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16. Abstract

Highway designers are often faced with the need to estimate small watershed runoff during the spring breakup season. During this time, culverts and small bridges are often clogged with ice and snow. In order to provide adequate drainage capacity, designers need an accurate estimate of spring runoff flow. An initial study focused on several alternative ways to estimate spring runoff flows for small basins. The estimation methods were tested on ten drainage basins in Interior Alaska. Two flow characterizations appear to be useful and worthy of further consideration. The first method tabulates the peak of the first significant rise in the stream hydrograph during the spring season. The second method selects the peak flow that occurs anytime during the spring quarter months of April, May or June. The selection process was carried out with the Lotus 1-2-3 spreadsheet program and used the streamflow data base from a CD-ROM. Once the peak flow record was tabulated, the rank order was created and the return period estimated for each flow series value. The results are presented as plots of the four combinations of flow and log-flow vs. return period and log-return period. The results were compared to the standard annual flood series. For most of the test basins the spring quarter peak flows values are very close to the annual flood series. The first seasonal peak series is usually ½ to 1/3 of the other two series. However, several watersheds indicated first seasonal peak values very close to those of the annual and spring quarter values. The log-flow vs. log-return period plot seemed to reveal the most linear relationship, which suggests that the series may be best explained by the log-normal frequency distribution. Further efforts should extend this trial study to other regions of Alaska, fit the data series to standard frequency distributions and develop a regression estimation relationship with the watershed characteristics.

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DETERMINATION OF SNOW MELT FLOOD PEAKS FOR HIGHWAY DRAINAGE DESIGN

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ABSTRACT

Highway designers are often faced with the need to estimate small watershed runoff during the spring breakup season. During this time, culverts and small bridges are often clogged with ice and snow. In order to provide adequate drainage capacity, designers need an accurate estimate of spring runoff flow. An initial study focused on several alternative ways to estimate spring runoff flows for small basins. The estimation methods were tested on ten drainage basins in Interior Alaska. Two flow characterizations appear to be useful and worthy of further consideration. The first method tabulates the peak of the first significant rise in the stream hydrograph during the spring season. The second method selects the peak flow that occurs anytime during the spring quarter months of April, May or June. The selection process was carried out with the Lotus 1-2-3 spreadsheet program and used the streamflow data base from a CD-ROM. Once the peak flow record was tabulated, the rank order was created and the return period estimated for each flow series value. The results are presented as plots of the four combinations of flow and log-flow vs. return period and log-return period. The results were compared to the standard annual flood series. For most of the test basins the spring quarter peak flows values are very close to the annual flood series. The first seasonal peak series is usually ½ to 1/3 of the other two series. However, several watersheds indicated first seasonal peak values very close to those of the annual and spring quarter values. The log flow vs. log return period plot seemed to reveal the most linear relationship, which suggests that the series may be best explained by the log-normal frequency distribution. Further efforts should extend this trial study to other regions of Alaska, fit the data series to standard frequency distributions and develop a regression estimation relationship with watershed characteristics.

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1. INTRODUCTION

This project, "Determination of Snow Melt Floods for Highway Drainage Design," was designed to be conducted in two phases. This final report describes the activity for Phase I. The Phase II portion of work was not completed due to lack of funding. In Phase I, researchers conducted a literature search of methods for determining snowmelt runoff that could be adapted to Alaska. On the basis of the literature search, we decided that most snowmelt studies were tailored for a particular area or required a large amount of input data. Little climatological data is available in most areas of Alaska, and the great regional heterogeneity of the state does not allow a general method to be easily applied to the whole state. We adopted a technique that had been successfully applied in estimating low snowmelt flows for different seasons of the year. Phase I completes the development of the method and illistrates its use on ten watersheds in Interior Alaska.

The objectives of the Phase I work were:

1) Survey present methods of spring runoff calculation both in Alaska and in the Western states. Assess what methods seem to work and what portions need improvement.

2) Carefully delineate the spring flow computation needs of AKDOT&PF hydraulic designers, including size of runoff area, region of the state, precision of the flow estimate, and other pertinent criteria.

3) Develop a straight forward runoff estimation method that works well for a range of

circumstances and can estimate probable degree of error. The method will probably consist of several parts that may or may not be used, depending on the circumstances.

4) Field test the runoff estimation methods with AKDOT&PF hydraulic engineers and adjust the process to better suit their needs.

With the resources available for the Phase I work, we were able to complete most of the first three objectives using a set of test data for several basins in Interior Alaska. The completion of the entire set of objectives for the whole state will require funding of Phase II.

The method for estimating peak spring snowmelt runoff is based on determining the frequency of three types of flow: the first peak of the year, the spring quarter peak flow (April, May and June are appropriate for most regions of the state), and the annual peak flow. The annual peak flow is used for comparison purposes because many other studies have been done on this flow value and a quantity of comparable data is available.

We developed an algorithm that allows an examination of peak flow for each year for all three series. Since the data is read directly from a CD-ROM drive, the process can quickly access information from any area of the state. For example, a design engineer may need to understand the spring snowmelt flood frequency regime for a area bounded by a set of latitude and longitude lines. The software supplied by the CD-ROM vendor and the spreadsheet algorithm developed during this project phase allows a search, analysis and display of information for all watersheds of a specified size within the area of interest. We eventually plan to develop a regression relationship for predicting flow based on watershed characteristics.

The analysis method is illustrated in Figures A, B, and 1 (a) to 10 (d). Four different methods of plotting the flow-frequency relationship are shown for each of ten Interior Alaska basins. Apparently the log flow : log frequency presentation is the most useful.

2. SURVEY OF PRESENT METHODS

This section presents the results of the task activity aimed at determining the current status of design procedures for snowmelt floods at drainage crossings of highway routes. It includes a brief summary of the current methods and suggestions for the remaining research plan. As a preliminary report, the material was circulated to AKDOT&PF hydraulic engineers for comments and guidance of the remaining research program.

A search of recent literature of the past ten years revealed several articles that may be of interest to the project. These are briefly summarized below generally in order of relevance.

1. Bengtsson and Westerstrom, "Urban Snowmelt and Runoff in Northern Sweden." This article's main conclusion is that urban watersheds show increased snowmelt rates but less infiltration. There is some comparison to runoff rates. Very small drainages were used in this study. Sixteen references.
2. Rango and van Katwijk, "Development and Testing of a Snowmelt-Runoff Forecasting Technique." The researchers have developed the Snowmelt-Runoff Model (SRM) to estimate snowmelt and subsequent runoff from mountain basins where snowmelt is the major source of streamflow. The main application has been to water supply forecasts in western U.S. mountain regions. SRM requires remote sensing data for parameter development. The model may be too complicated for our purposes, but it contains some useful ideas. Seven references.

3. Rango, "Progress in Developing an Operational Snowmelt-Runoff Forecast Model with Remote Sensing Input." This paper reports on an effort to extend the SRM to operational real time flood forecasting, and is limited use at this time. Ten references.

4. Sogaard and Thomsen, "Satellite Data for Monitoring Snow Cover." This effort is very similar to that by Rango et al. Again, some interesting ideas but probably no direct application to AKDOT&PF needs. Eleven references.

5. Bengtsson, "Movement of Meltwater in Small Basins." This is a very solid paper on the description of component processes in the snowmelt runoff season. Some ideas could be adapted to the use of HEC-1 for our problem. Eleven references.

6. Buttle and Xu, "Snowmelt Runoff in Suburban Environment." This article reports on a comparative study of two rural and suburban watersheds and uses both field data and a fairly complex snowmelt runoff simulation model. Their model is probably too complex for AKDOT&PF needs, but it does illuminate the importance of hydrologic processes. Thirty-four references.

7. Martinec, "Snowmelt Runoff Models for Operational Forecasts." This report is very similar in direction by those Rango mentioned above. No direct application is apparent, but maybe we should keep in mind the use of satellite data for this project. Seven references.

