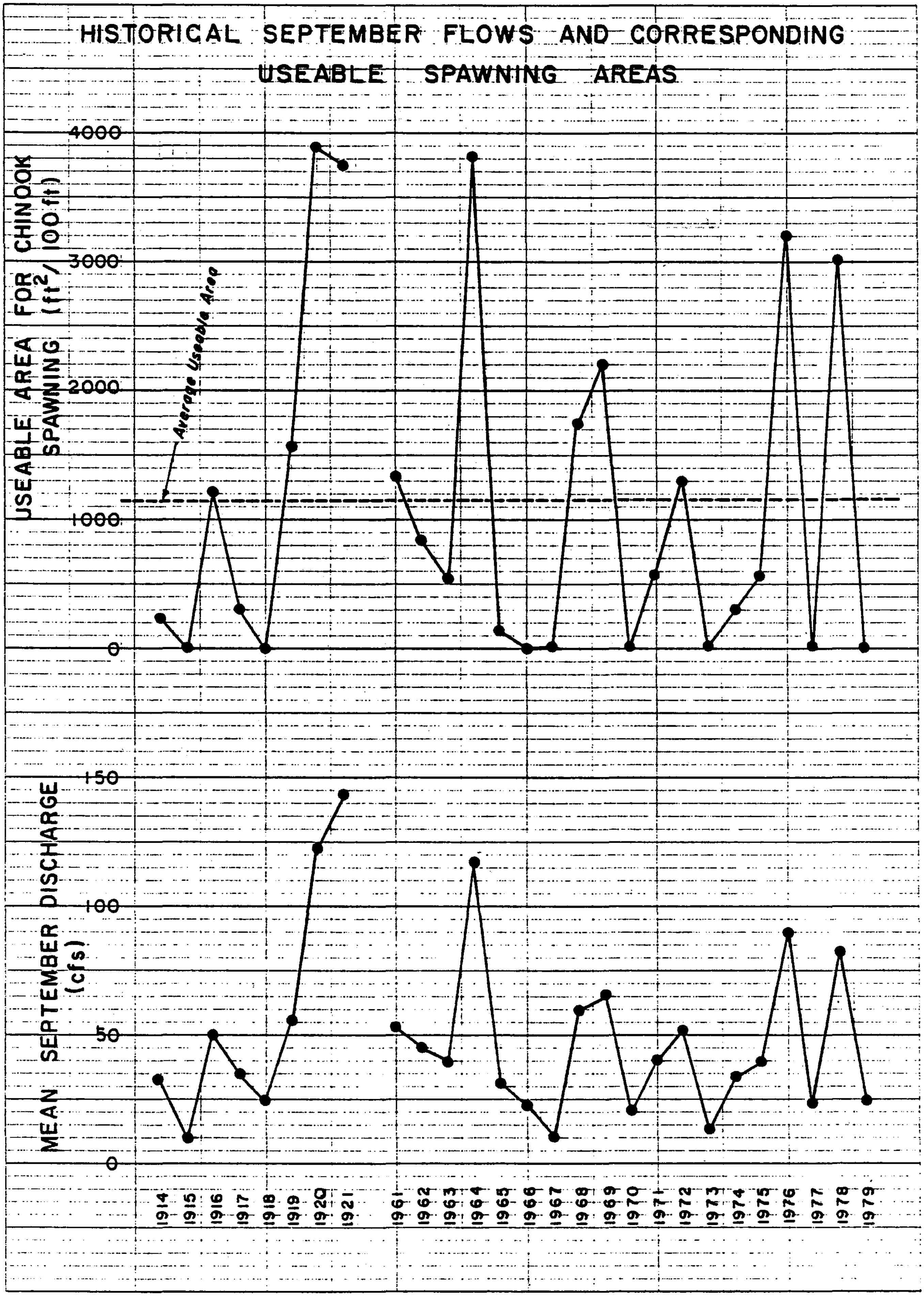


COLDWATER RIVER

FIGURE 34

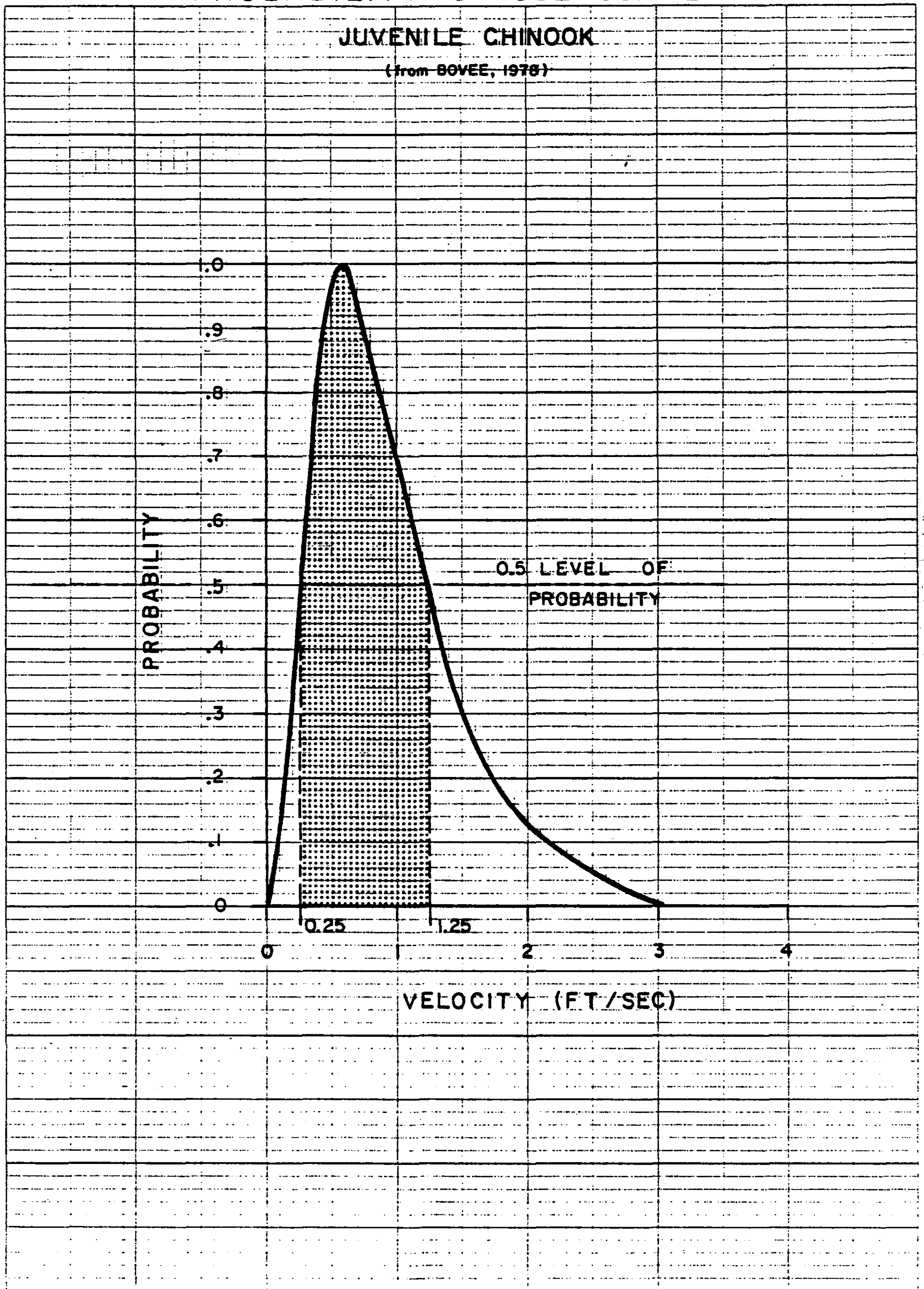


COLDWATER RIVER FIGURE 35



PROBABILITY OF USE CURVE

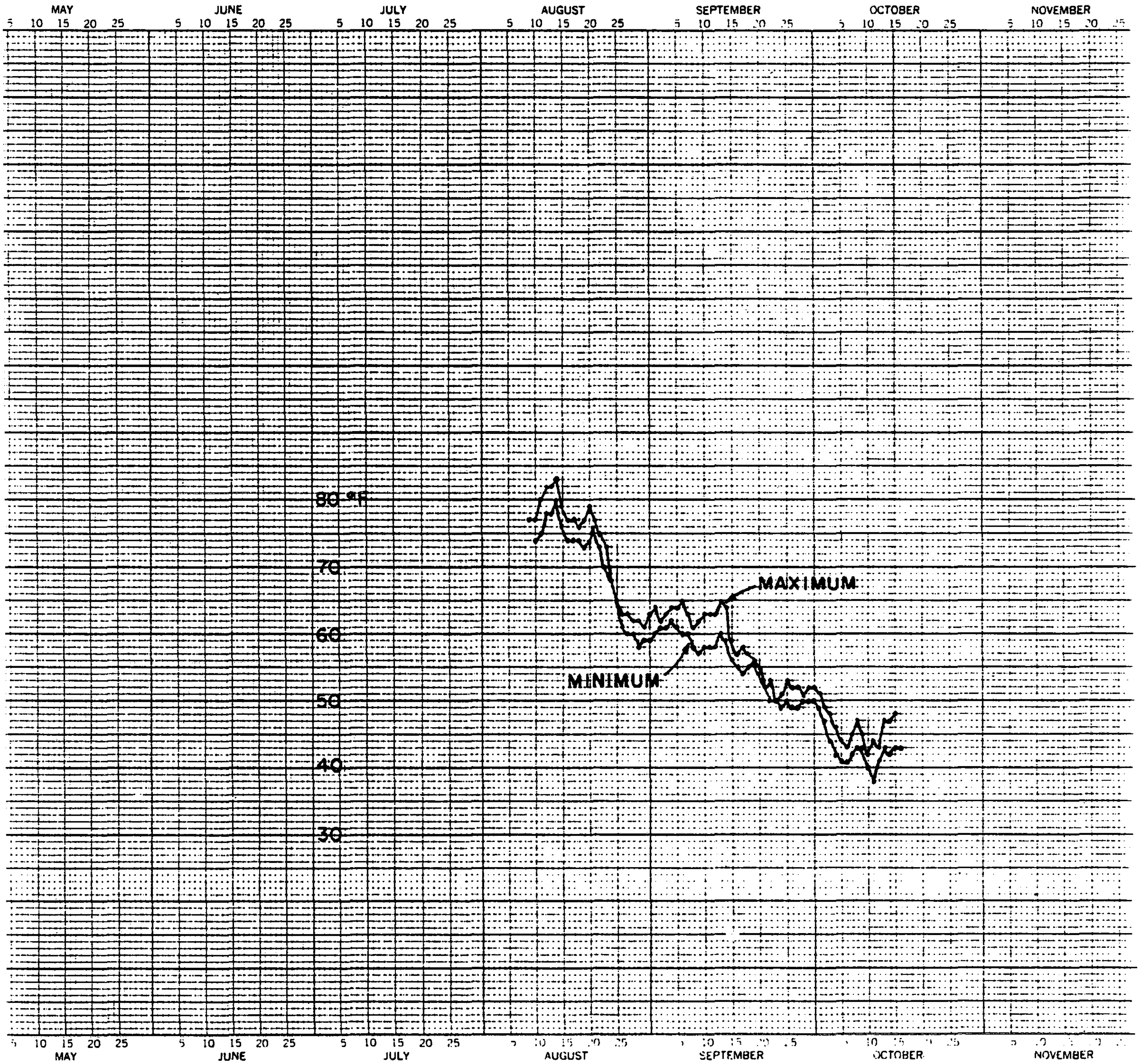
FIGURE 36



NICOLA LAKE

WATER TEMPERATURES NEAR OUTLET
1977

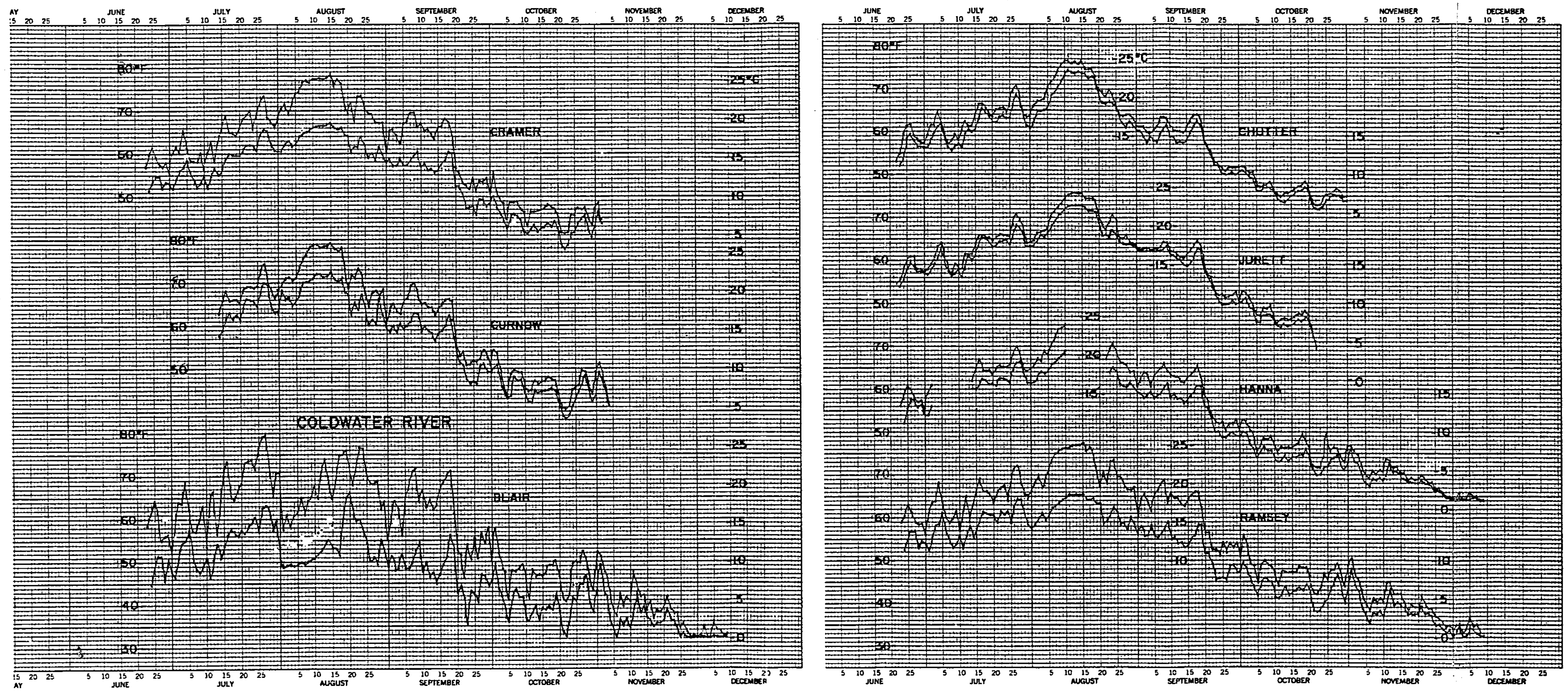
FIGURE 37



NICOLA and COLDWATER RIVERS

WATER TEMPERATURES — 1981

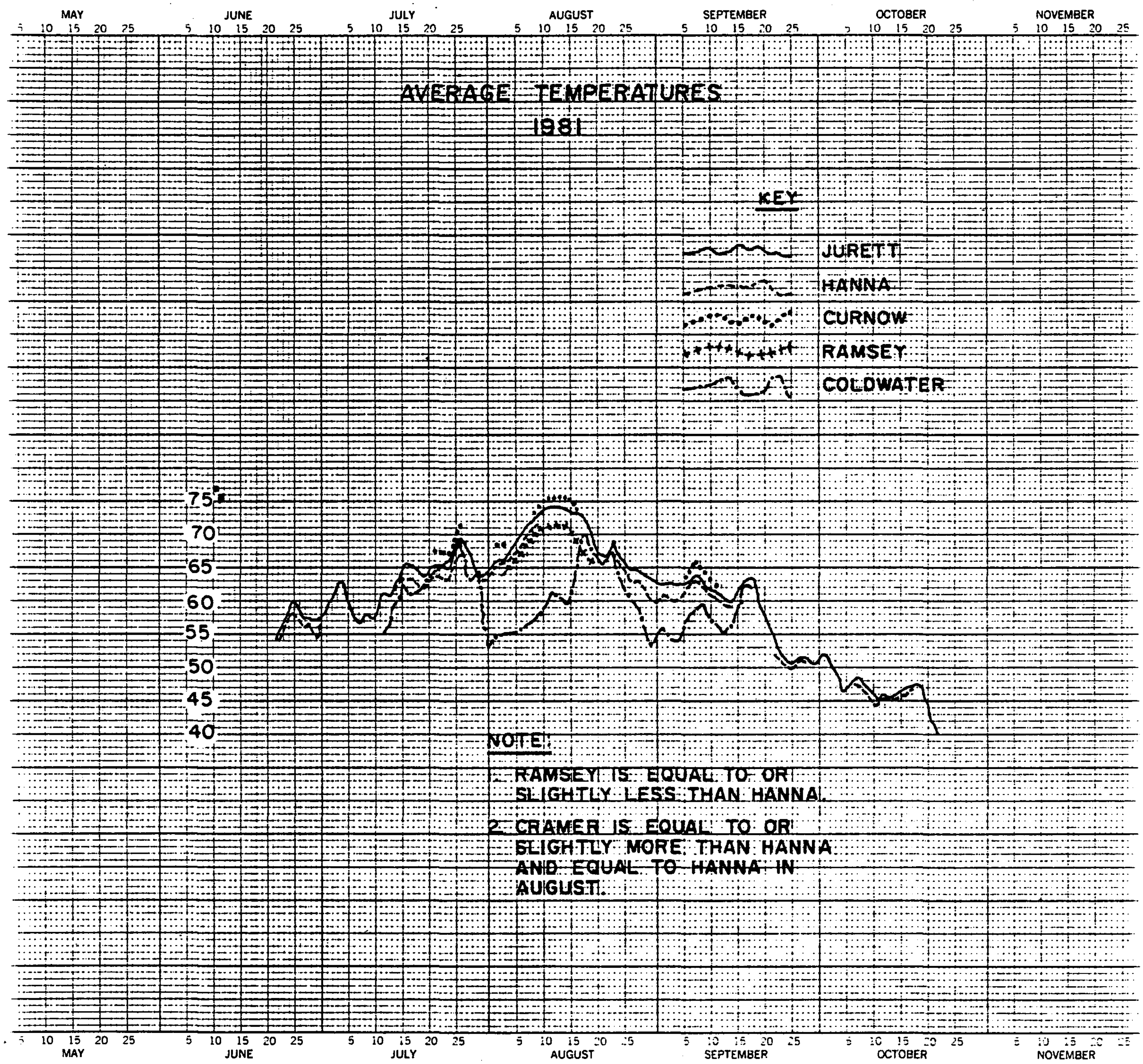
FIGURE 38



NICOLA & COLDWATER RIVERS

RELATIVE WATER TEMPERATURES

FIGURE 39

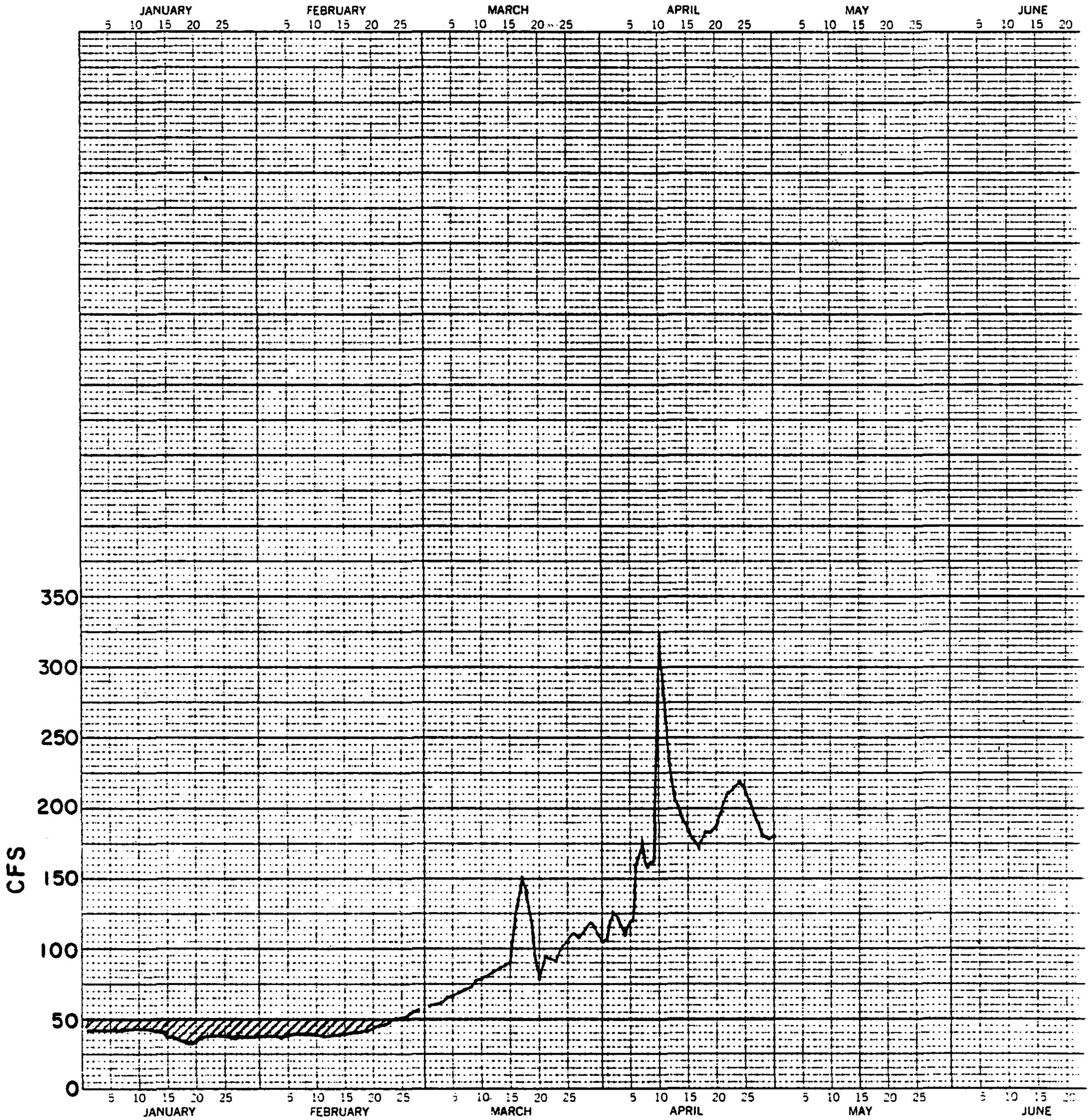


APPENDIX A

HYDROGRAPHS

COLDWATER RIVER 8LG10

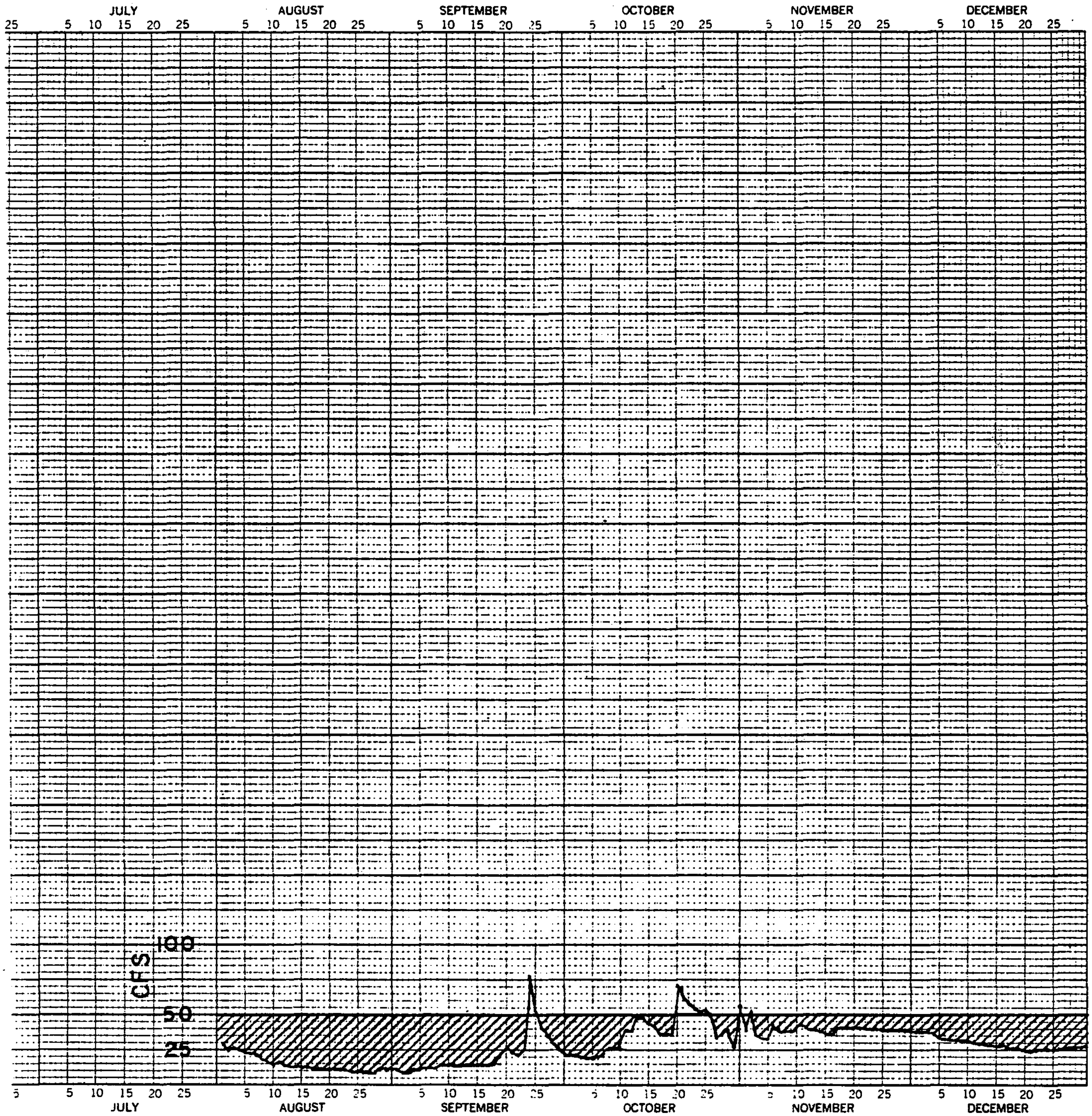
1970 FIGURE A1



COLDWATER RIVER 8LG10

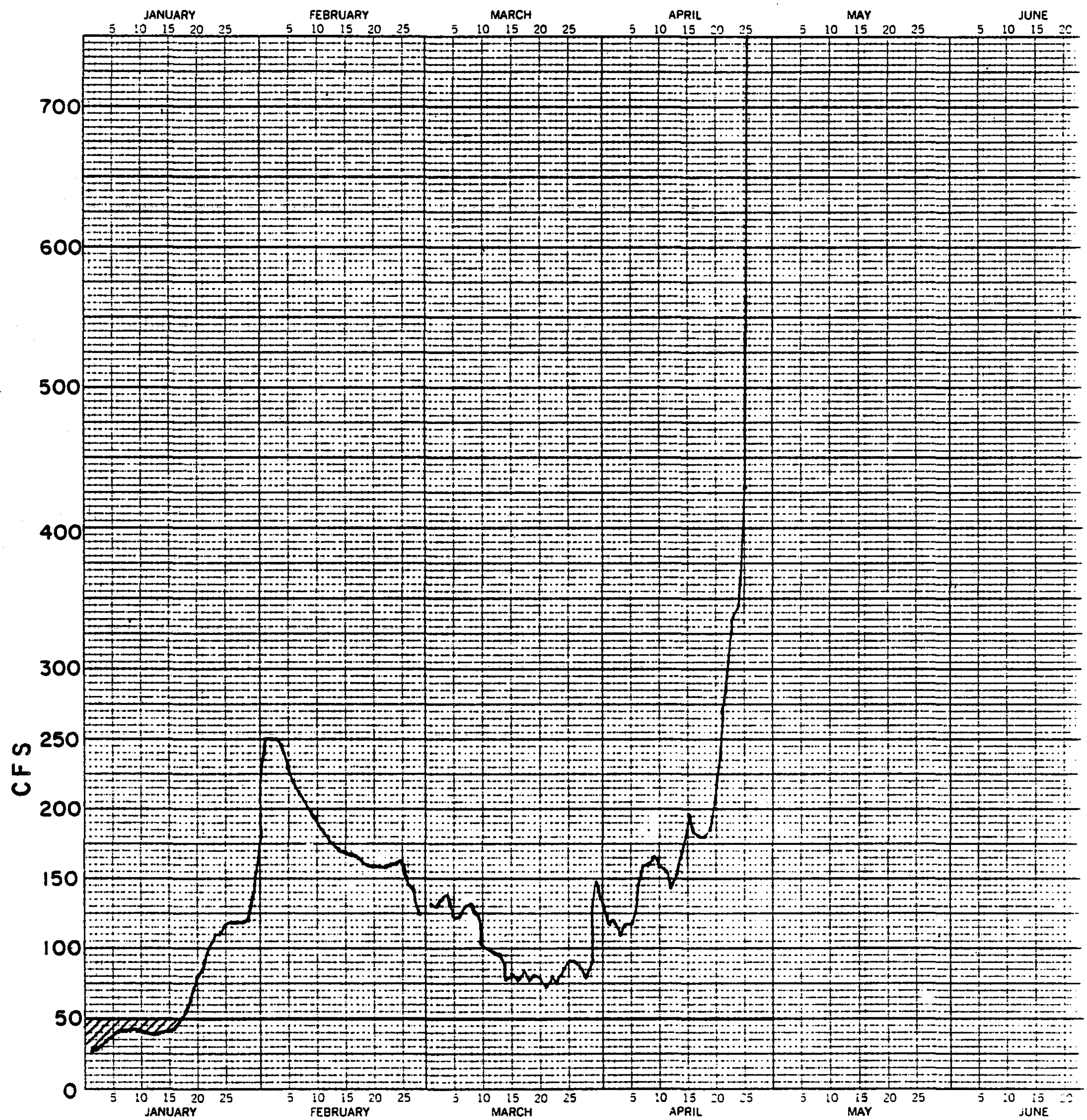
1970

FIGURE A2



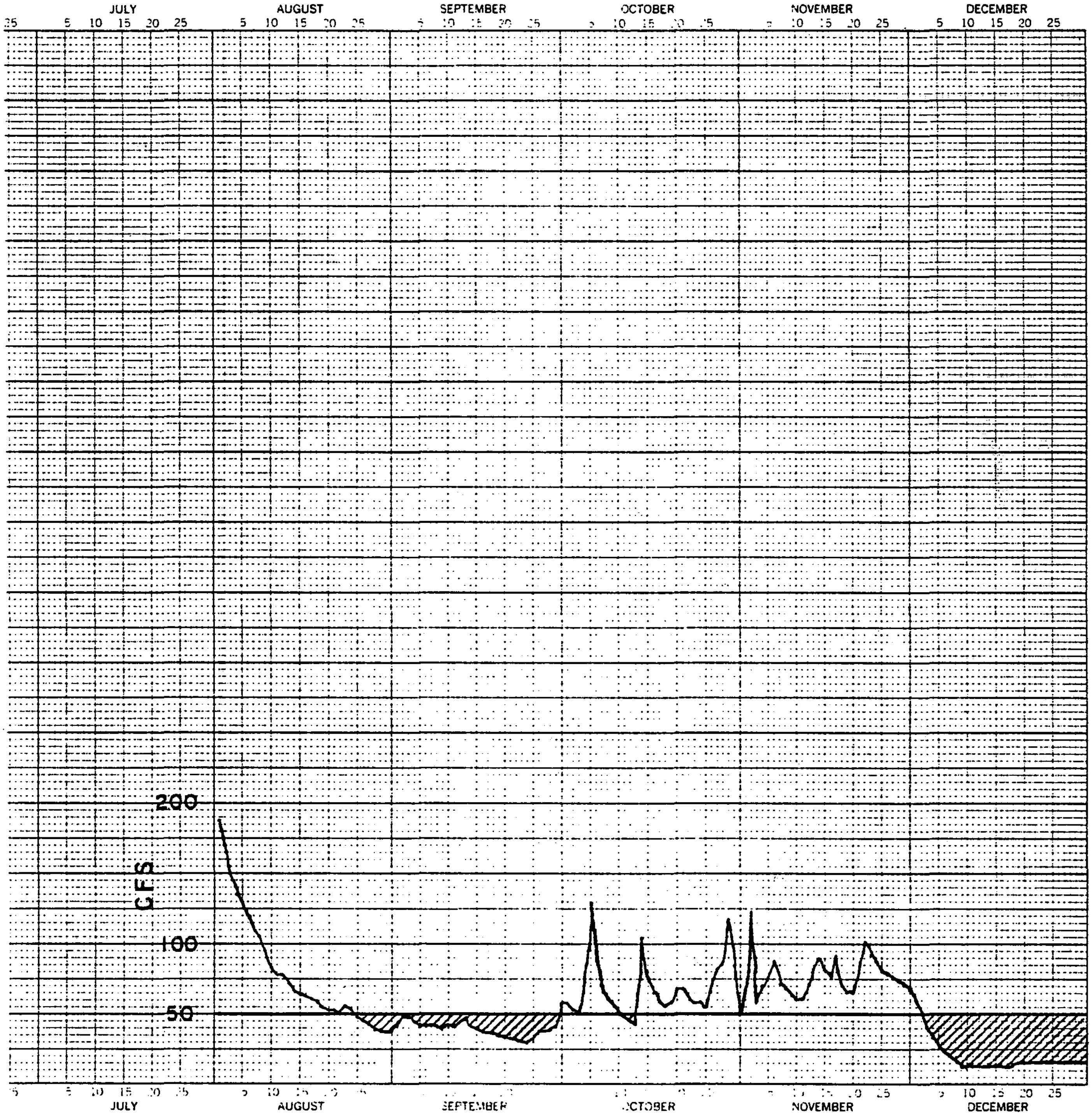
COLDWATER RIVER 8LG10

1971 FIGURE A3

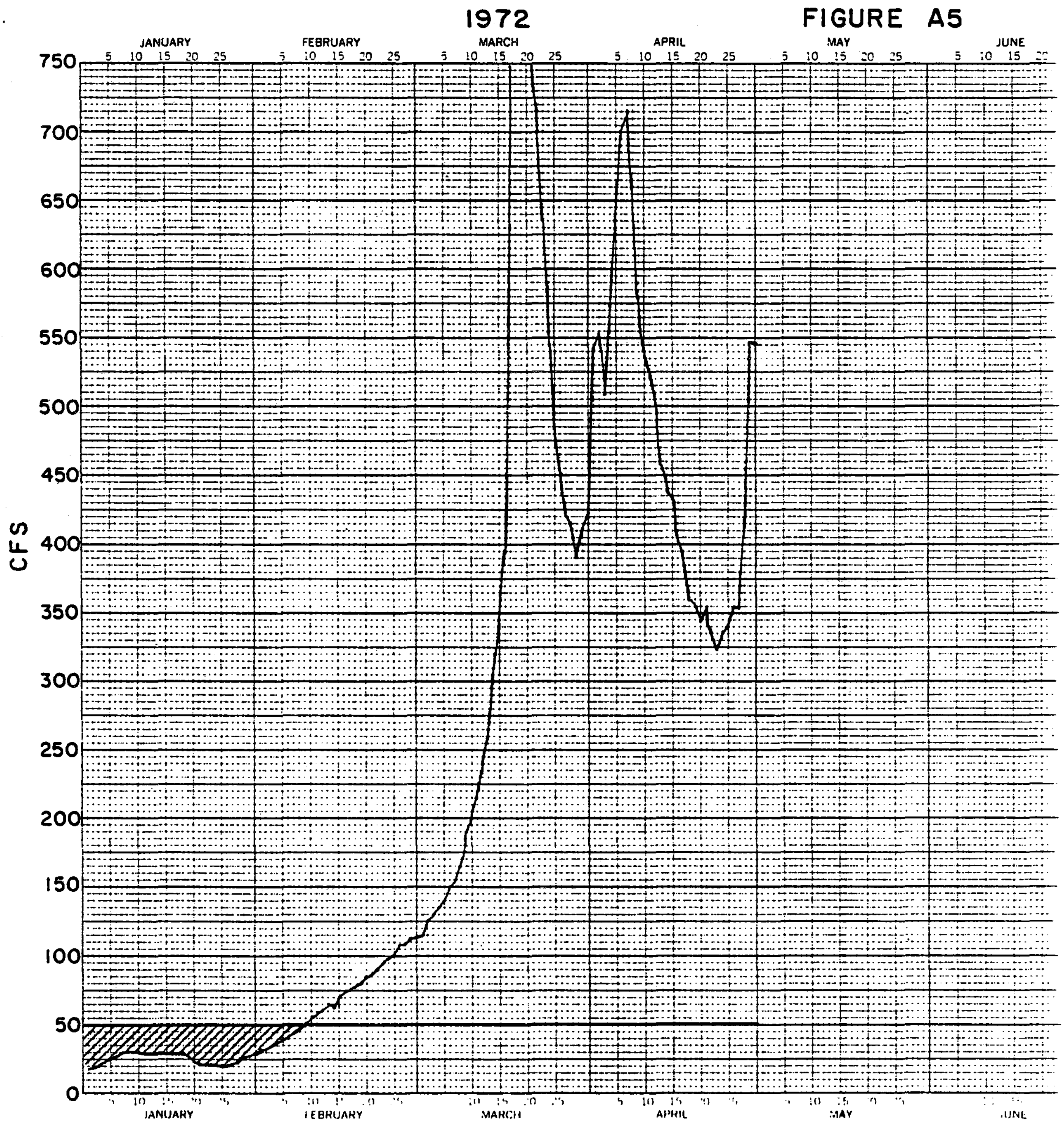


COLDWATER RIVER 8LG10

1971 FIGURE A4

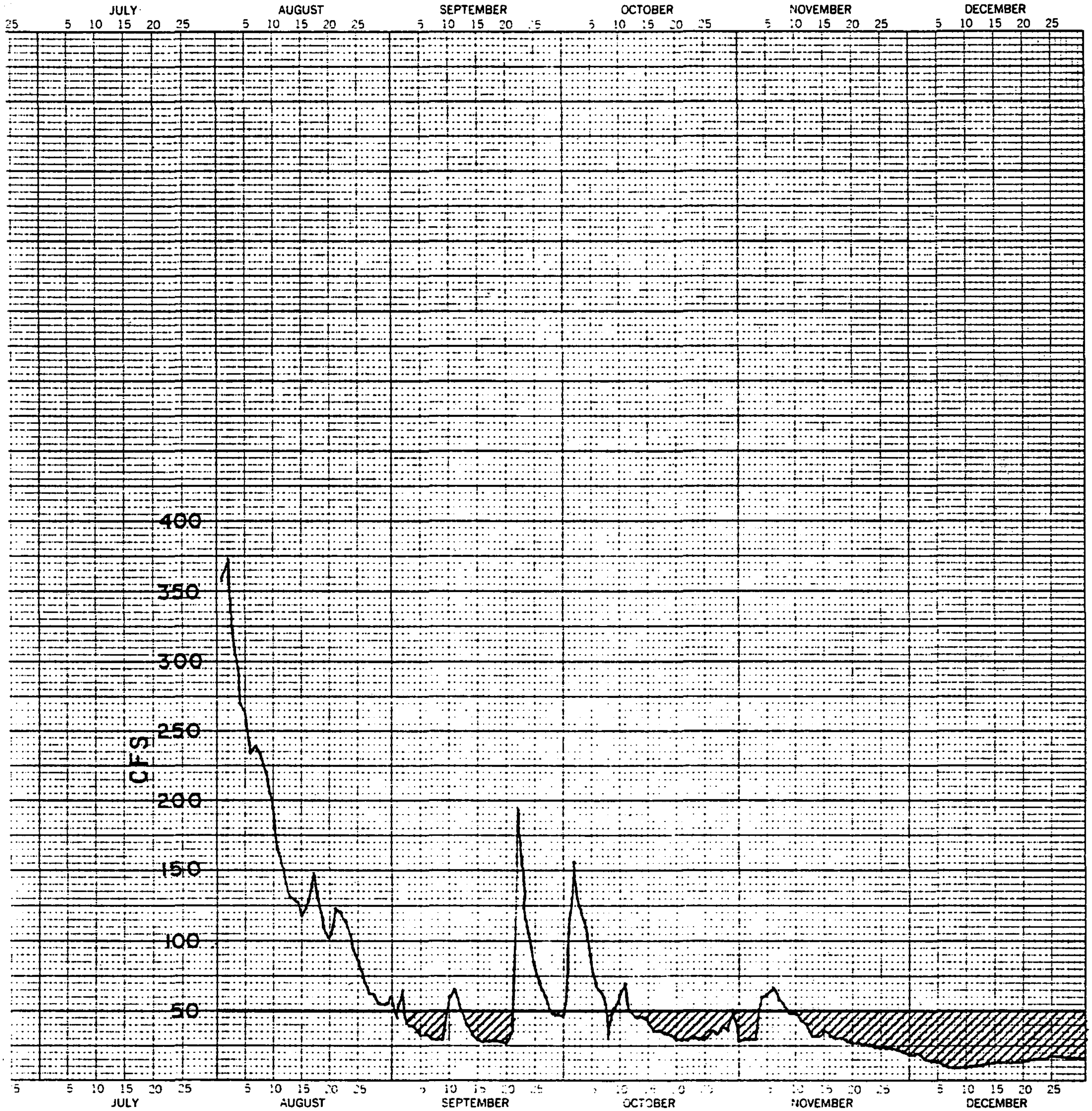


COLDWATER RIVER 8LG10



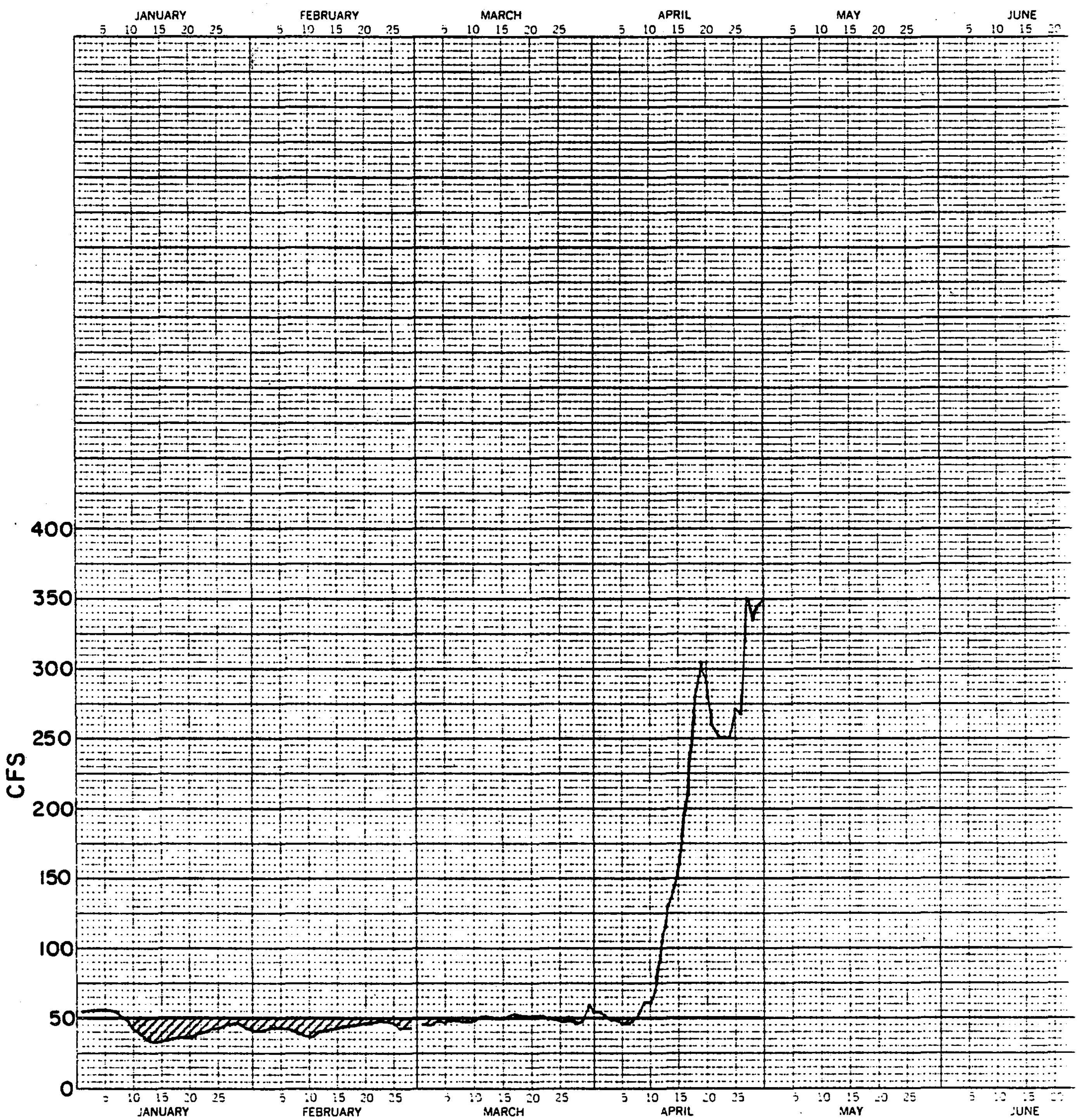
COLDWATER RIVER 8LG10

1972 FIGURE A6



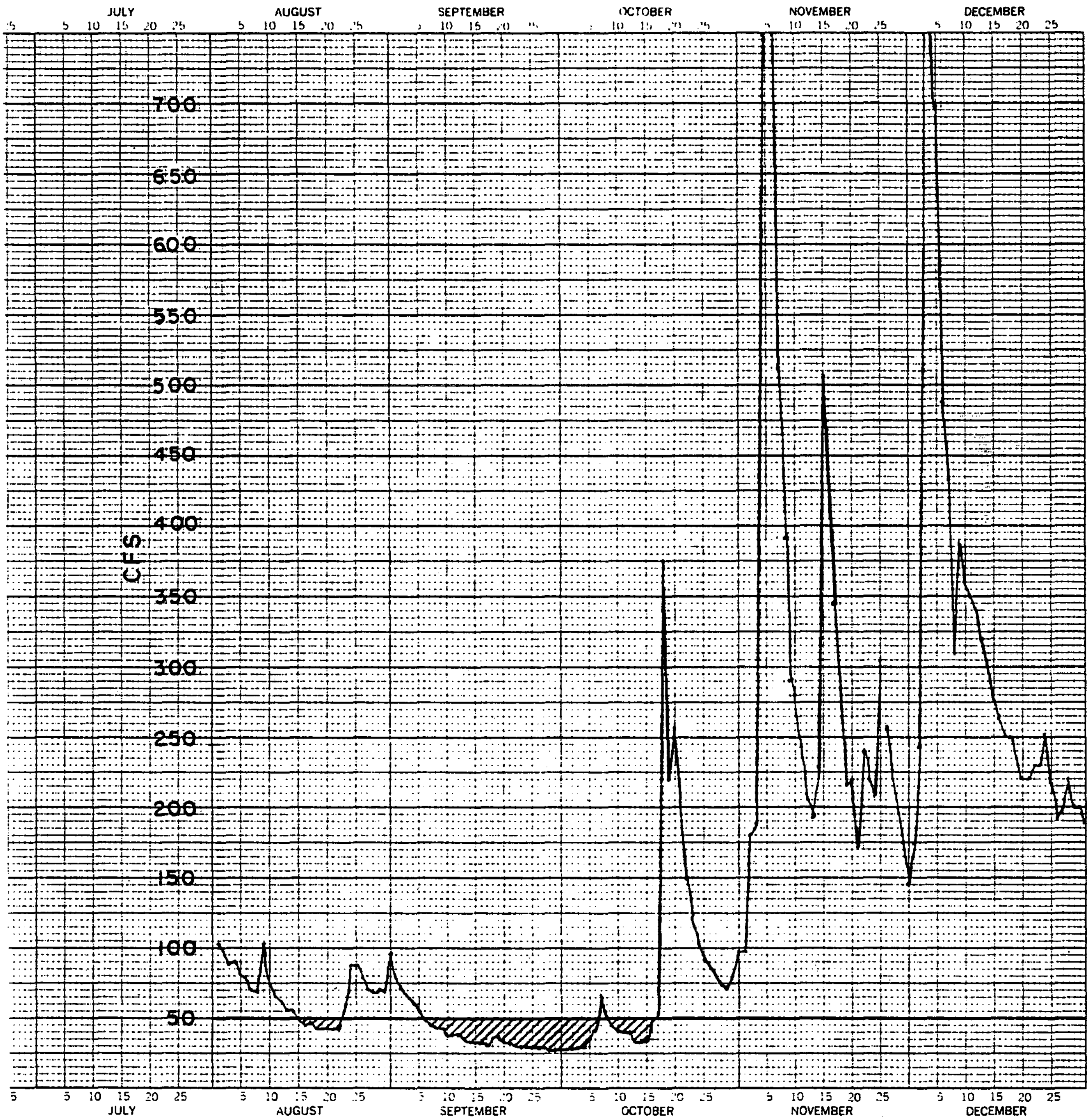
COLDWATER RIVER 8LG10

1975 FIGURE A7



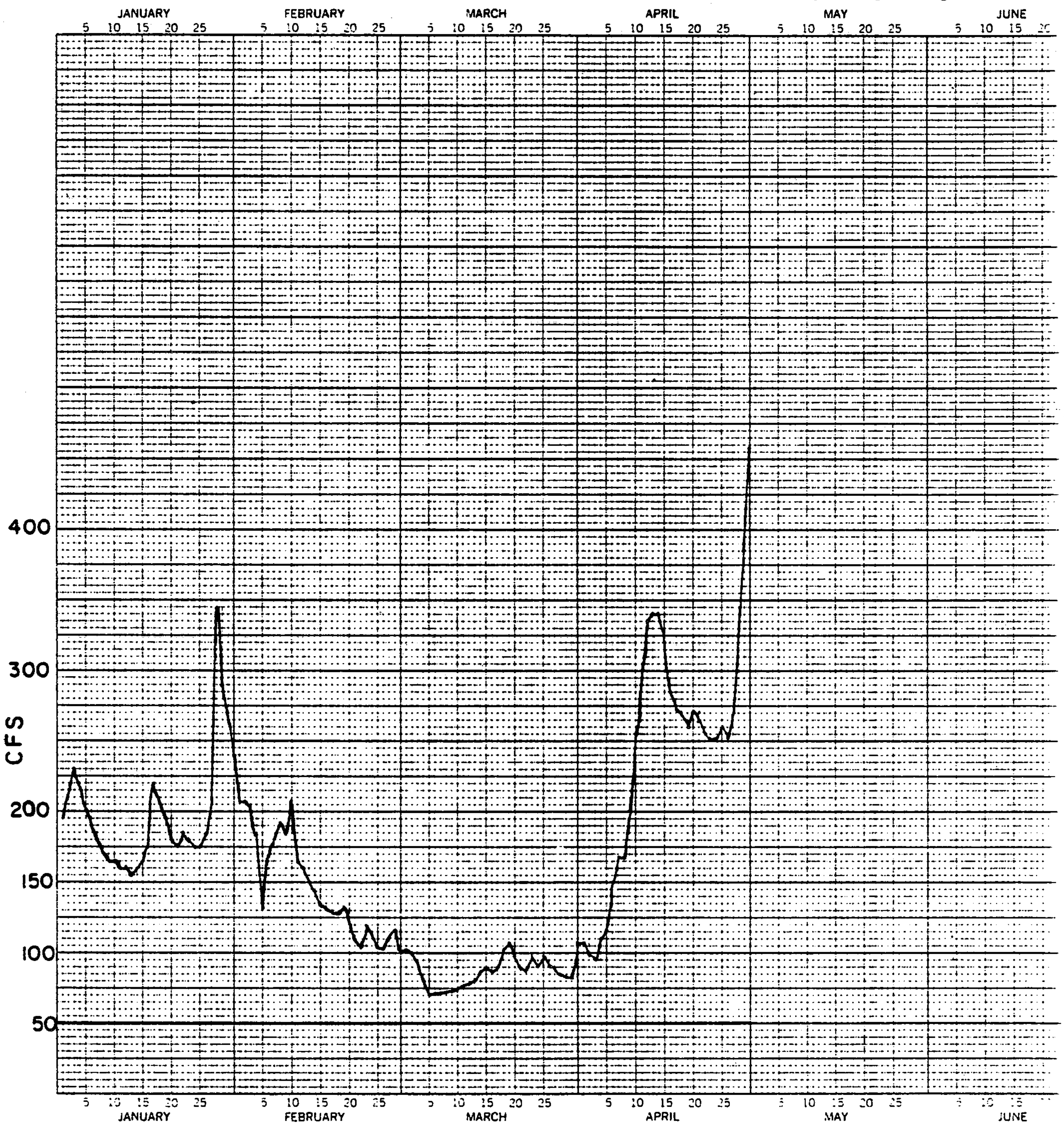
COLDWATER RIVER 8LG10

1975 FIGURE A8



COLDWATER RIVER 8LG10

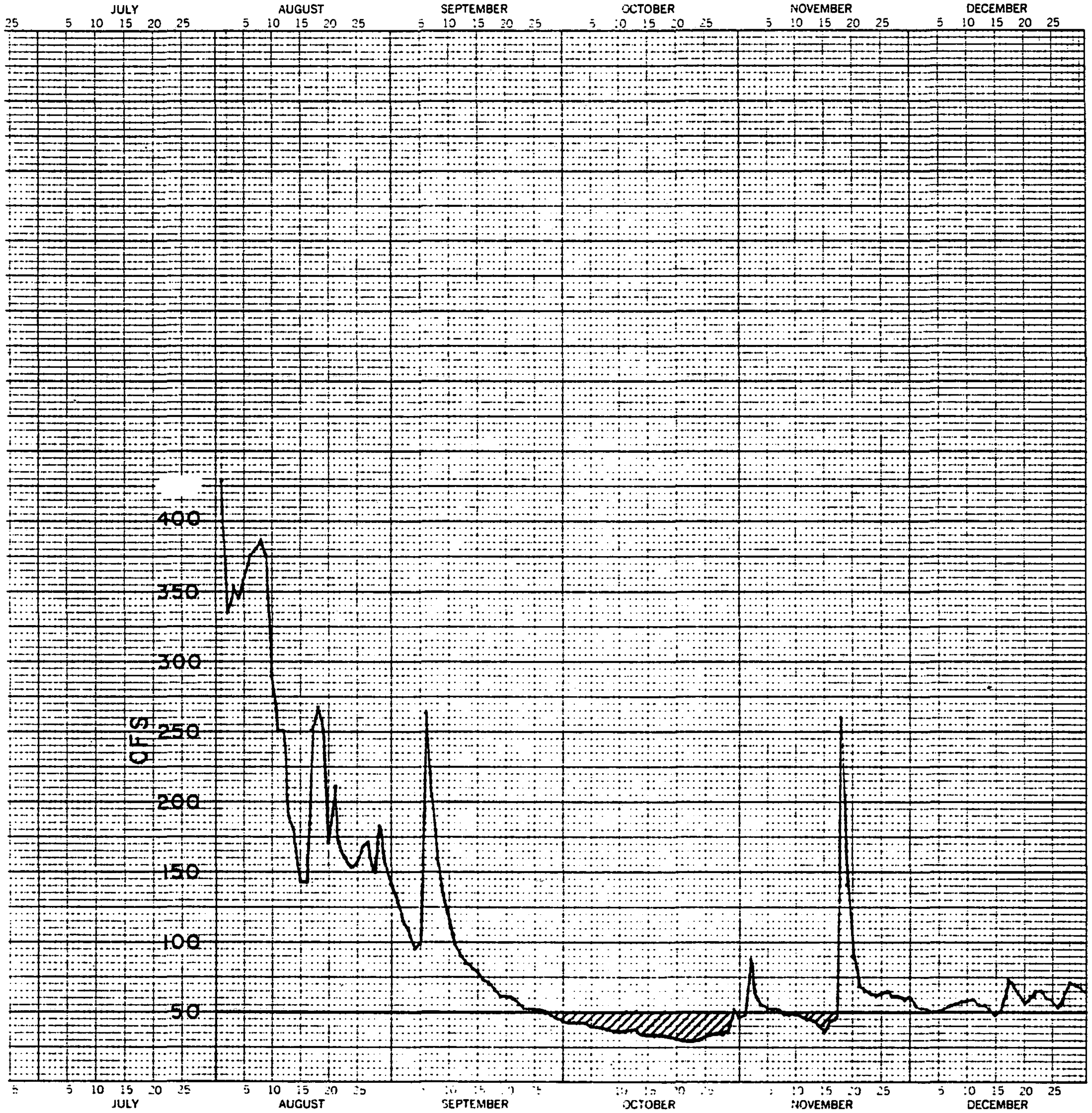
1976 FIGURE A9