8. Bengtsson, "Characteristics of Snowmelt Induced Peak Flows in a Small Northern Basin." This article presents the results of several years of study from a small research watershed in northern Sweden. The project compares the results of runoff events from

snowmelt and rainfall for open and wooded areas. It also has a good discussion of other studies in other countries and of theoretical concepts. This report will be useful in adaptating HEC-1 to our work. Twenty-six references.

2.1 Summary of Literature Review

These references represent available literature that may be useful to this study. Of the many snowmelt-related reports, only a small portion are applicable to engineering design studies for highway drainage crossings. The eight papers referenced will be primarily useful from a conceptual point of view. At this time we have found no previous work that is directly applicable to our research plan.

2.2 Study Outline and Delineation of Flow Computation Method

At the completion of the survey of literature, we planned to proceed with the study along the same paths outlined in the original proposal plan which follows:

1) We will develop a flood frequency analysis for the spring break-up season of April, May and June. The project will concentrate on small basins normally served by culverts. The results will be much like a low flow frequency study completed several years ago. The results will be compared to the annual flood frequency relationship established by the United States Geological Survey (USGS).

2) We expect that results from the spring breakup flood frequency analysis will be suitable for most regional designs. However, extracting the peak spring flood flow for each year and subjecting the resulting data series to a standard frequency analysis would yield more

precise results. This method is more time intensive, since each hydrograph must be visually examined. We later developed a way to program the selection point for the beginning of spring flow with a visual check as backup. This method is only possible through the use the streamflow data on CD-ROM available to the project. The data extraction technique is illustrated in Figures A and B (Appendix A). The full frequency analysis must await a future funded project.

3) The full two year project also intended to investgate a method that would be applicable in areas outside of the data set on which the two regression methods are available. Here we will attempt to apply the HEC-1 snowmelt routine to spring runoff prediction. The challenge will be to specify the appropriate model parameters and develop a useful frequency relationship.

4) Each of the three methods will be developed initally for several stream basins in interior Alaska, and then for others in South Central Alaska. Following this activity, the technical advisors will be consulted and a path will be chosen for the remainder of the study.

After the original research plan was revised , the study proceeded with the following activities:

1) We acquired a CD-ROM based streamflow data series for all USGS Alaskan surface water data through the 1993 water year. This data base method allows for nearly instant retrieval of streamflow data on a PC computer. Using vendor-supplied software as well as our own, we retrieved data by basin, drainage area size, location, year and season. First

we selected the desired data base, loaded it into the Lotus 1-2-3 package, then plotted the streamflow hydrographs. The final product is illustrated in Figures A and B (Appendix A). These plots are easily made and give a good interpretive sense of the nature of the spring runoff compared to runoff at other times of the year.

2) We analyzed several small basins in interior Alaska for the following data series:

a) The annual flood peak based on the entire water year. This is the most commonly used series, and it forms the basis for comparison of other series.

b) The annual flood peak based on the spring quarter (April, May and June). This spring quarter includes the spring runoff in most areas of the state. The time period could easily be adjusted to a more suitable period if necessary.

c) The first peak of the spring. This flow determination is a new experimental data series. It indicates the earliest flow that may be significant while the culverts and small bridge openings are still full of ice and snow.

Each of the three data series are extracted for each year of record. The flow determination results for several interior streams appear in Figures 1 (a) to 10 (d) (Appendix A).

3) Once the three data series are formed for each stream, the following analysis steps may be followed to complete a spring runoff data analysis:

a) The data series is ranked and the return period plotting position is calculated for each value. The flood frequency determination will be eventually based on the log-normal distribution. In this preliminary analysis we used four combinations of flow, log-flow, return period and log-return period plots to show the general nature of the relationship. In the Phase II study, the theoretical and plotted values will be compared for each of the three series on a single plot. Other analysis will be conducted to determine if there is a consistent ratio relationship between the three data series for various return periods, basin areas and other basin characteristics.

b) Once the overall study is finished, the data will be normalized with division by the mean flood value. The normalized data can then be compared to determine an appropriate regionalized flood frequency curve along with other regionalization methods.

3. CONCLUSION

This exploratory study attempted to find a way of describing peak streamflow values in the spring season. During this season, many small drainage structures are blocked with snow and ice and accurate flow information is necessary to estimate an accurate flow capacity. The standard flood peak estimation procedure gives a value irrespective of the time of the year and the relationship to the spring runoff values is uncertain. Hydrologic designers and roadway engineers needed a new data series developed that would give more accurate values during the spring breakup season.

We examined two data series: that defined by the first significant peak of the spring and that defined by the highest flow of the spring calender quarter of April, May and June. Each has its advantages and drawbacks. The first peak of the year usually occurs much earlier than the spring quarter peak and, therefore, should give a more accurate indication of flow when the drainage structures are likely to be blocked. On the other hand,. the first peak data must be subjectively defined and is more difficult to program for extraction from the streamflow data series. The spring quarter series is easy to objectively define and extract, but it gives values that occur much later in the spring. By the time of occurrence, much of the snow and ice blockage may be melted.

The results presented in Figures 1 (a) - 10 (d), Appendix A show that, for most basins, the spring quarter series varies little from the annual flood series used for comparison. Thus, the series is providing little new information. The first peak of the season data, on the other hand, has flow values that are only ½ to 1/3 of the other two series for most of the basins. This information suggests that drainage structures may be sized for considerably less flow and still accommodate the snow and ice blockage.

The data extraction procedure was automated with spreadsheet programming, as illustrated in Figures Aand B (Appendix A). The procedure could be extended to larger data series for basins throughout Alaska. The final step would be to characterized the flow return period relationship and establish a regression estimation procedure with the basin characteristics. The linear relationship shown by the log flow-log return period plots suggests that the data series could be characterized by a log normal frequency distribution.

The data analysis procedure, when fully implemented, would allow the hydrologic designer to choose the appropriate data series sets for a given region, examine the streamflow hydrographs, conduct the first peak of the year analysis and compare the results to regression equations of previous studies. She or he could then estimate the appropriate flow spring breakup flow value for a given drainage site.

APPENDIX A

ANALYSIS AND RESULTS

Appendix A: Flood Analysis Procedure

The procedure utilized in analysis of runoff is outlined below:

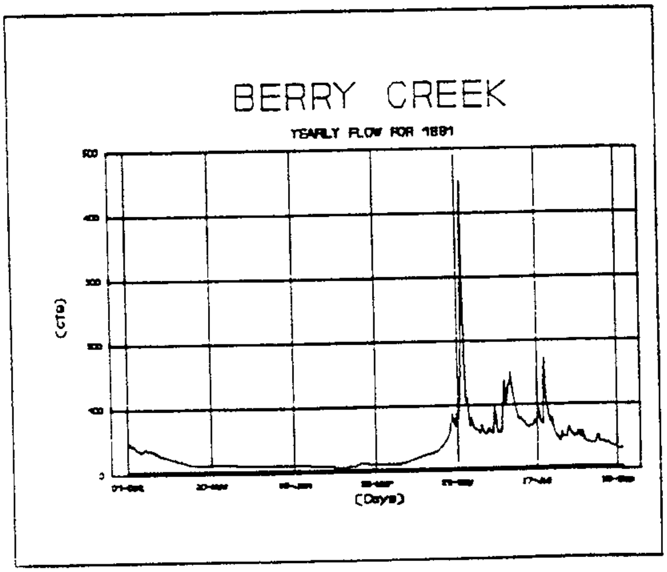
USGS Data Records
The USGS streamflow data is available for all gaging stations in Alaska on CD-ROM. This data can be extracted into a spreadsheet format for all years of record for any particular USGS station Id. The data is next imported into a Lotus 123 master worksheet.

Master Worksheet File
The master worksheet file is subdivided into the following areas:

Master Screen
The master screen area consists of a window area that includes the filename, year of analysis, yearly totals for the highest peak flow with associated date, spring quarter totals for highest peak flow with associated date and first peak flow with associated data. Visual representation of the data is supplied in an adjacent graph window. This window allows the operator to visually analyze the data for accuracy during runtime. The yearly data is graphed first, followed by a graph for the spring quarter. The time allotted to visualize the graphs can also be altered to enhance analysis.

MASTER SCREEN AREA

FileName	BERRY.WK3
Yearly Totals	YEAR
Evaluation Year	1981
Highest Peak Flow	450
Date Highest Flow	02 Jun
	Spg Qtr
First Peak Flow	88
Date First Peak Flow	25-May
Highest Peak Flow	450
Date Highest Flow	01-Jun
First Year of Data	1971
Last Year of Data	1981
Graph Time (sec):	5



Data Base

The imported data is stored in the master worksheet as an internal dBase. The dBase automatically sizes itself to meet the diversity of recorded years from different USGS gage stations. The dbase consists of all streamflow records for the particular station sorted by year and day.

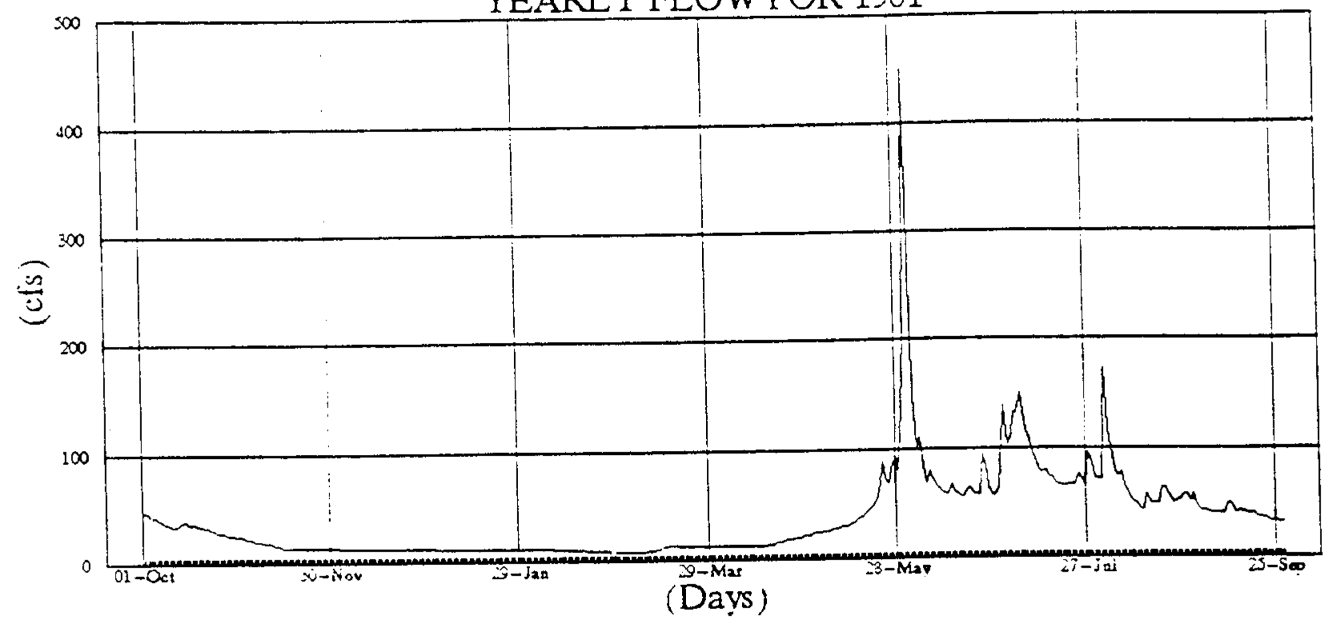
Algorithms

The master worksheet consists of numerous algorithms that analyze for maximum yearly flow rate with associated date, maximum spring quarterly flow rate with associated date, and first spring quarter peak flow rate with associated date. The algorithms include error trapping to prevent erroneous data transfer and lockup of computer hardware.

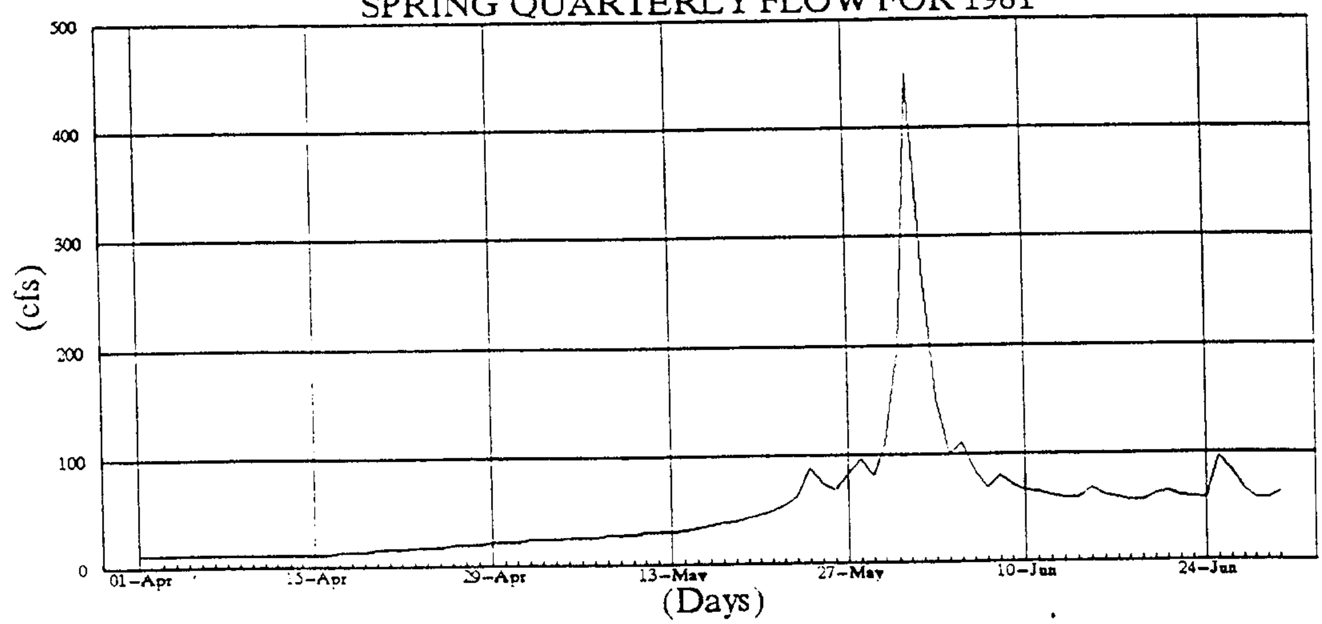
Reports

The data and graph windows discussed above are named and stored within the masterwork sheet in a report area. This report area can easily be printed for the analysis year. The data is also stored in a summary dBase which allows printing analyzed data for all the record years.