COLDWATER RIVER 8 LG 10

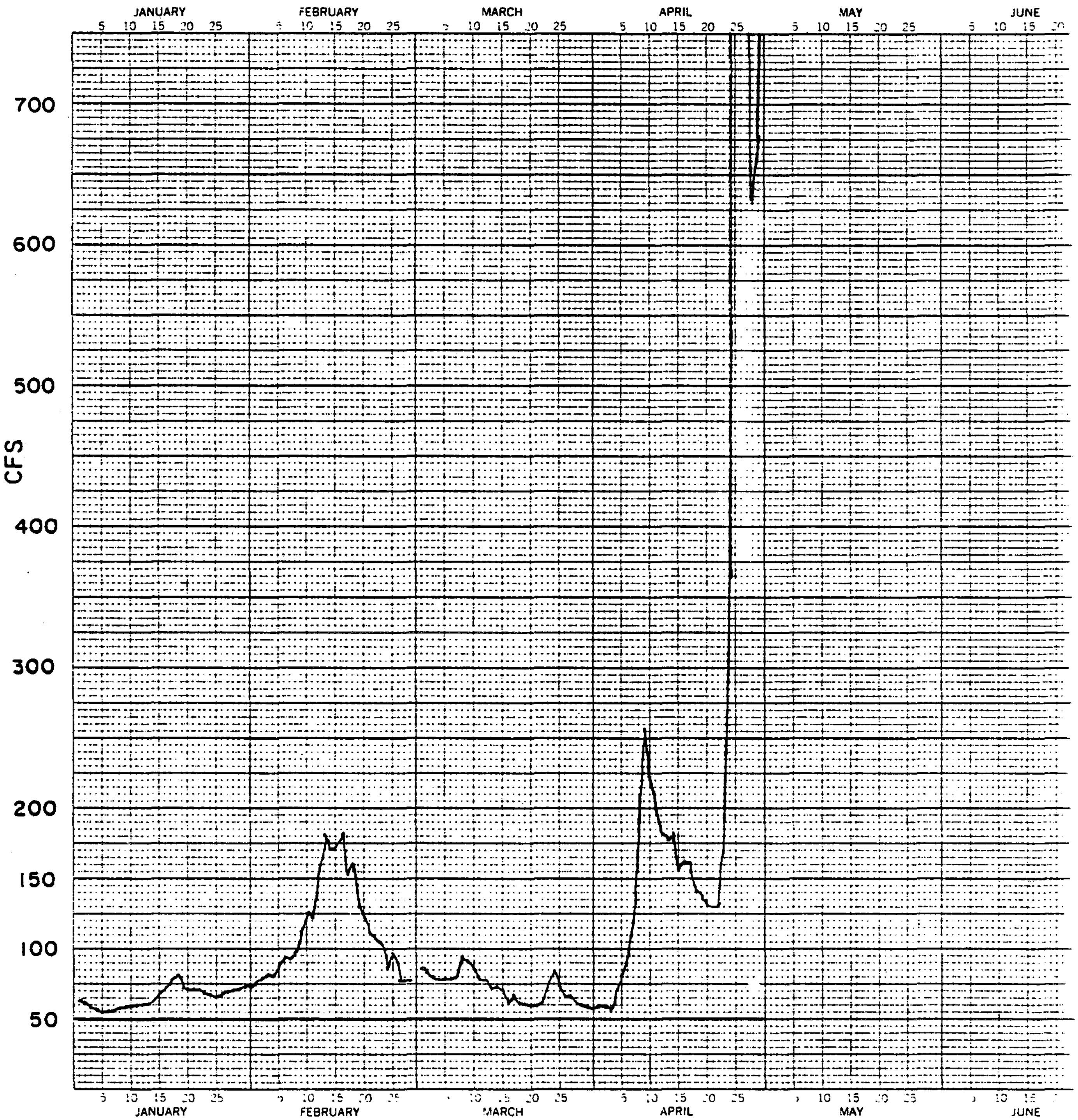
1976

FIGURE A10



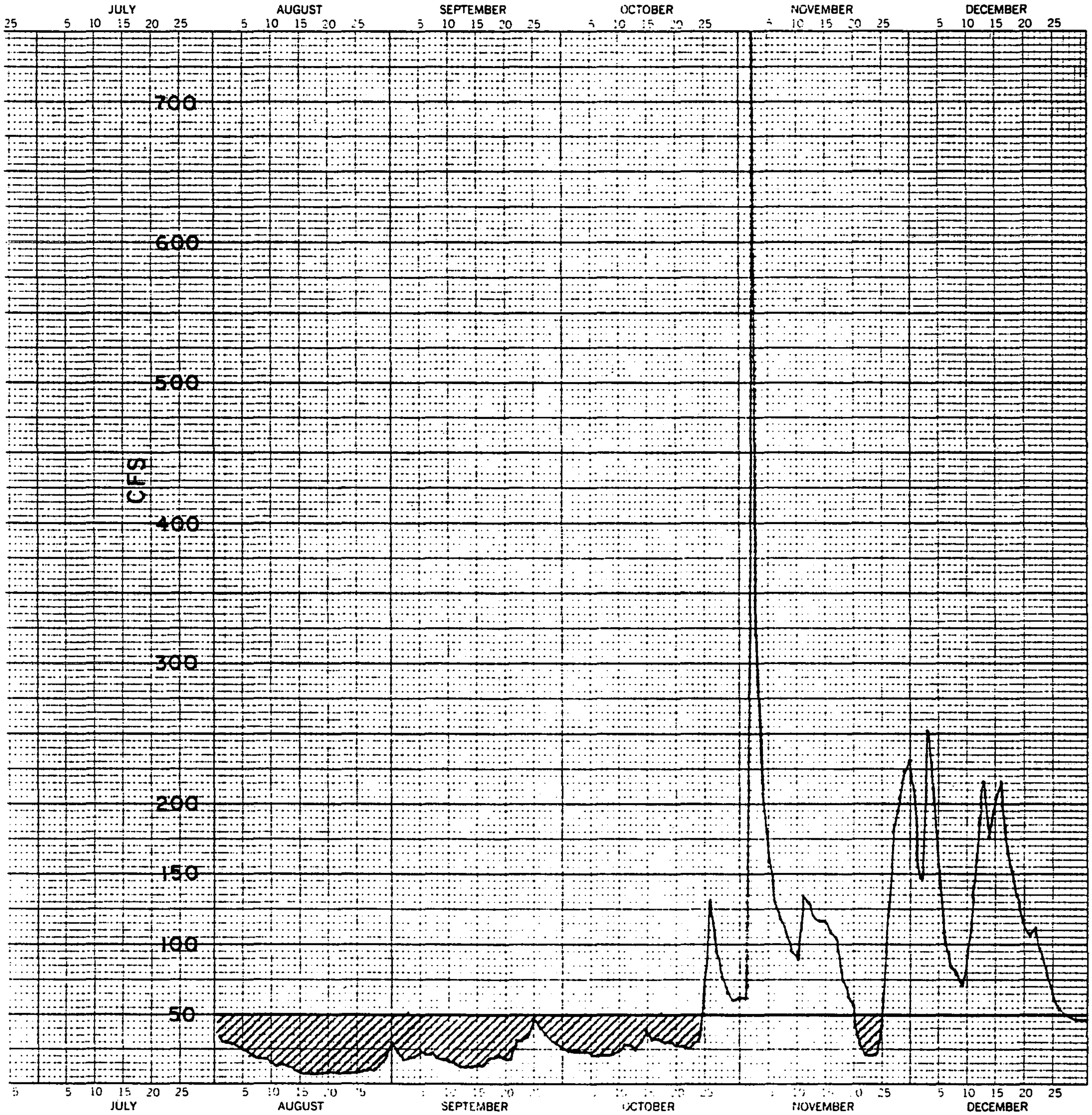
COLDWATER RIVER 8LG10

1977 FIGURE A11



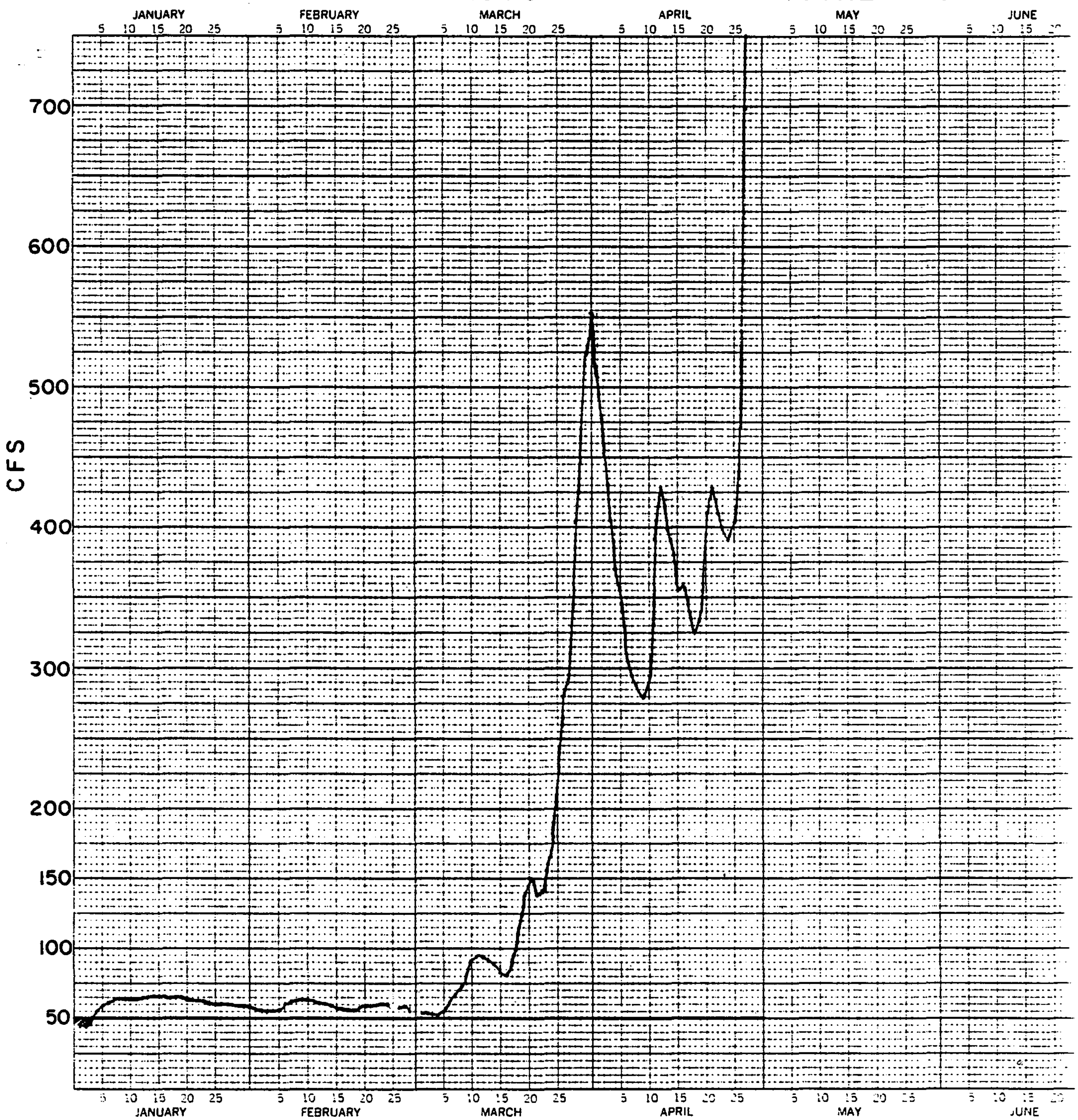
COLDWATER RIVER 8LG10

1977 FIGURE A12



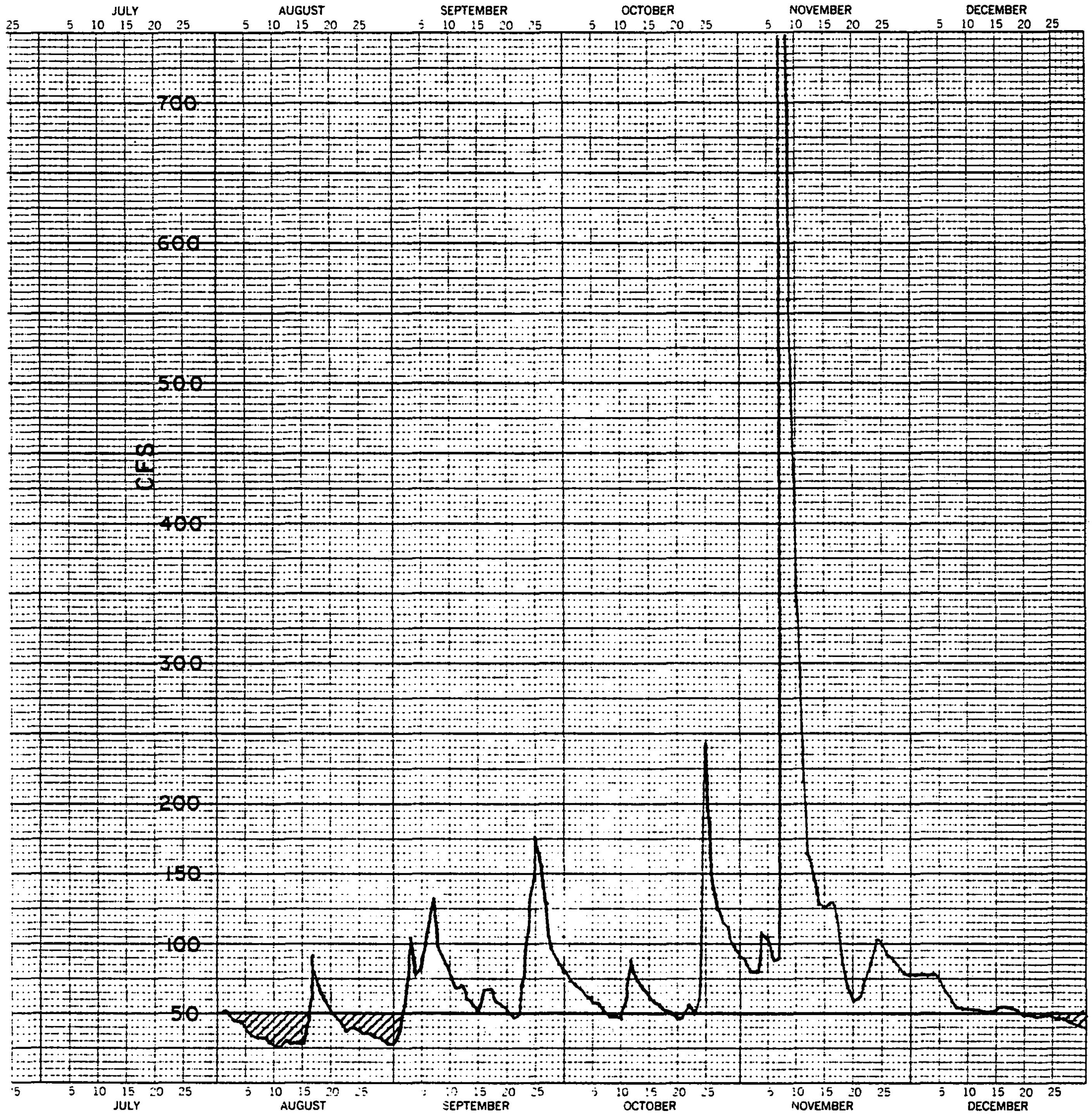
COLDWATER RIVER 8LG10

1978 FIGURE A13



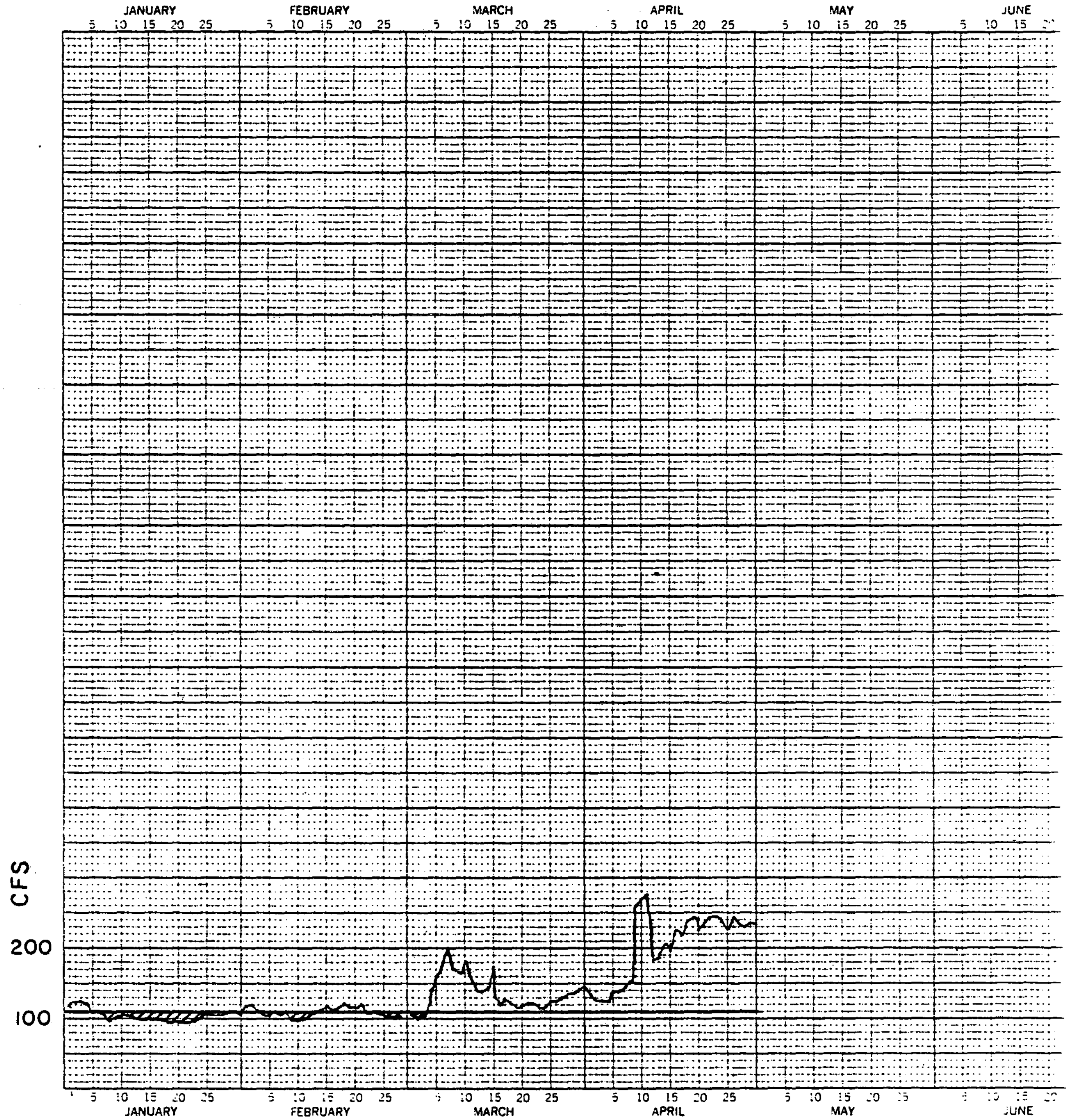
COLDWATER RIVER 8LG10

1978 FIGURE A14



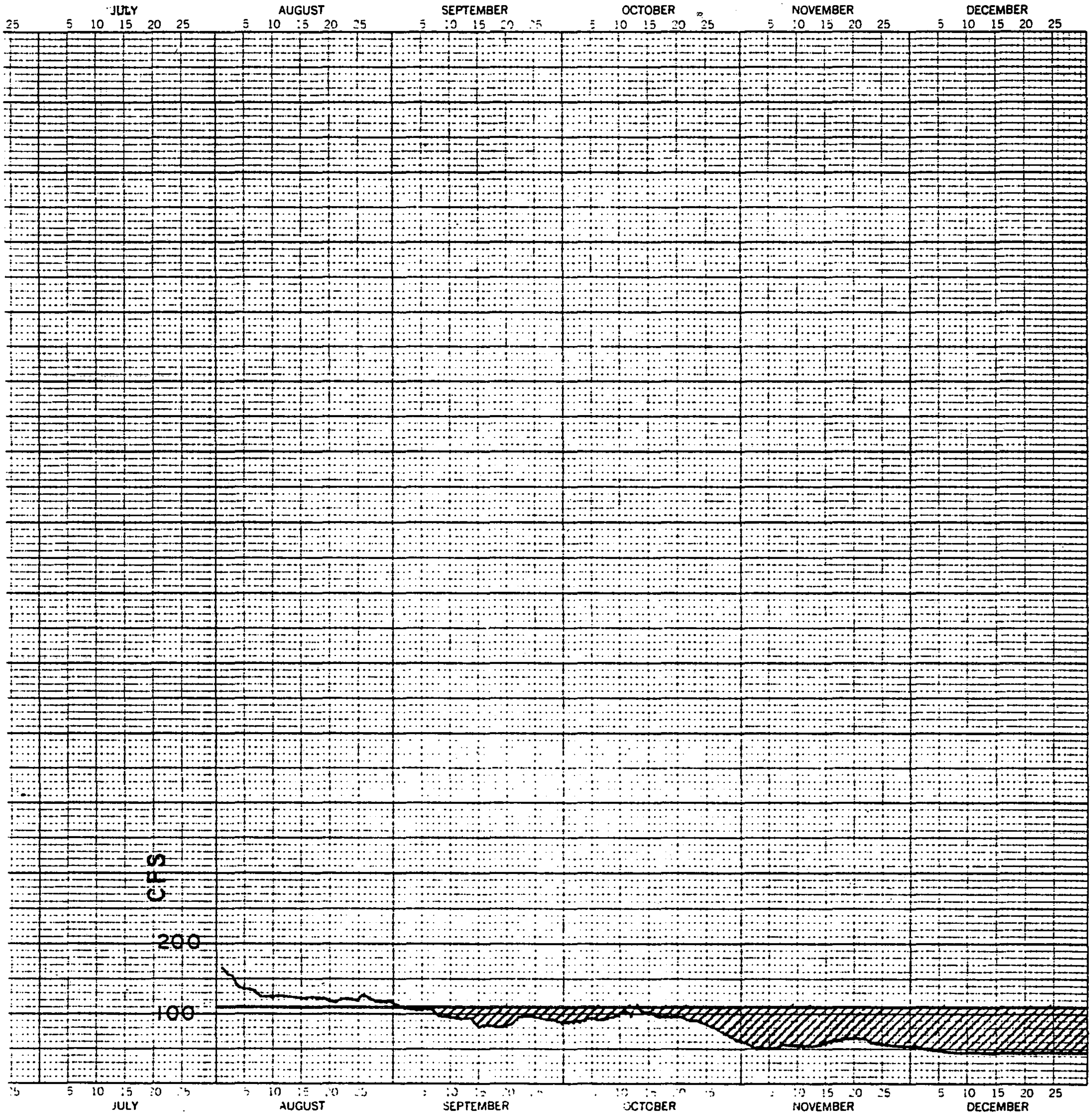
NICOLA RIVER 8 LG 7

1970 FIGURE A15



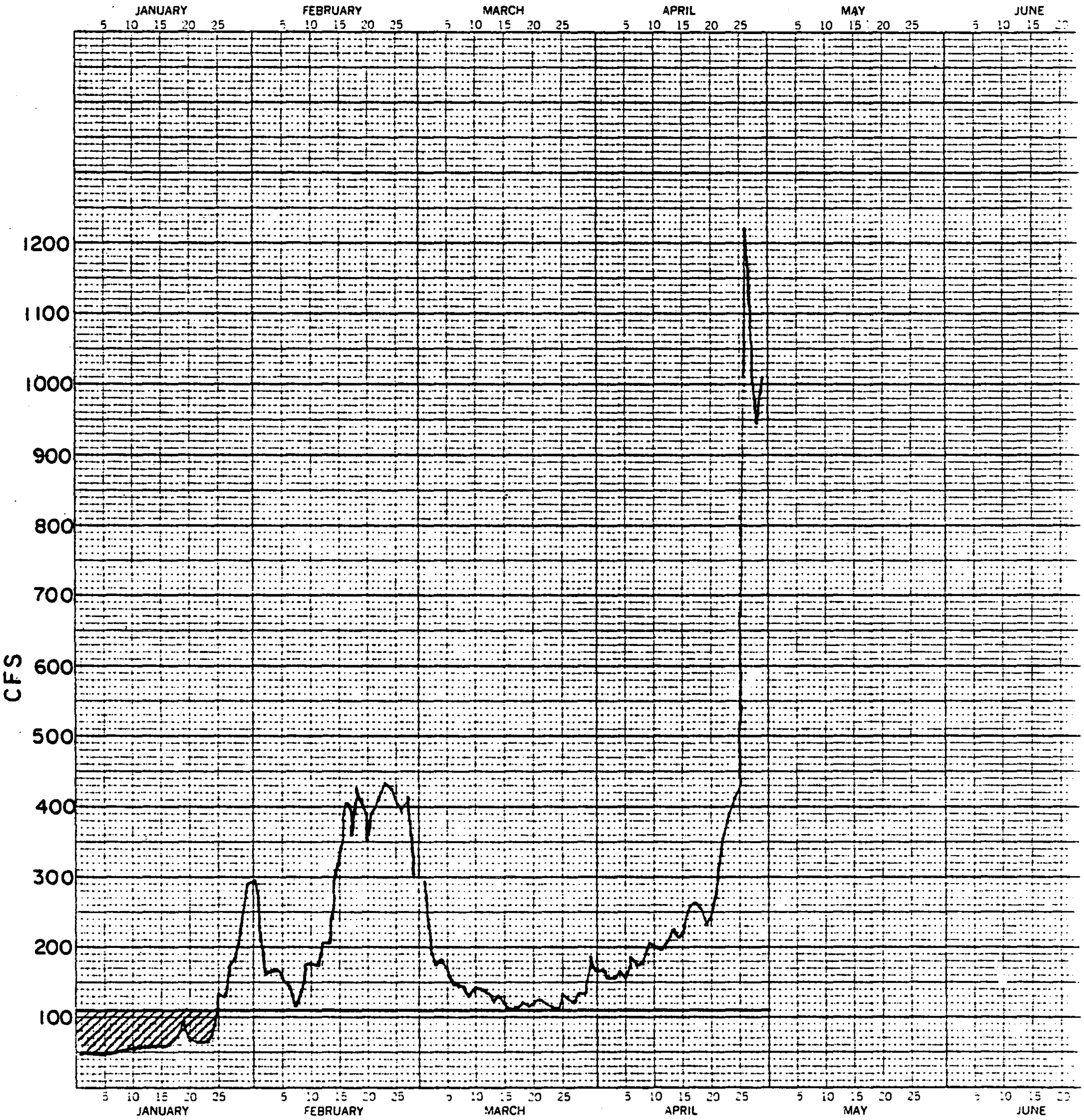
NICOLA RIVER 8LG 7

1970 FIGURE A16



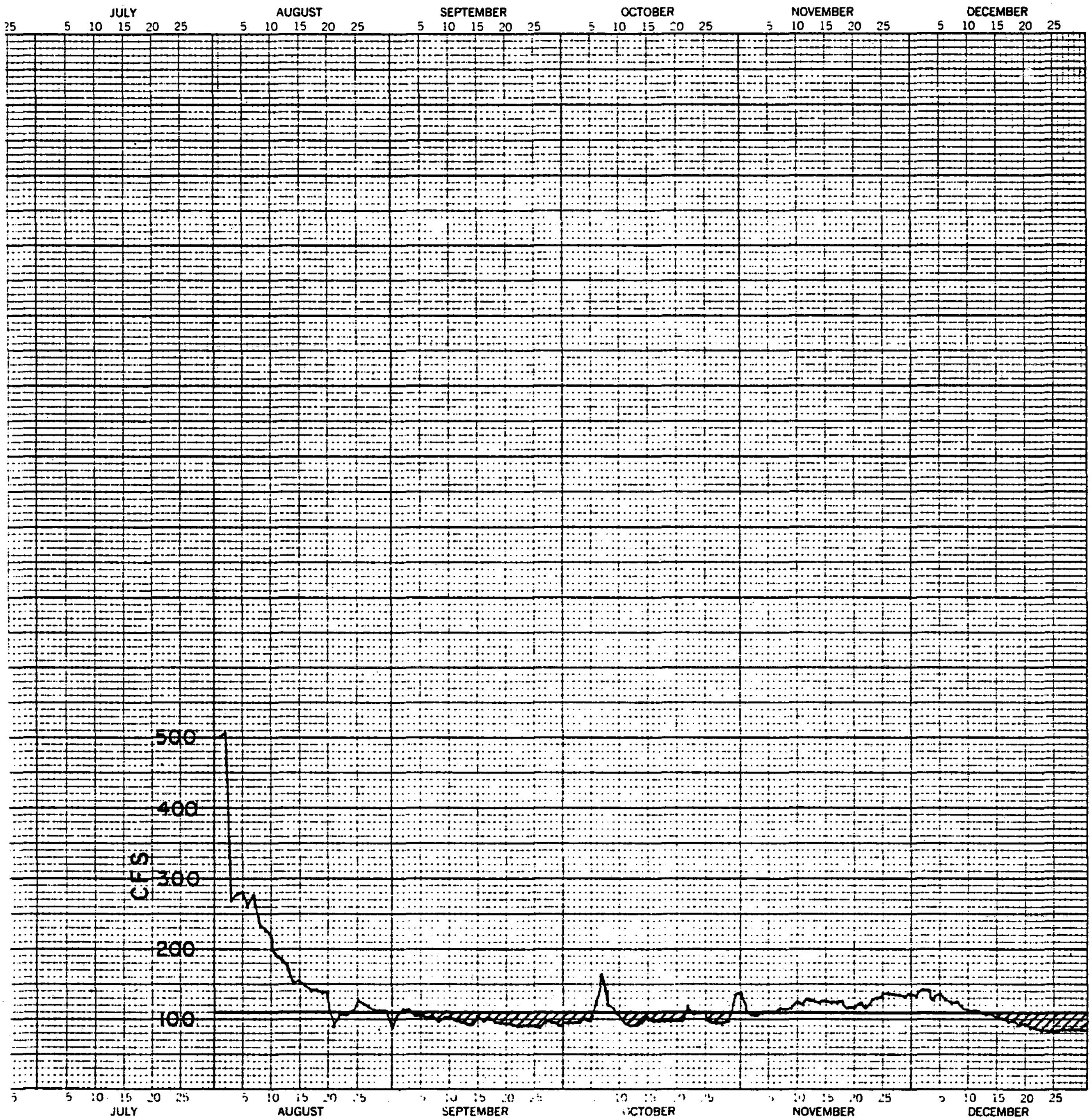
NICOLA RIVER 8LG7

1971 FIGURE A17



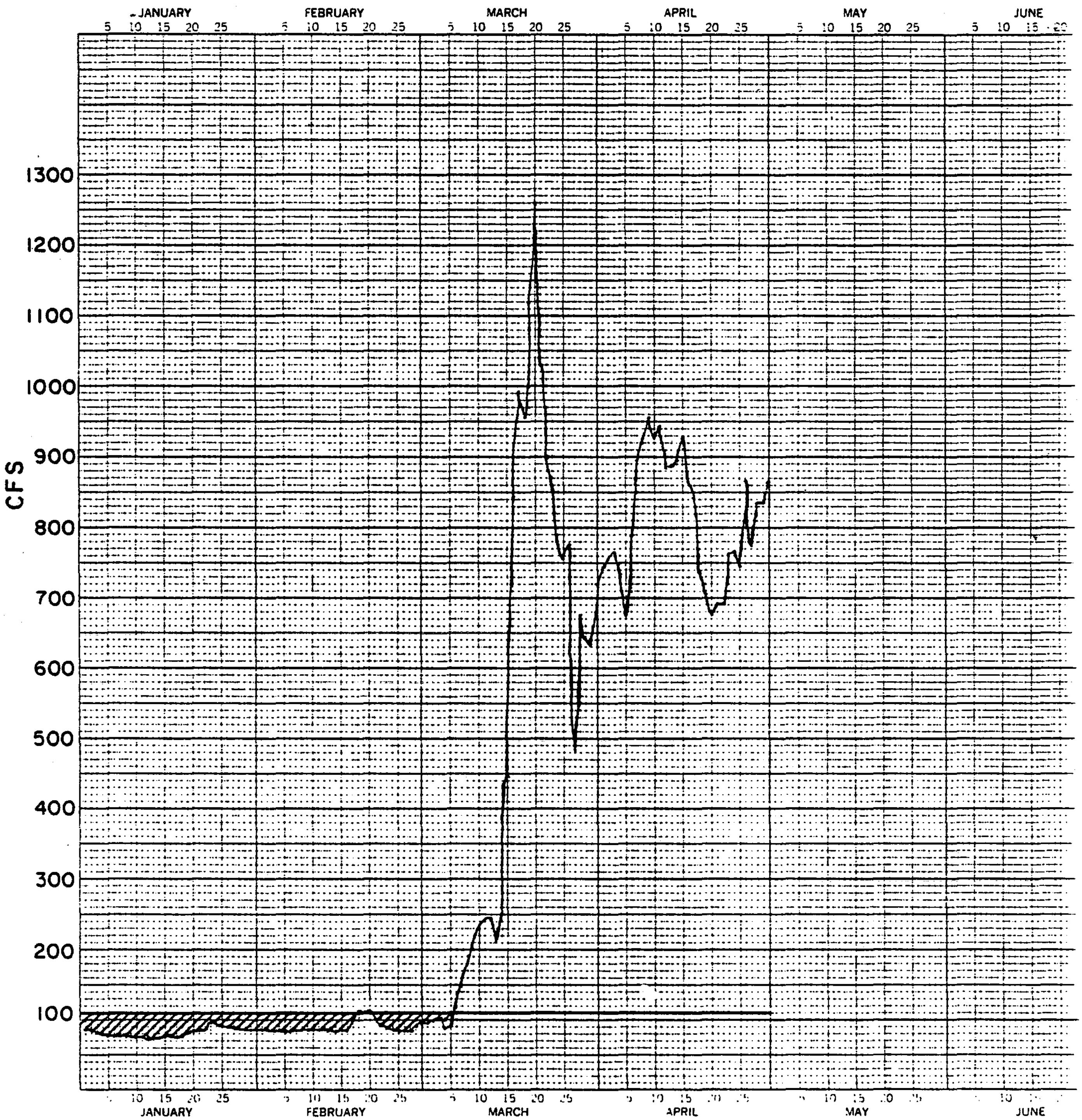
NICOLA RIVER 8LG 7

1971 FIGURE A18



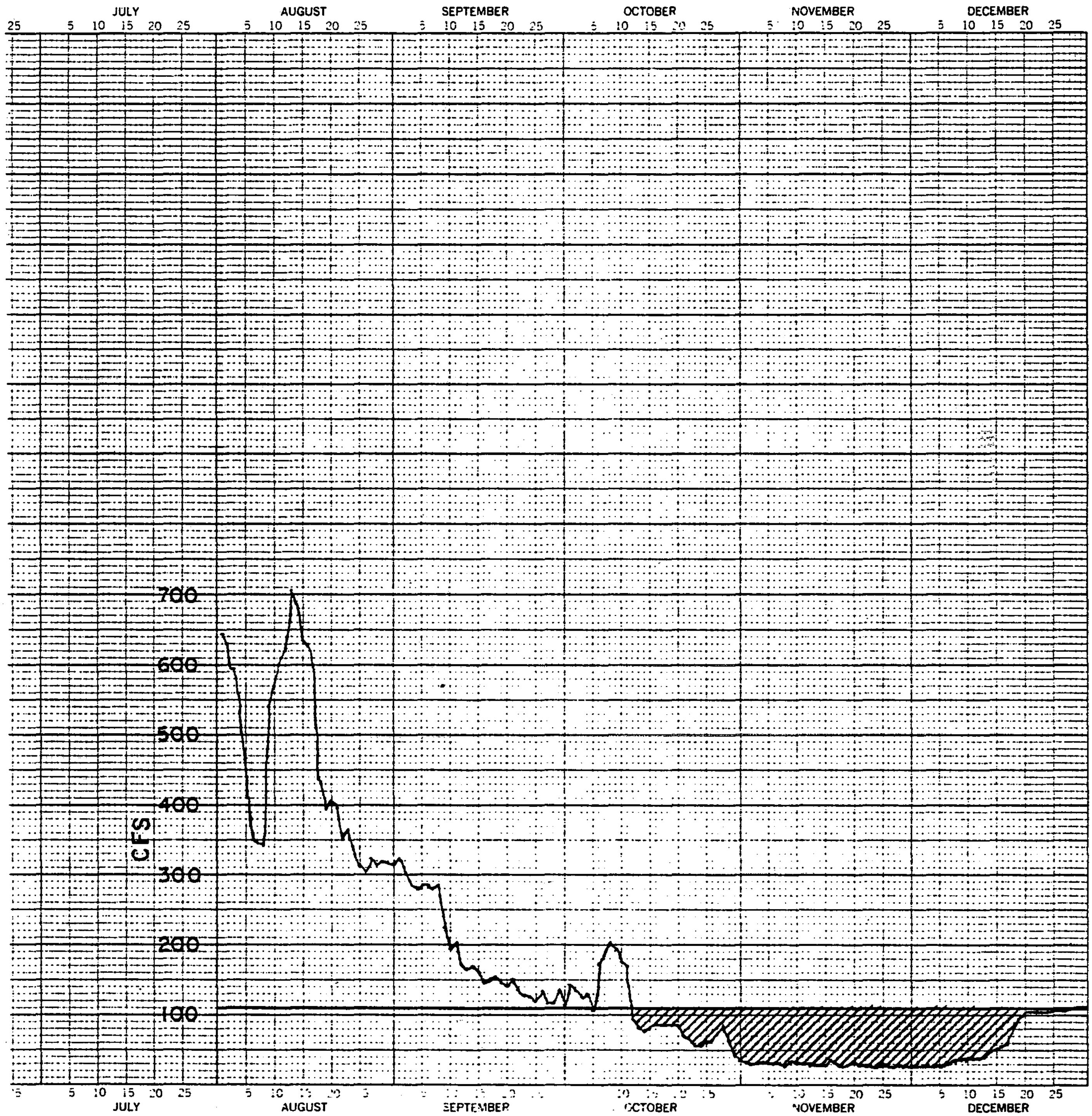
NICOLA RIVER 8 LG 7

1972 FIGURE A19



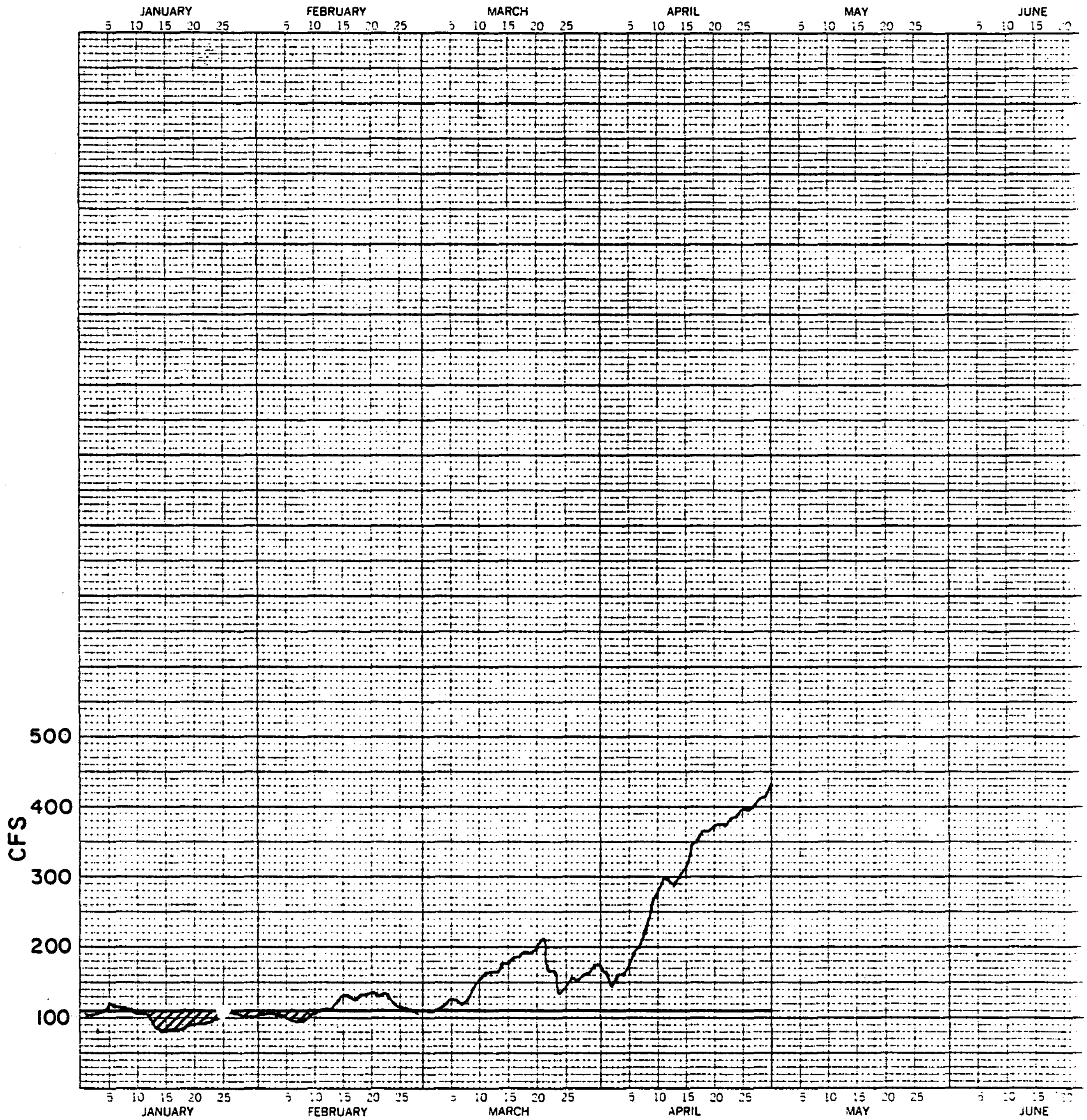
NICOLA RIVER 8LG7

1972 FIGURE A20



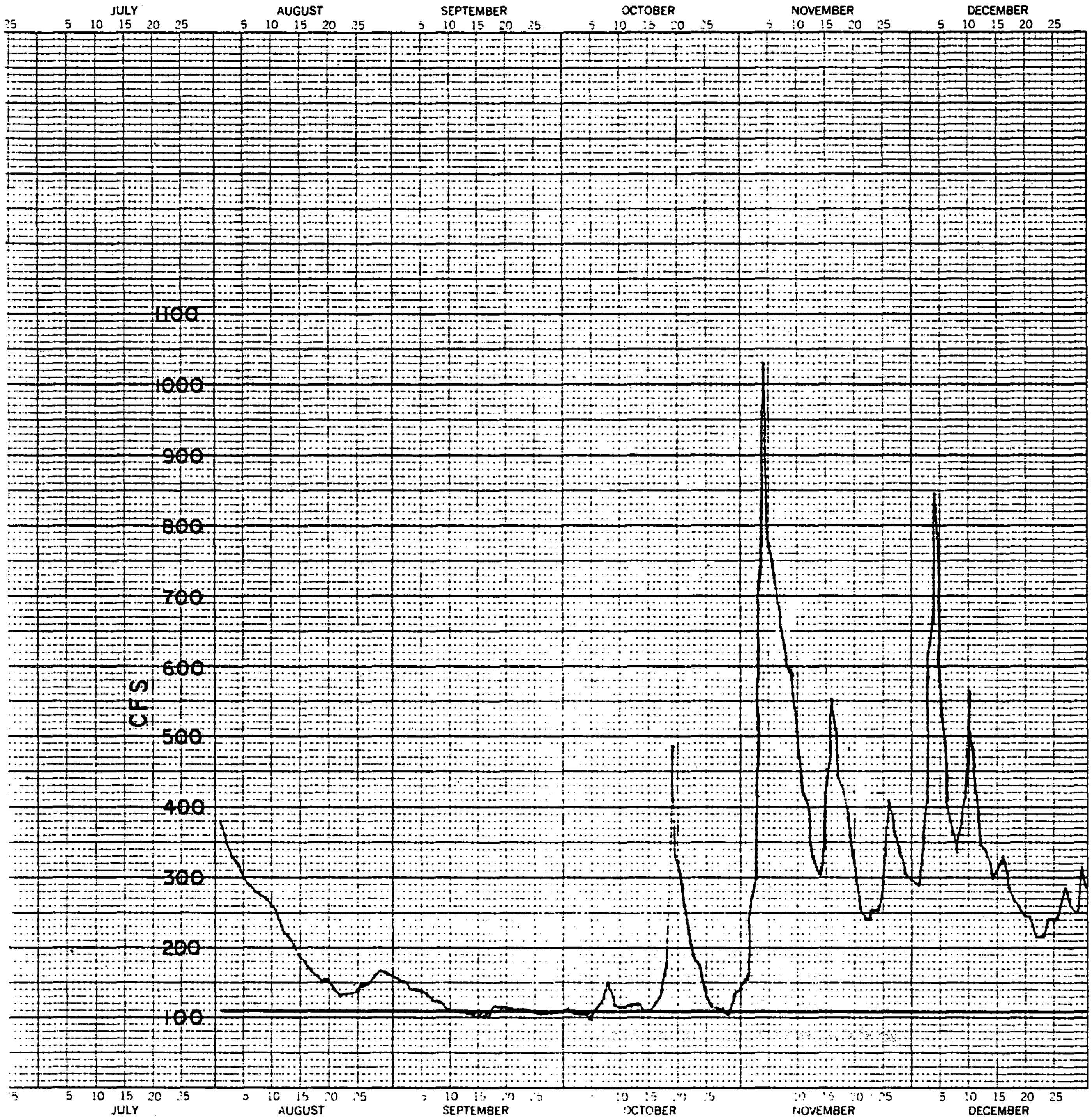
NICOLA RIVER 8 LG 7

1975 FIGURE A21



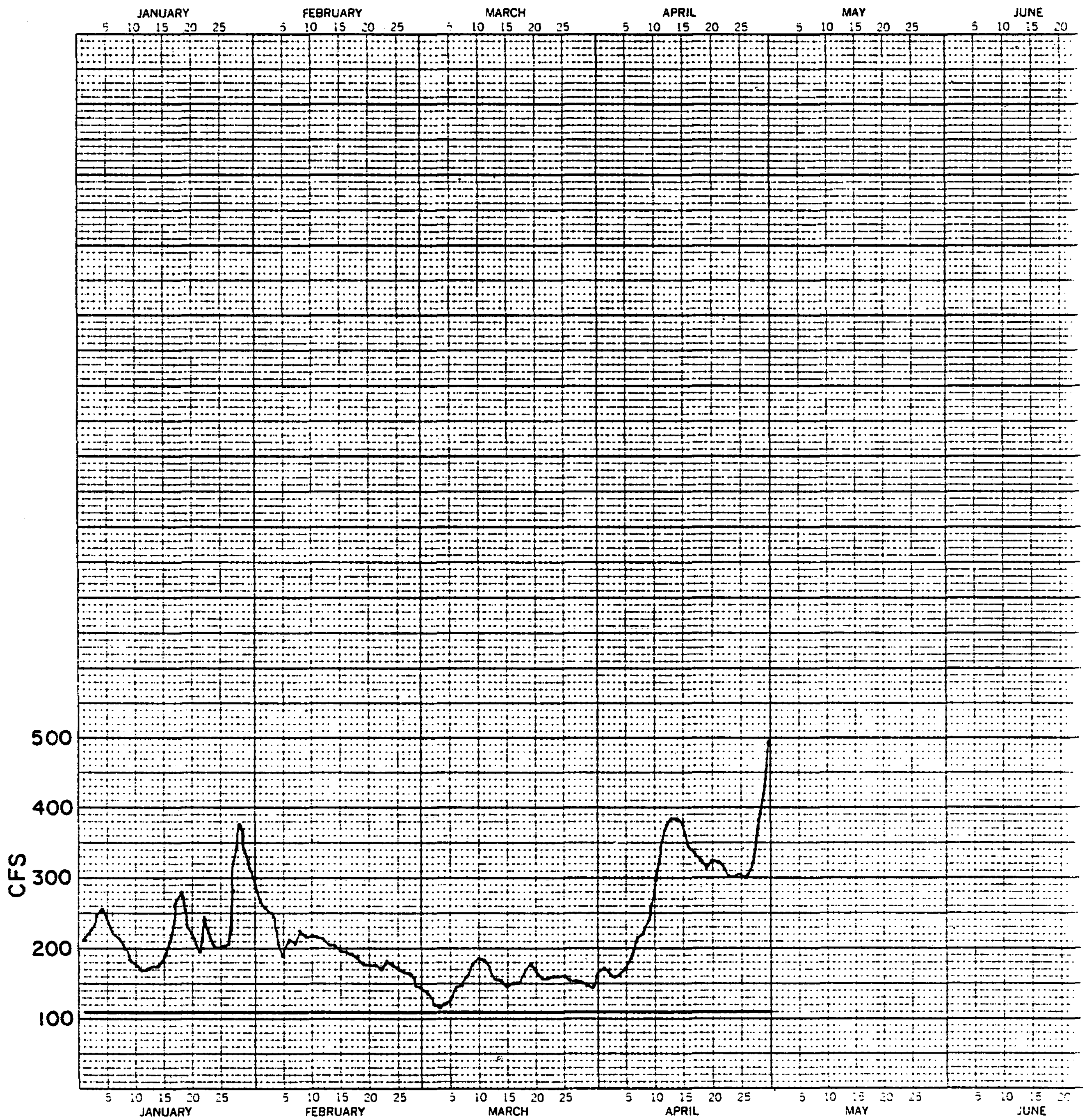
NICOLA RIVER 8 LG 7

1975 FIGURE A22



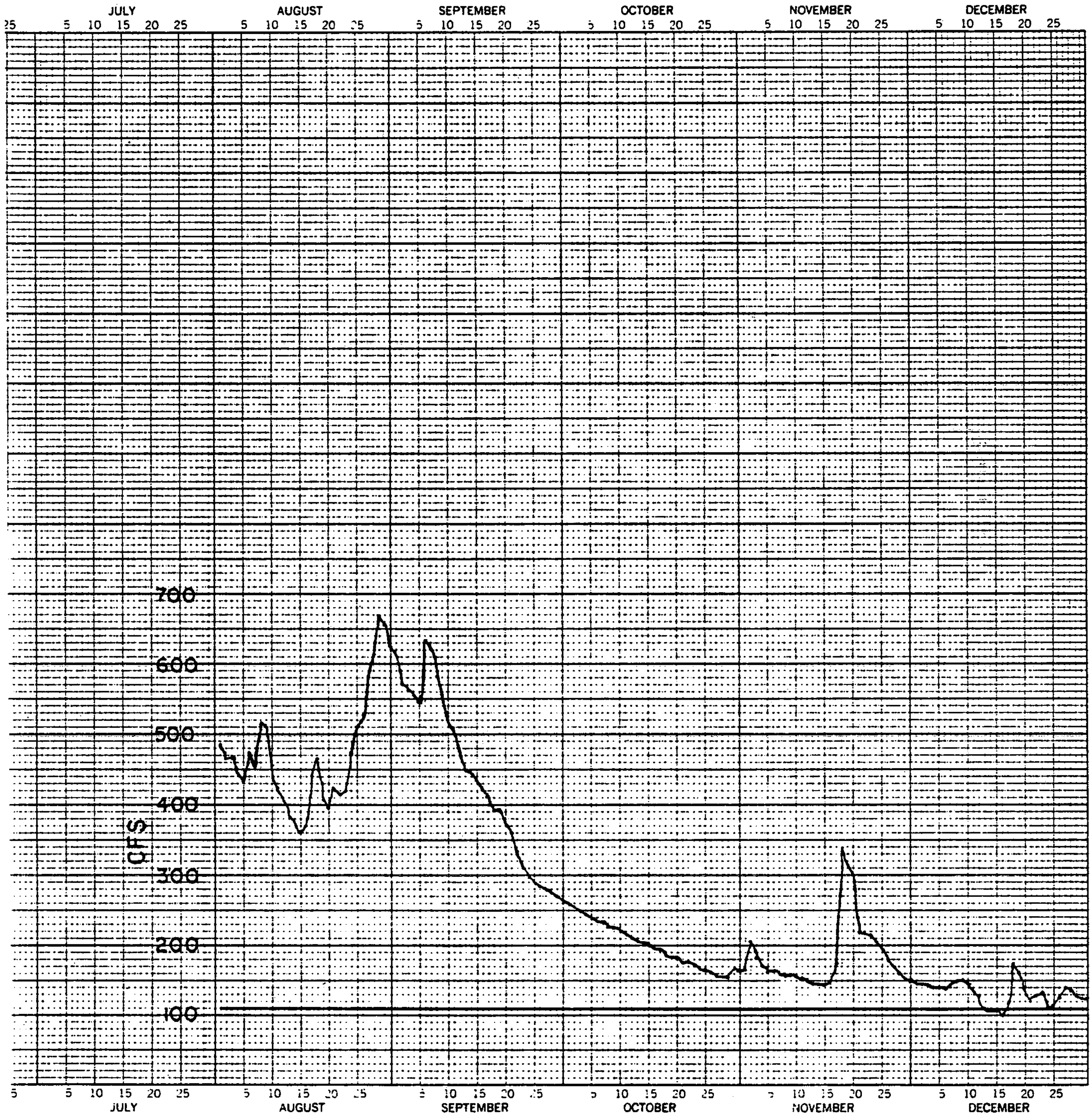
NICOLA RIVER 8 LG 7

1976 FIGURE A23



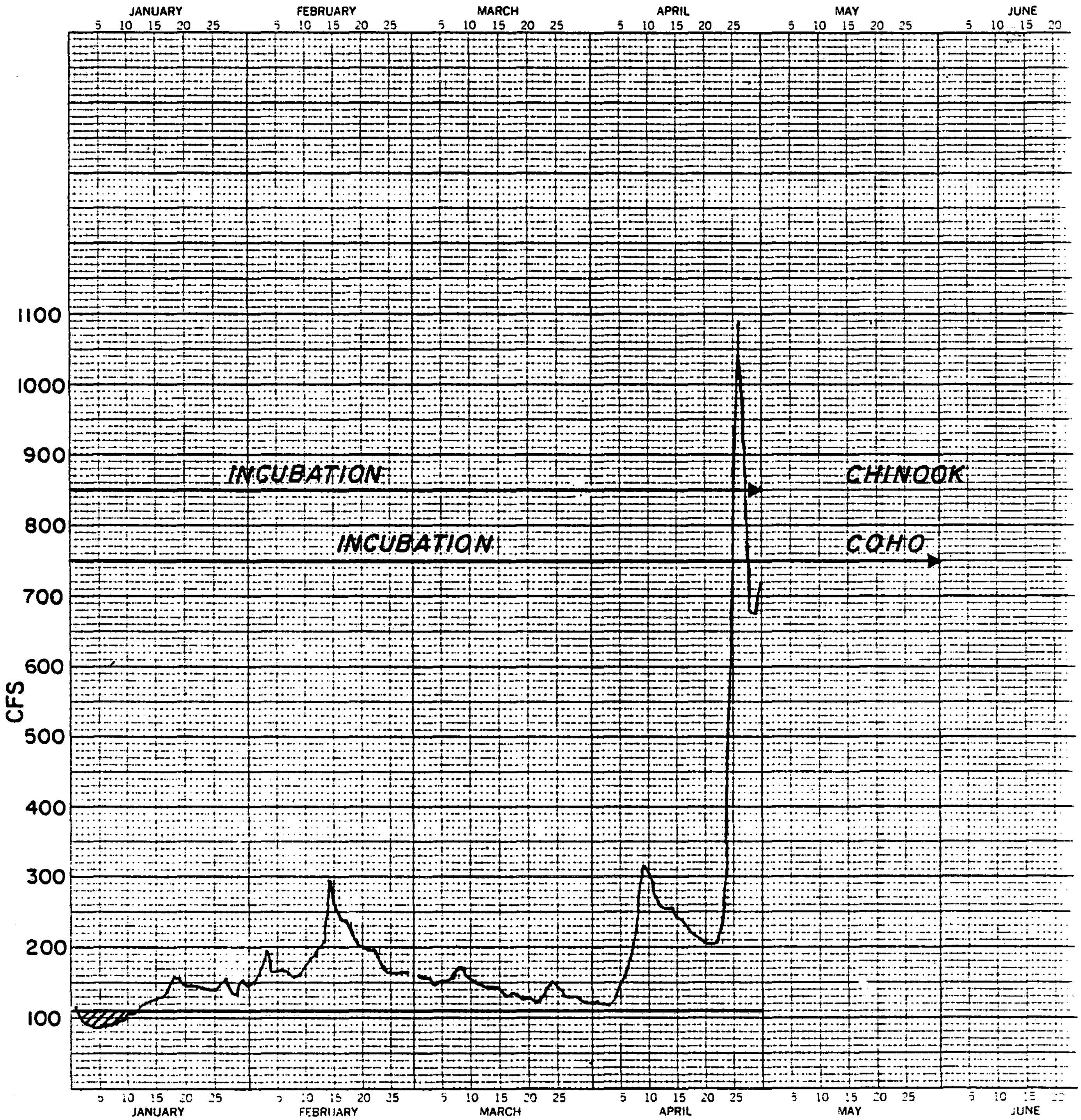
NICOLA RIVER 8 LG 7

1976 FIGURE A24



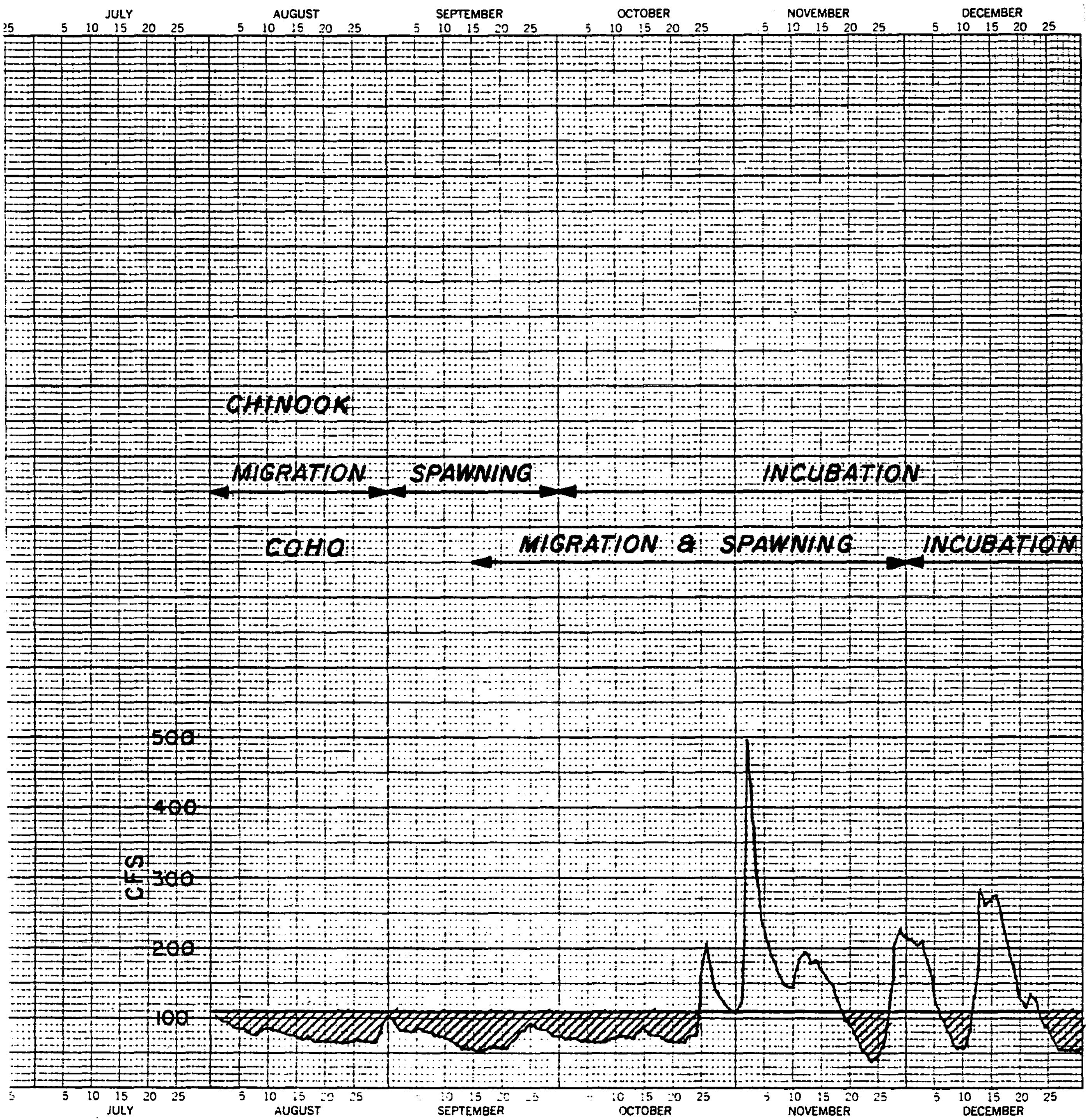
NICOLA RIVER 8 LG 7