BERRY CREEK
YEARLY FLOW FOR 1981



BERRY CREEK
SPRING QUARTERLY FLOW FOR 1981

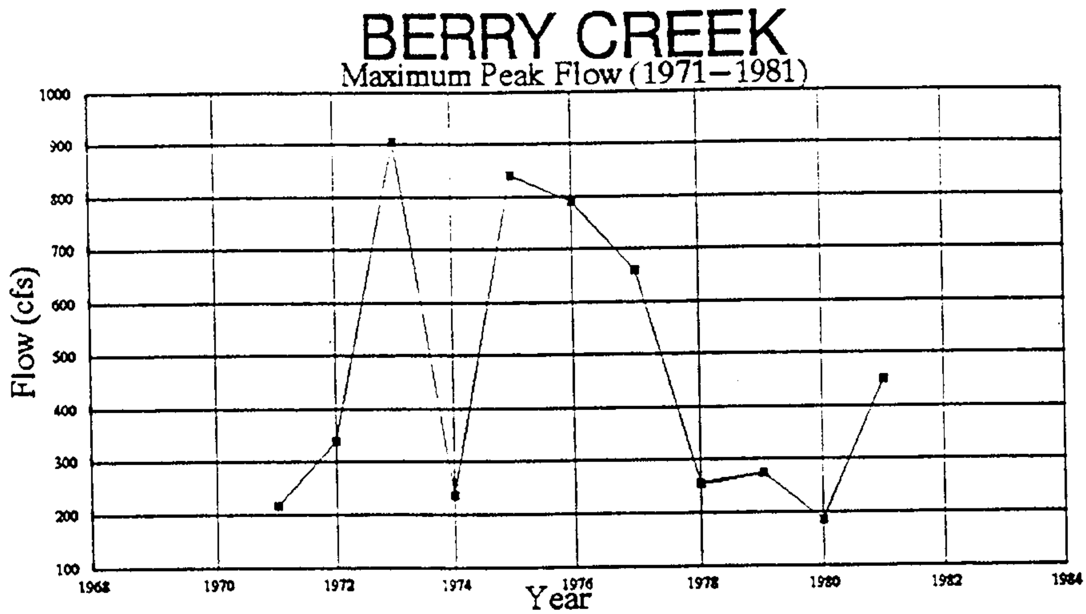


FileName:	BERRY.WK3
Yearly Totals	YEAR
Evaluation Year	1981
Highest Peak Flow	450
Date Highest Flow	02-Jun-92
Spg Qtr Totals	
First Peak Flow (cfs)	88
Date First Peak Flow	25-May-92
Highest Peak Flow	450
Date Highest Flow	01-Jun-92

Figure A

BERRY CREEK ANALYSIS: 1971–1981

Yearly Totals	Evaluation Year	Highest Peak Flow	Date Highest Flow	Qtr	First Peak Flow	Date First Peak Flow
YEAR	1971	217	14–Aug	Spg Qtr	0	NA
YEAR	1972	340	27–May	Spg Qtr	300	20–May
YEAR	1973	904	09–Jun	Spg Qtr	140	06–May
YEAR	1974	235	30–Jun	Spg Qtr	210	22–May
YEAR	1975	841	04–Jun	Spg Qtr	400	22–May
YEAR	1976	790	10–Jun	Spg Qtr	120	02–May
YEAR	1977	659	22–Jun	Spg Qtr	200	18–May
YEAR	1978	256	29–May	Spg Qtr	40	28–Apr
YEAR	1979	274	02–Aug	Spg Qtr	200	03–May
YEAR	1980	185	17–Jul	Spg Qtr	43	28–May
YEAR	1981	450	01–Jun	Spg Qtr	88	25–May



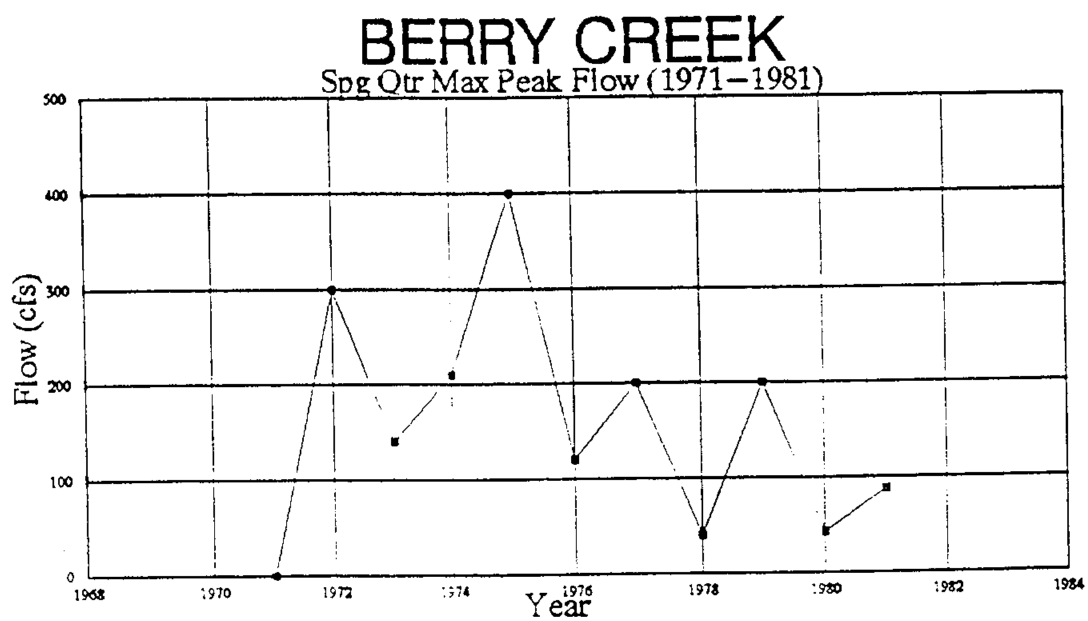
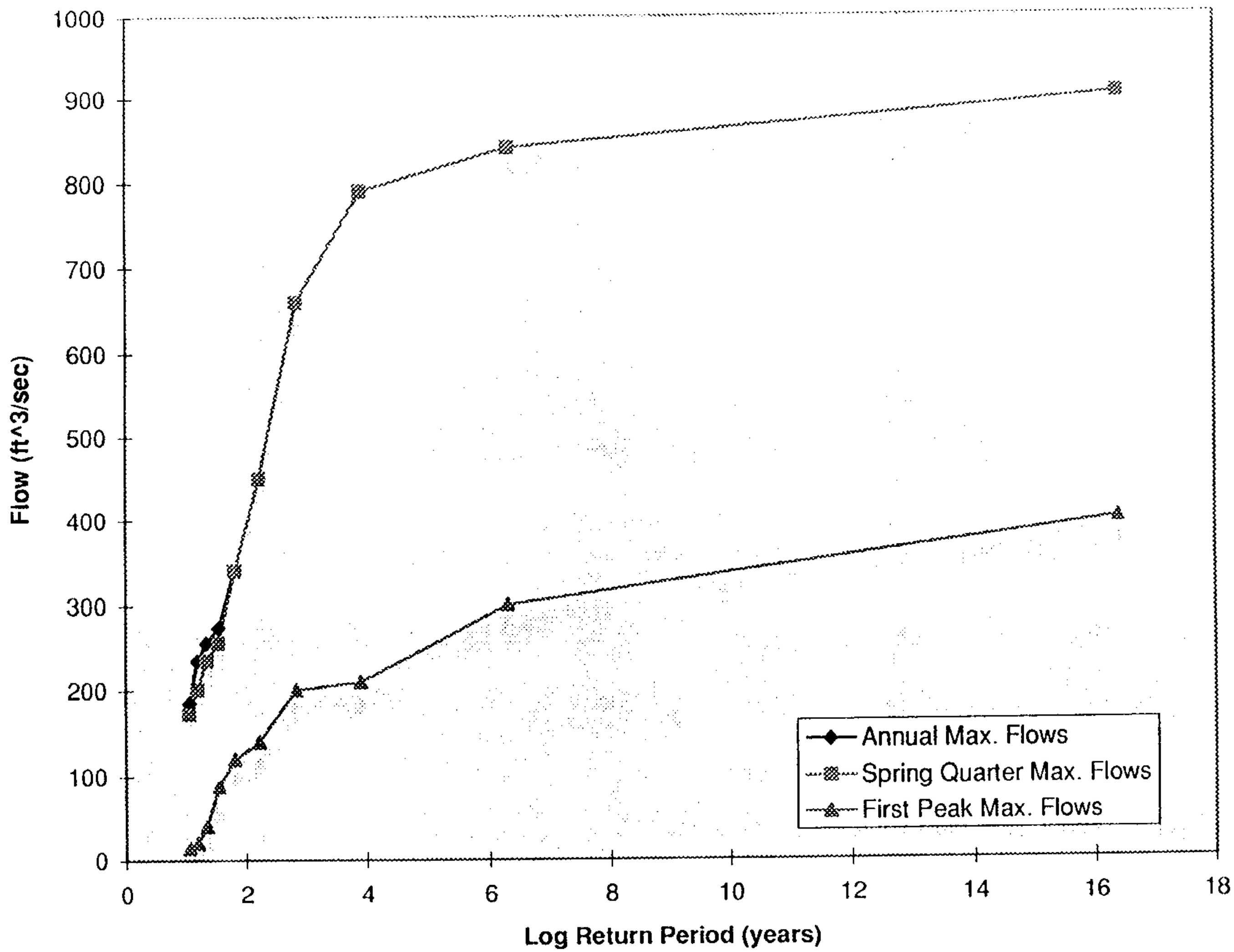
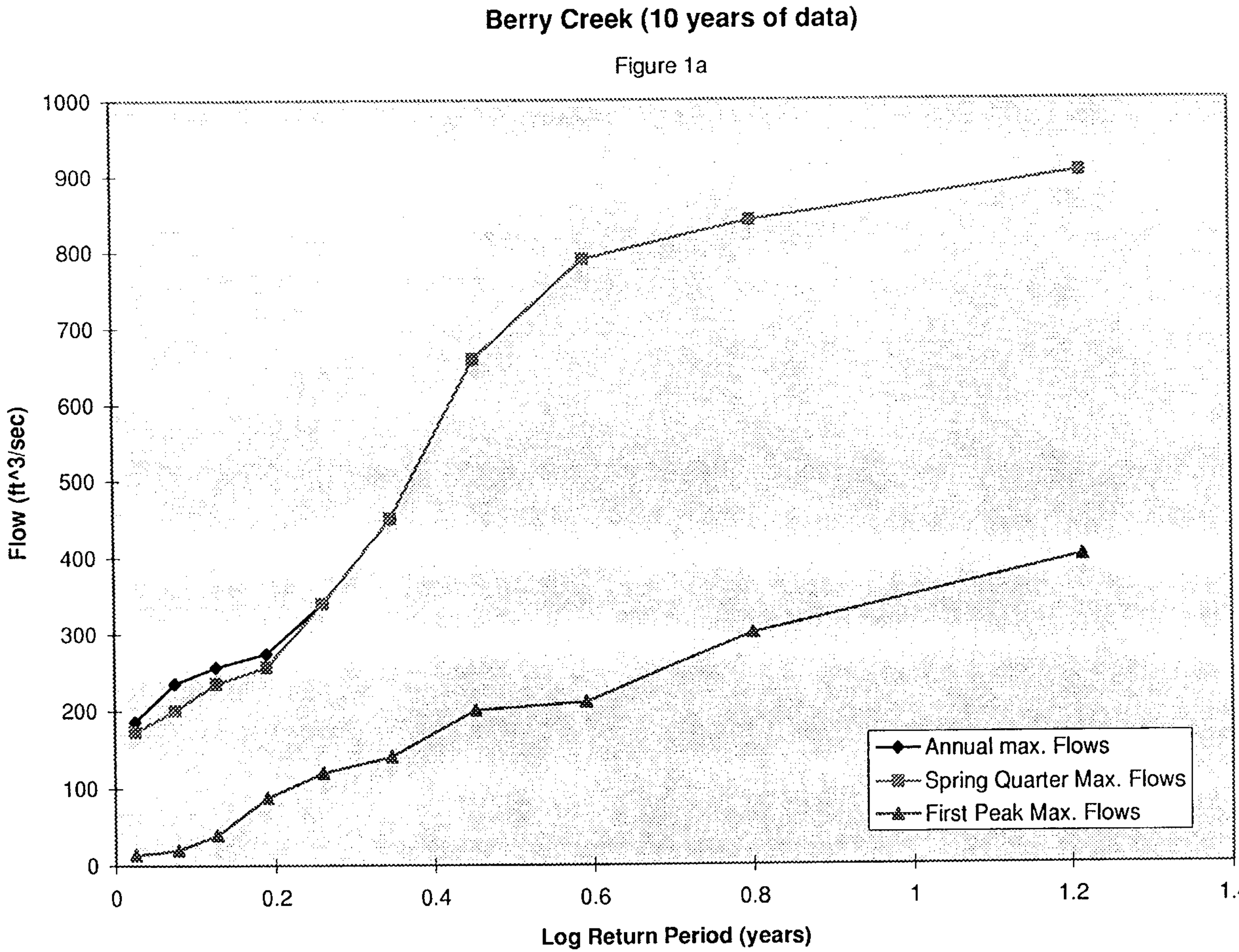