1977 FIGURE A25



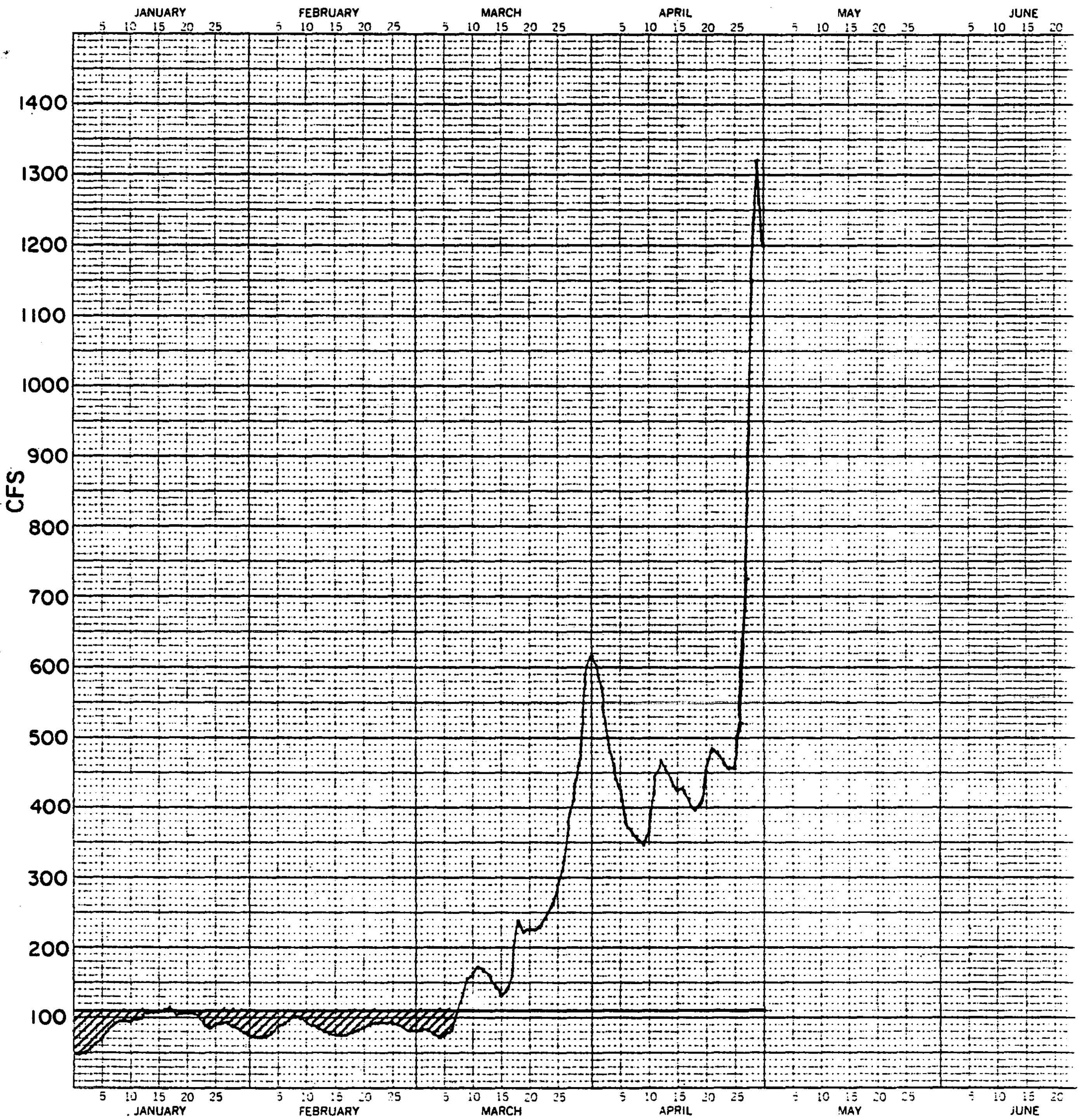
NICOLA RIVER 8 LG 7

1977 FIGURE A26



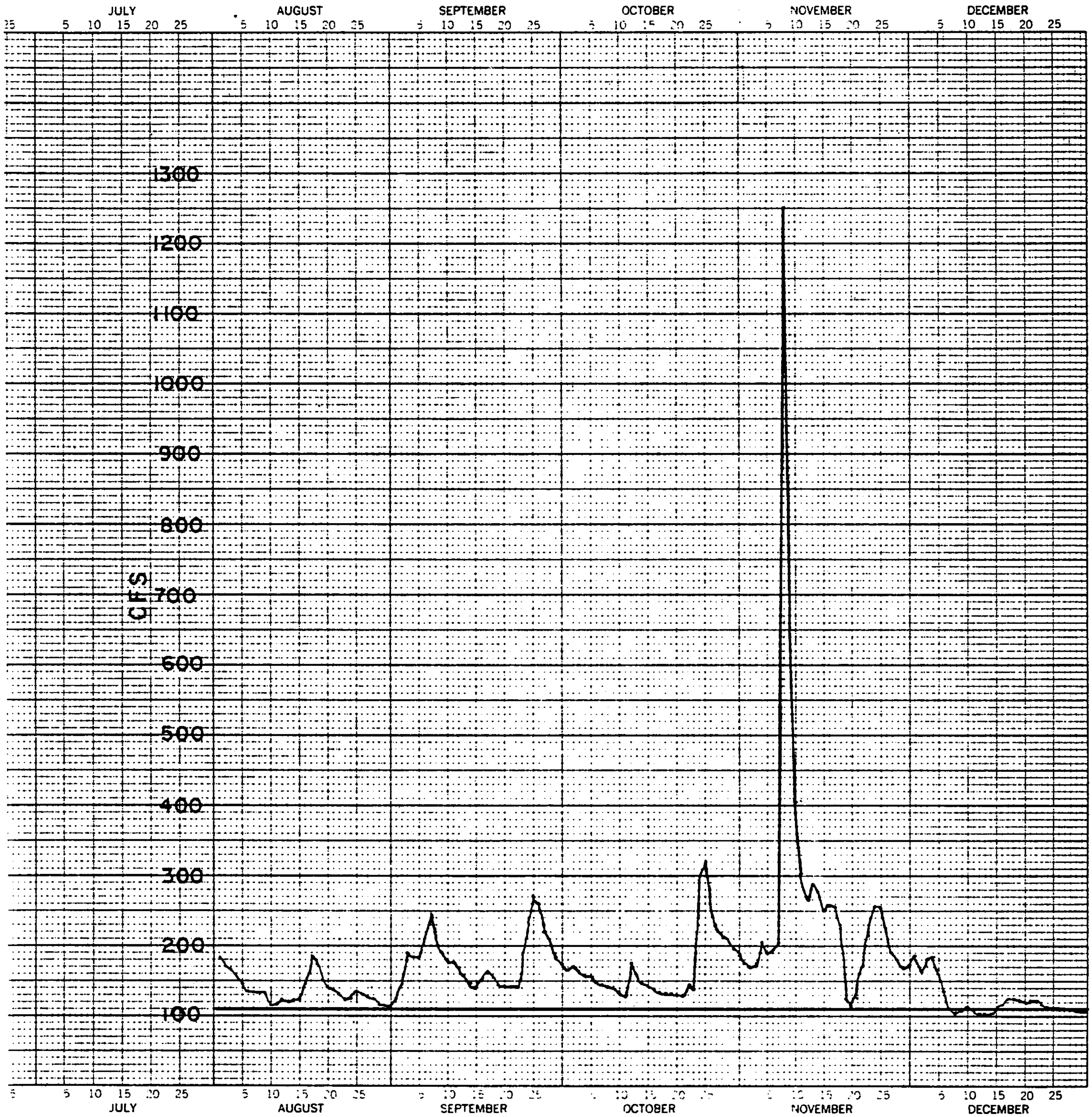
NICOLA RIVER 8 LG 7

1978 FIGURE A27



NICOLA RIVER 8 LG 7

1978 FIGURE A28



APPENDIX B

NICOLA LAKE MANAGEMENT ORDER

NICOLA LAKE

COPY

078766

489B

515 Columbia Street
Kamloops, B. C.

April 21st, 1948

WATER ACT 1939

(SEC. 34)

It having been established by survey that certain Crown Lands are flooded by the raising of the Nicola Lake water level above a certain elevation, and the crops on these said lands suffer if not drained by a certain date, and as the flooding of these lands has been aggravated in the past by the control exercised by the dam at the Nicola Lake outlet constructed under Conditional Water Licence 13594 and held by the Nicola Lake Stock Farms Ltd.:

THEREFORE I ORDER YOU, the Nicola Lake Stock Farms Ltd. to control, as closely as your operations allow, the water level of the Nicola Lake by adjusting the gates in the dam and canal so that the water level of the said lake is not above the 3.00' mark on the gauge established by the Water Rights Branch on the north shore of the said lake immediately East of the dam, and up to this 3.00' mark is allowed between April 1st and July 31st in any year.