Figure B

Berry Creek (10 years of data)

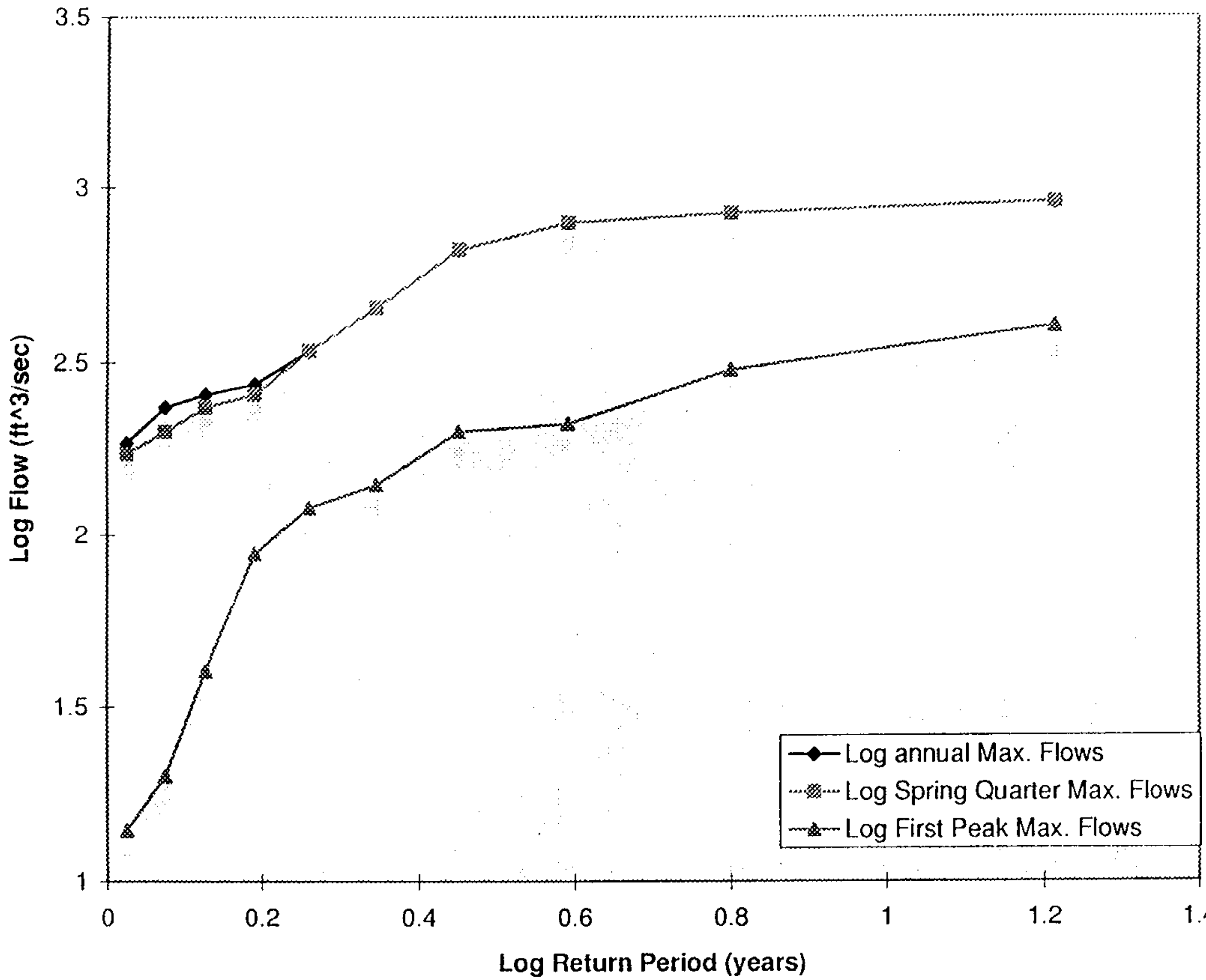
Figure 1

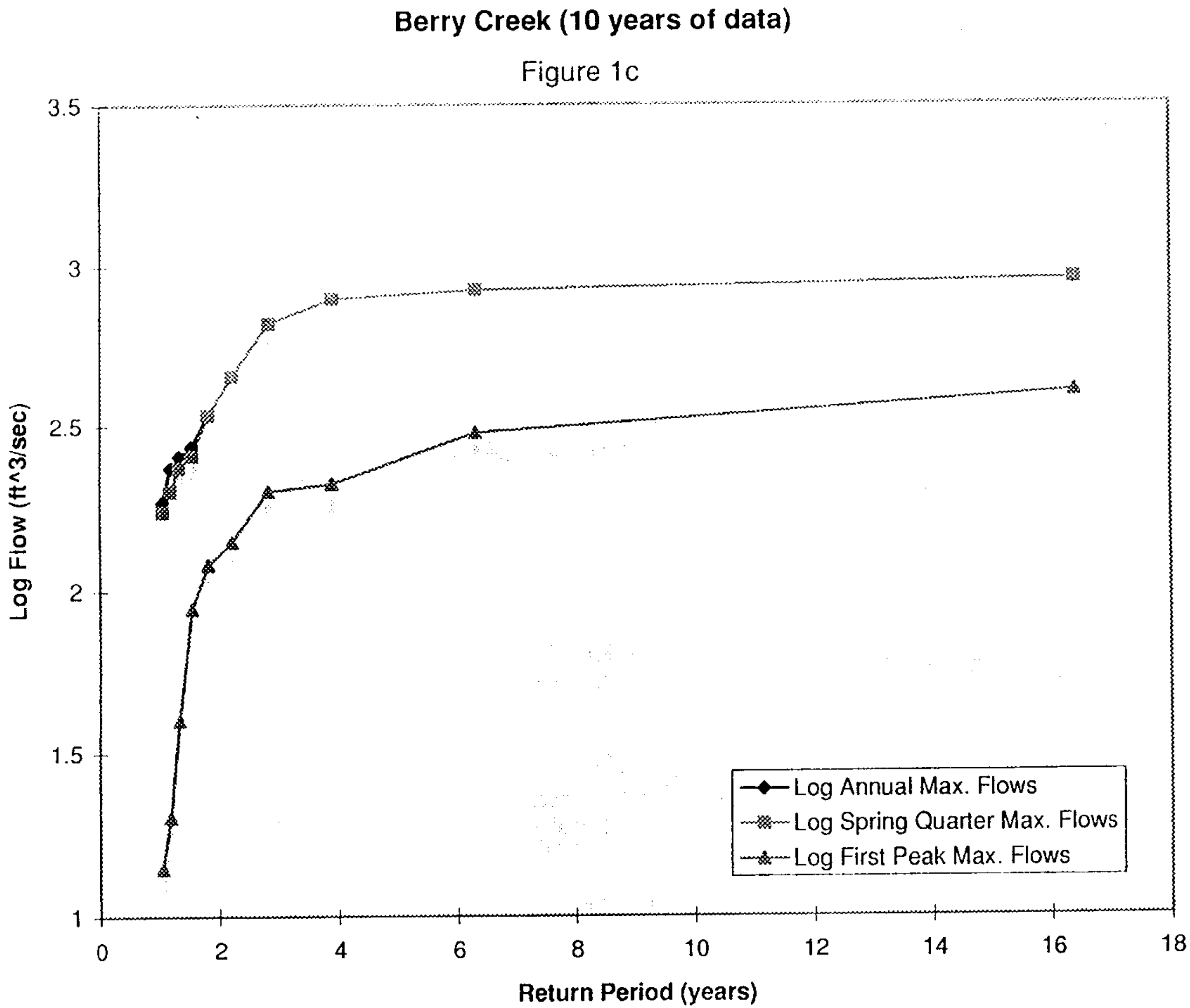



Berry Creek (10 years of data)
Figure 1a
1000
900
800
700
600
500
400
300
200
100
0
Flow (ft^3/sec)
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Log Return Period (years)
Annual max. Flows
Spring Quarter Max. Flows
First Peak Max. Flows

Berry Creek (10 Years of data)

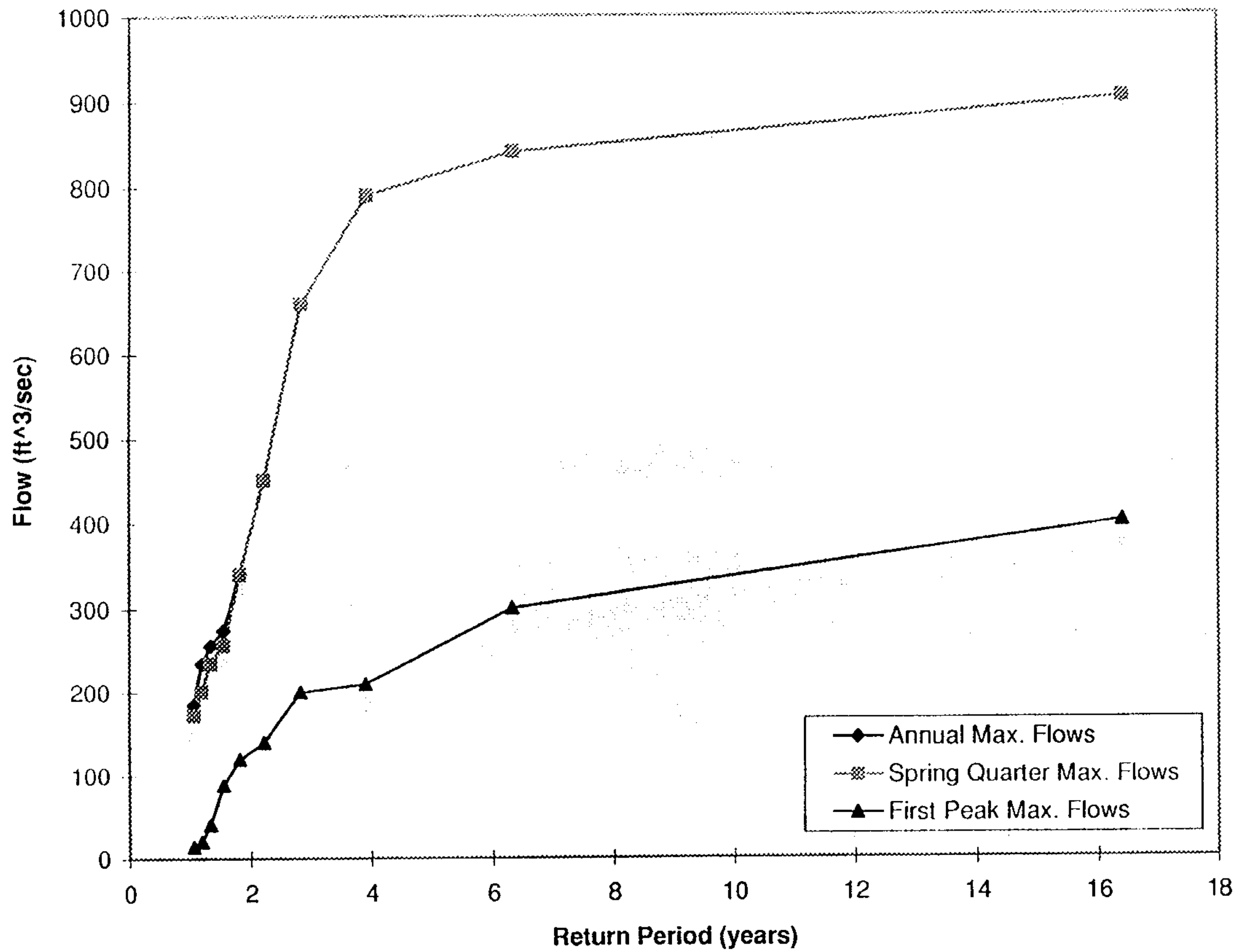
Figure 1b




Berry Creek (10 years of data)
Figure 1c
Log Flow (ft^3/sec)
3.5
3
2.5
2
1.5
1
0
2
4
6
8
10
12
14
16
18
Return Period (years)
Log Annual Max. Flows
Log Spring Quarter Max. Flows
Log First Peak Max. Flows

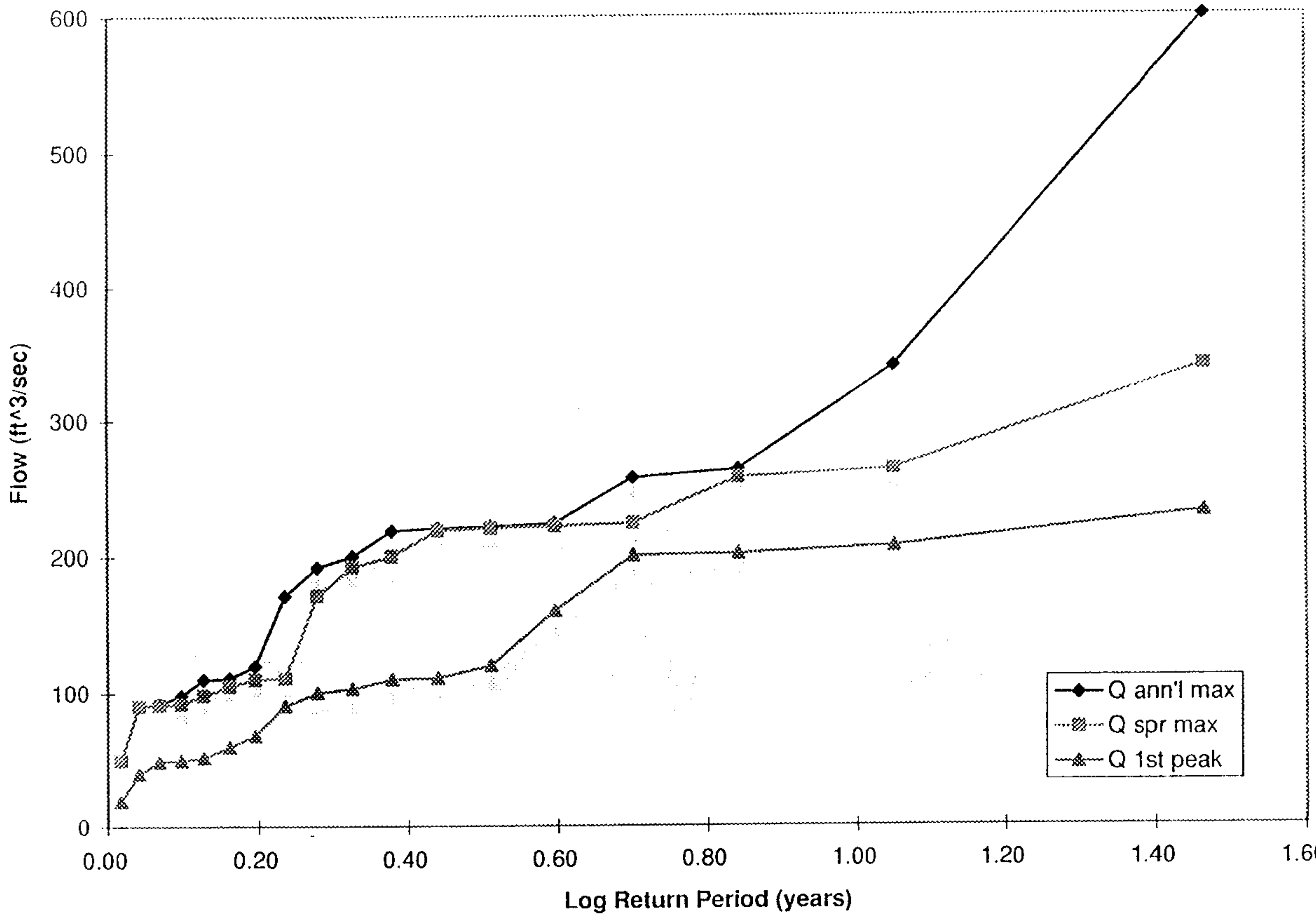
Berry Creek (10 years of data)

Figure 1d



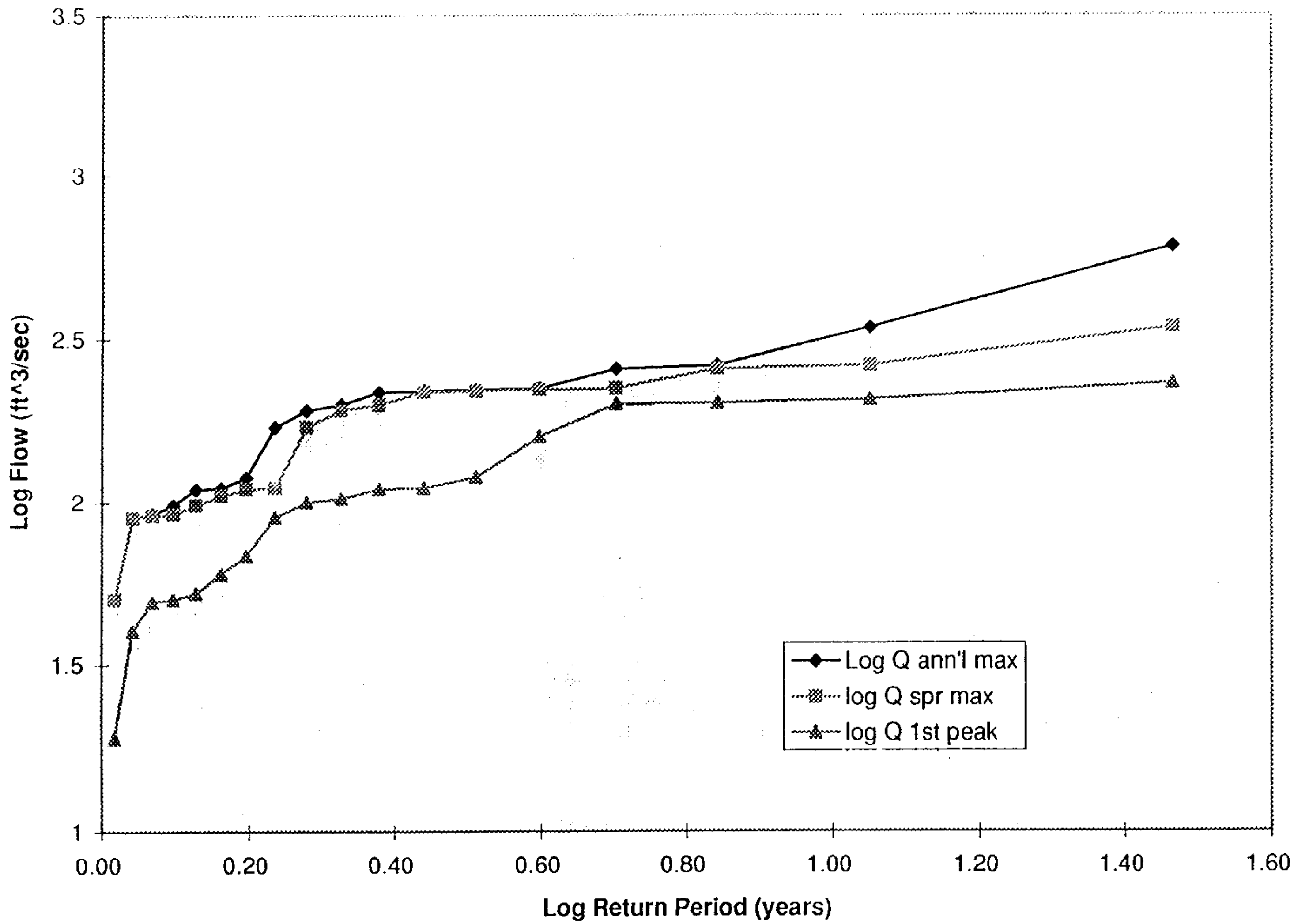
Boulder Creek (18 Years of data)