AND I FURTHER ORDER YOU, on the 1st of August of each year to fully open the said gates until the water level of the said lake reaches the 2.00' mark on the said gauge and up to this mark is allowed until Sept. 30th of any year.

DATED AT KAMLOOPS this 21st day of April 1948.

Original Signed by..."A. G. Hotton"......
Engineer for the
Nicola Water District

APPENDIX C

SALMON CATCH AND VALUES

TABLE 1: CURRENT AND OPTIMUM SALMONID CATCH AND ANNUAL VALUE FOR NICOLA, COLDWATER AND SPIUS SYSTEM

	Total Catch[4] Pieces		Net Wholesale Value[6] $1982	
	Current	Potential	Current	Potential
Nicola River				
Canadian Commercial[1]	8,283	11,346	161,357	226,534
Sport Tidal[2]	6,288	9,008	182,696	241,727
Sport Fresh[2]	597	840	64,489	90,741
Native Food[5]	627	897	24,375	34,525
U.S. Commercial[7]	2,064	2,716	31,366	46,780
Sport[7]	39	76	1,133	2,208
	17,898	24,883	$465,416	$642,515
Coldwater System				
Canadian Commercial[1]	1,708	4,560	32,535	75,517
Sport Tidal[2]	1,455	3,720	42,274	108,085
Sport Fresh[2]	103	180	11,126	19,444
Native Food[5]	143	360	4,744	9,992
U.S. Commercial[7]	446	1,440	7,319	21,128
Sport[7]	54	240	1,569	6,973
	3,909	10,500	$99,567	$241,139
Spius System				
Canadian Commercial[1]	567	1,506	9,635	28,551
Sport Tidal[2]	466	1,284	13,539	37,306
Sport Fresh[2]	25	90	2,701	9,722
Native Food[5]	46	126	1,326	4,161
U.S. Commercial[7]	173	396	2,586	6,494
Sport[7]	28	48	813	1,395
	1,305	3,450	$30,600	$87,629

Footnotes presented on page 119.

TABLE 2: ESTIMATE OF THE CURRENT AND POTENTIAL SALMON CATCH AND VALUE ASSOCIATED WITH THE NICOLA RIVER

Chinook

Average Escapement (1976-80) 3,320 Current C/E Ratio 4.5:1
Potential Escapement 7,000 Potential C/E Ratio 3:1
Estimated Current Catch 14,940
Estimated Potential Catch 21,000

	Estimated Catch[4] Pieces		Net Wholesale Value[6] $1982	
	Current	Potential	Current	Potential
Canadian				
Commercial[1]	6,575	9,240	149,118	209,574
Sport Tidal[2]	5,976	8,400	173,632	244,062
Sport Fresh[2]	597	840	64,489	90,741
Native[5]	597	840	23,911	33,643
U.S.				
Commercial[7]	1,195	1,680	25,044	35,211
	14,940	21,000	$436,194	$613,231

Coho

Average Escapement (1976-80) 325 Current C/E Ratio 3:1
Potential Escapement 950 Potential C/E Ratio 2:1
Estimated Current Catch 975
Estimated Potential Catch 1,900

	Current	Potential	Current	Potential
Canadian				
Commercial[1]	419	817	4,971	9,692
Sport Tidal[2]	312	608	9,064	17,665
Native[5]	30	57	464	882
U.S.				
Commercial[7]	175	342	2,201	4,301
Sport[7]	39	76	1,133	2,208
	975	1,900	$17,833	$34,748

Pink

Average Escapement (1968-79) 708 Current C/E Ratio 2:8
Potential same as average
Estimated Current Catch 1,983

	Current		Current	
Canadian				
Commercial[1]	1,289		7,268	
U.S.				
Commercial[7]	694		4,121	
	1,983		$11,389	

Footnotes presented on page 119.

TABLE 3: ESTIMATE OF THE CURRENT AND POTENTIAL SALMON CATCH AND VALUE ASSOCIATED WITH THE COLDWATER SYSTEM

Chinook

Average Escapement (1976-80)	572	Current C/E Ratio	4.5:1
Potential Escapement	1,500	Potential C/E Ratio	3:1
Estimated Current Catch	2,574		
Estimated Potential Catch	4,500		

	Estimated Catch[4] Pieces		Net Wholesale Value[6] $(1982	
	Current	Potential	Current	Potential
Canadian				
Commercial[1]	1,134	1,980	25,726	44,909
Sport Tidal[2]	1,029	1,800	29,897	52,299
Sport Fresh[2]	103	180	11,126	19,444
Native[5]	103	180	4,125	7,209
U.S.				
Commercial[7]	205	360	4,289	7,545
	2,574	4,500	$75,163	$131,406

Coho

Average Escapement (1976-80)	445	Current C/E Ratio	3:1
Potential Escapement	3,000	Potential C/E Ratio	2:1
Estimated Current Catch	1,335		
Estimated Potential Catch	6,000		

	Current	Potential	Current	Potential
Canadian				
Commercial[1]	574	2,580	6,809	30,608
Sport Tidal[2]	426	1,920	12,377	55,786
Native[5]	40	180	619	2,783
U.S.				
Commercial[7]	241	1,080	3,030	13,583
Sport[7]	54	240	1,569	6,973
	1,335	6,000	$24,404	$109,733

Footnotes presented on page 119.

TABLE 4: ESTIMATE OF THE CURRENT AND POTENTIAL SALMON CATCH AND VALUE ASSOCIATED WITH THE SPIUS SYSTEM

Chinook

Average Escapement (1976-80)	136	Current C/E Ratio	4.5:1
Potential Escapement	750	Potential C/E Ratio	3:1
Estimated Current Catch	612		
Estimated Potential Catch	2,250		

	Estimated Catch[4] Pieces		Net Wholesale Value[6] $ (1982)	
	Current	Potential	Current	Potential
Canadian				
Commercial[1]	269	990	6,101	22,430
Sport Tidal[2]	244	900	7,089	26,149
Sport Fresh[2]	25	90	2,701	9,722
Native[5]	25	90	1,001	3,604
U.S.				
Commercial[7]	49	180	1,027	3,776
	612	2,250	$17,919	$65,681

Coho

Average Escapement (1976-80)	231	Current C/E Ratio	3:1
Potential Escapement	600	Potential C/E Ratio	2:1
Estimated Current Catch	693		
Estimated Potential Catch	1,200		

	Current	Potential	Current	Potential
Canadian				
Commercial[1]	298	516	3,534	6,121
Sport Tidal[2]	222	384	6,450	1,157
Native[5]	21	36	325	557
U.S.				
Commercial[7]	124	216	1,559	2,718
Sport[7]	28	48	813	1,395
	693	1,200	$12,681	$21,948

Footnotes presented on page 119.

FOOTNOTES FOR TABLES 1 THROUGH 4

1. Commercial methodology outlined in The Economic Rationale for the Salmonid Enhancement Program and Appendices. Appendix 2. Estimation of Commercial Fishery Benefits and Associated Costs for the National Income Account. J. Barclay and R. Morley.

2. Recreational methodology outlined in Appendix 6 of the same report. Appendix 6. Evaluation of Incremental Recreational Benefits from Salmonid Enhancement. A day of salt water sport fishing was valued at $15.00 (1976$) while a day of freshwater chinook fishing was valued at $25.00/day (1976$). One freshwater chinook is estimated to generate 2.5 angler days of effort.

3. The Consumer Price Index was used to adjust values to reflect current dollars.

   1978-79 = 9.1   1979-80 = 10.1   1980-81 = 12.5   1981-82 = 10.5 (expected)

4. Salmonid Catch was allocated to the various fisheries using Production Distribution Tables developed for S.E.P.

5. Salmon caught in the native food fishery have been valued at the highest price associated with "net caught salmon".

6. Net wholesale values are reported for commercially caught species. Harvesting and processing costs have been subtracted from the wholesale value of the salmon.

7. Salmon caught in U.S. are valued at Canadian prices.

TABLE 5: ESTIMATES OF EMPLOYMENT IN THE HARVESTING AND PROCESSING SECTORS GENERATED AS A RESULT OF COMMERCIAL CATCH FROM THE NICOLA, COLDWATER AND SPIUS SYSTEMS[1]

	Person Years of Work at Current Production Levels	Person Years of Work at Optimum Production Levels
Harvesting Sector[2]		
Direct Employment	.28 person years	.52
Indirect Employment	5.83 " "	10.69
Total Employment	6.11	11.21
Processing Sector[3]		
Direct Employment	1.49	2.74
Indirect Employment	2.15	3.97
Total Employment	3.64	6.71
Combined Processing & Harvesting Sectors		
Direct Employment	1.77	3.26
Indirect Employment	7.98	14.66
Total Employment	9.75	17.92

1. Methodology outlined in The Economic Rationale for Salmonid Enhancement Program and Appendices. Appendix 15. Economic impacts Associated with the Salmon Industry in B.C. Acres Consulting Services.

2. It is assumed that 630 person days of harvesting employment are generated for every million lbs. of salmon commercially caught. The multiplier is 21.5. It is also assumed that there are 232 working days in a person year.

3. It is assumed that 3,300 person days of processing employment are generated for every million pounds of salmon commercially caught. The multiplier is 2.45.

APPENDIX D

SUBSTRATE SCALE

APPENDIX D

SUBSTRATE SCALE (MODIFIED WENTWORTH)

Code	Description	Size Range mm. (inches)
1	Silt-clay	0.62
2	Sand	0.62-2
3	Pea Gravel Fine Gravel Medium Gravel	2-16 (.1-.6)
4	Coarse Gravel Very Coarse Gravel	16-64 (.6-2.5)
5	Small Cobble	64-125 (2.5-5)
6	Large Cobble	125-250 (5-10)
7	Boulder	250+ (10+)
8	Bedrock	

Example:

a. Identify dominant material, eg. small cobble (5)

b. Identify subdominant material (if greater than 25% of substrate area), eg. coarse gravel (4)

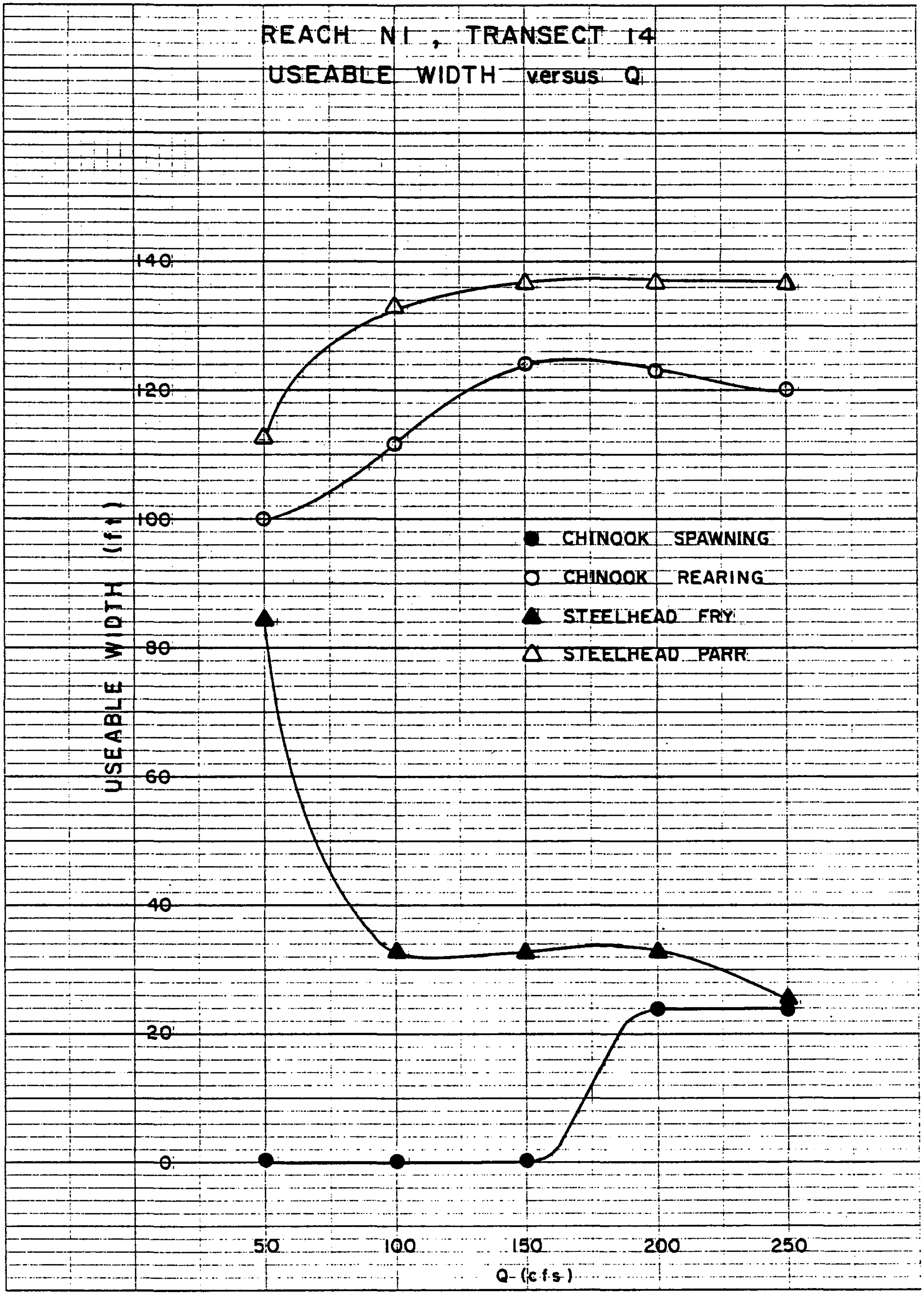
c. Coding for this example would be 5/4

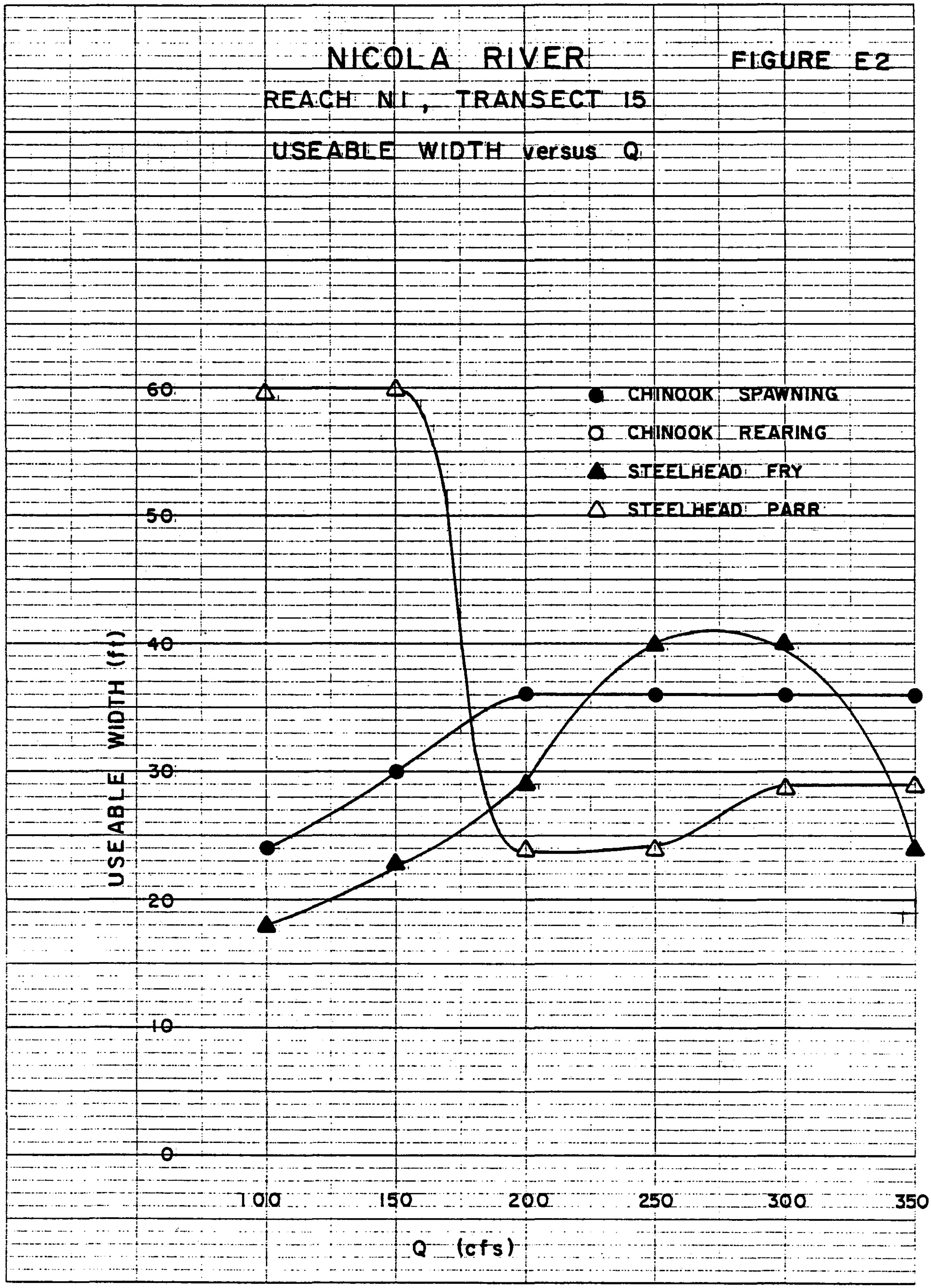
APPENDIX E

USEABLE WIDTH VS. Q FOR TRANSECTS 14-17

NICOLA RIVER

FIGURE E1




NICOLA RIVER
FIGURE E2
REACH N1, TRANSECT 15
USEABLE WIDTH versus Q
CHINOOK SPAWNING
CHINOOK REARING
STEELHEAD FRY
STEELHEAD PARR
USEABLE WIDTH (ft)
60
50
40
30
20
10
0
100
150
200
250
300
350
Q (cfs)

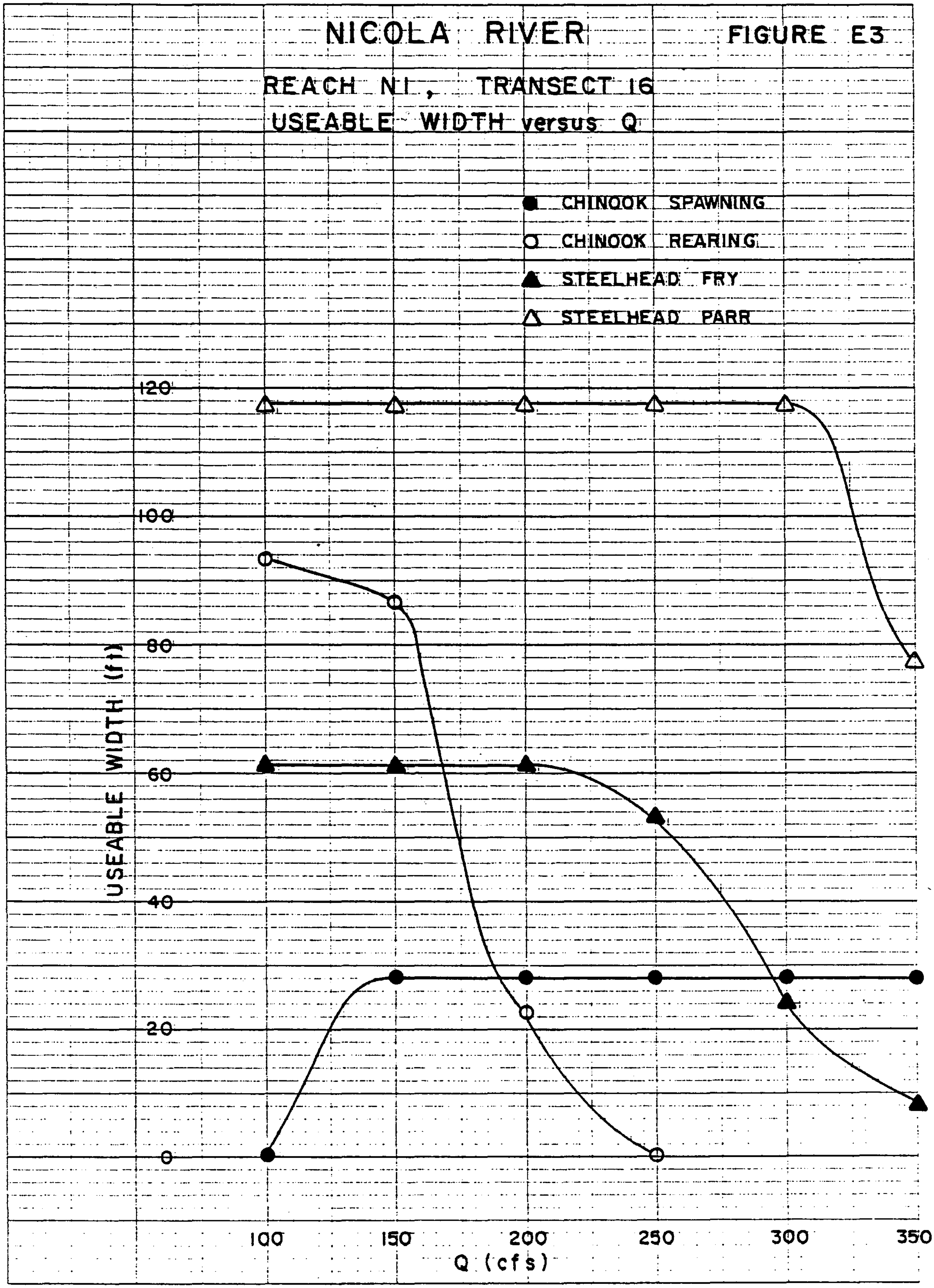
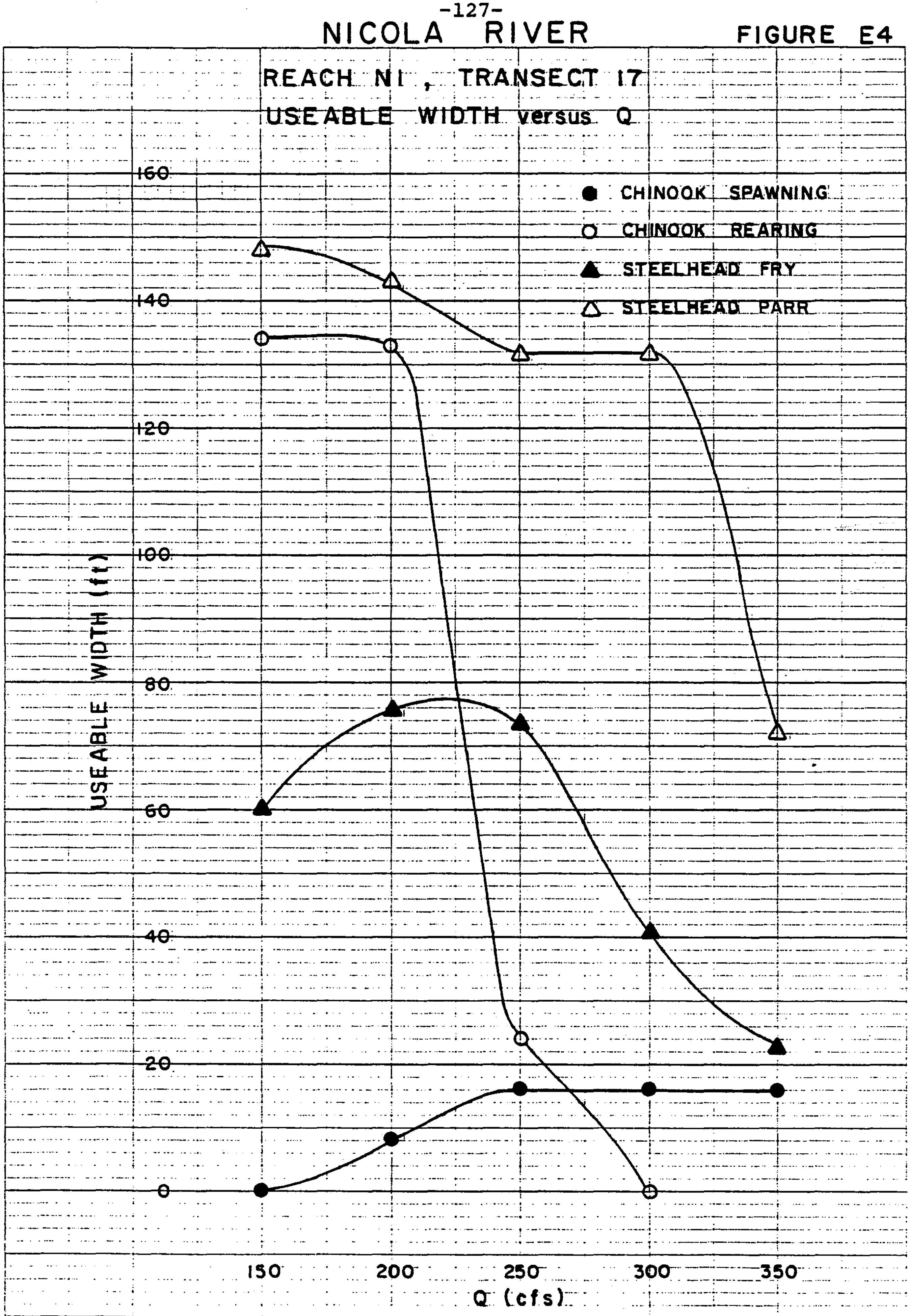

NICOLA RIVER
FIGURE E3
REACH N1, TRANSECT 16
USEABLE WIDTH versus Q
CHINOOK SPAWNING
CHINOOK REARING
STEELHEAD FRY
STEELHEAD PARR
120
100
80
60
40
20
0
USEABLE WIDTH (ft)
100
150
200
250
300
350
Q (cfs)

FIGURE E4


NICOLA RIVER
REACH NI , TRANSECT 17
USEABLE WIDTH versus Q
CHINOOK SPAWNING
CHINOOK REARING
STEELHEAD FRY
STEELHEAD PARR
USEABLE WIDTH (ft)
160
140
120
100
80
60
40
20
0
150
200
250
300
350
Q (cfs)