Figure 2a



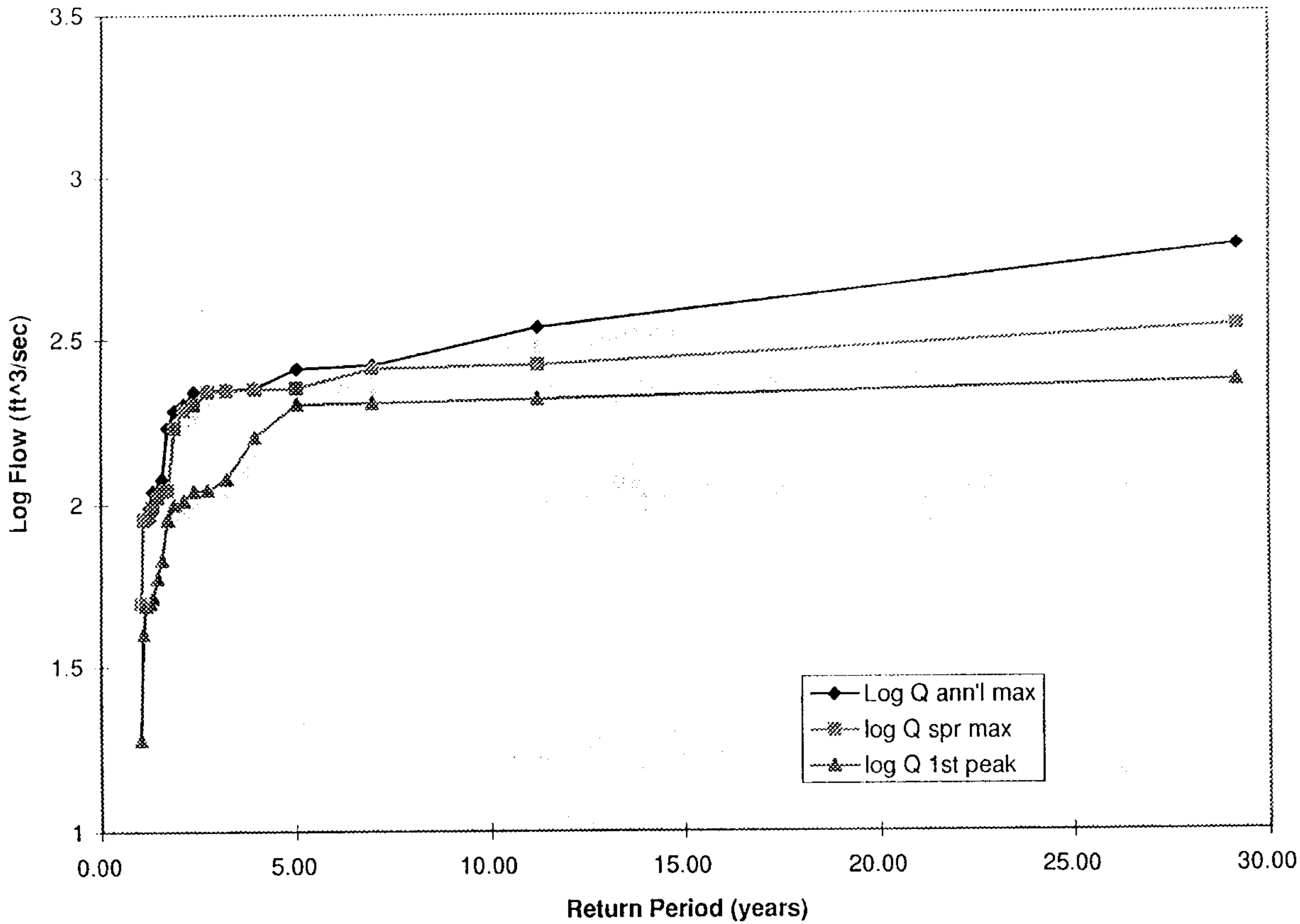
Boulder Creek (18 years of data)

Figure 2b



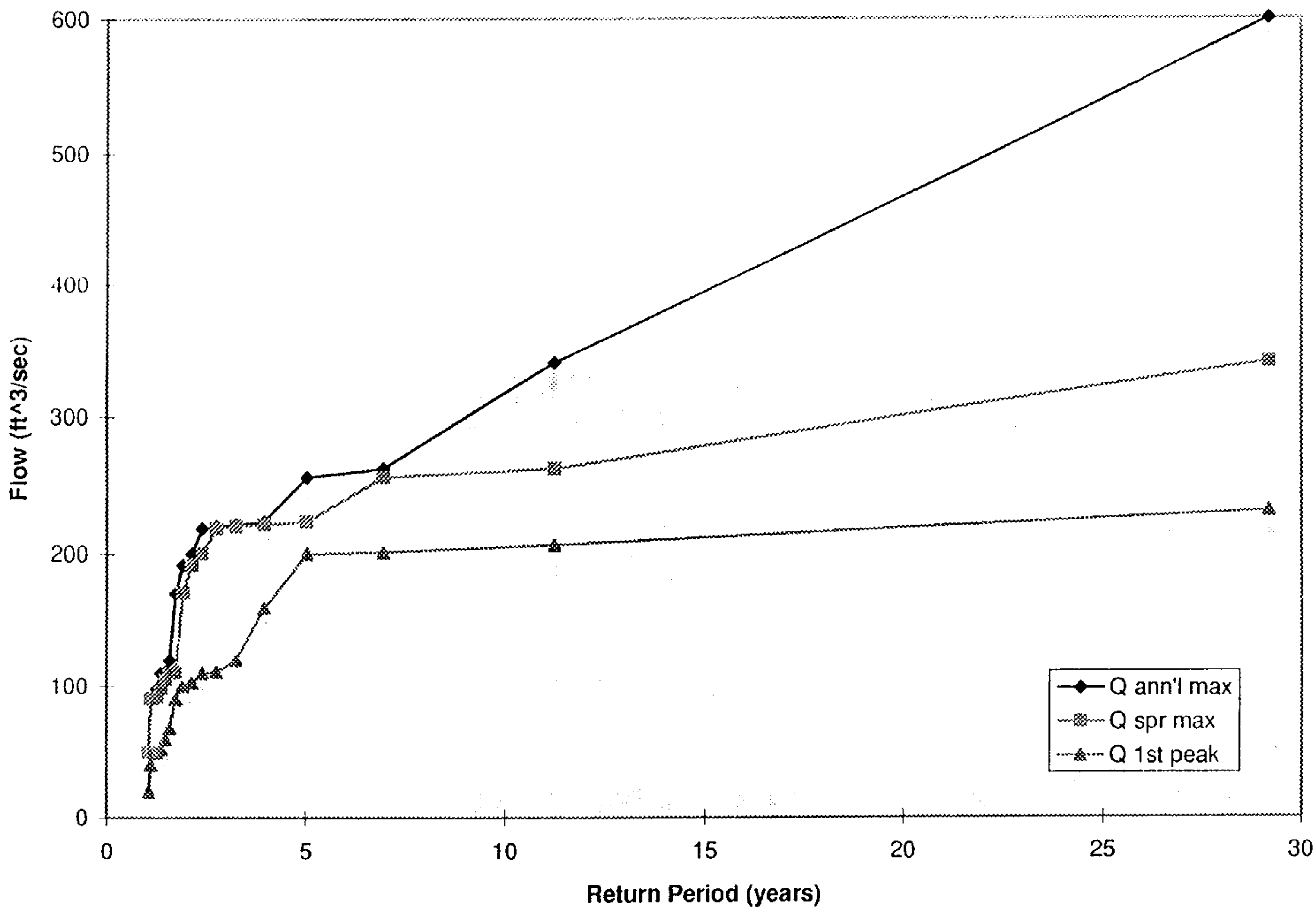
Boulder Creek (18 years of data)

Figure 2c



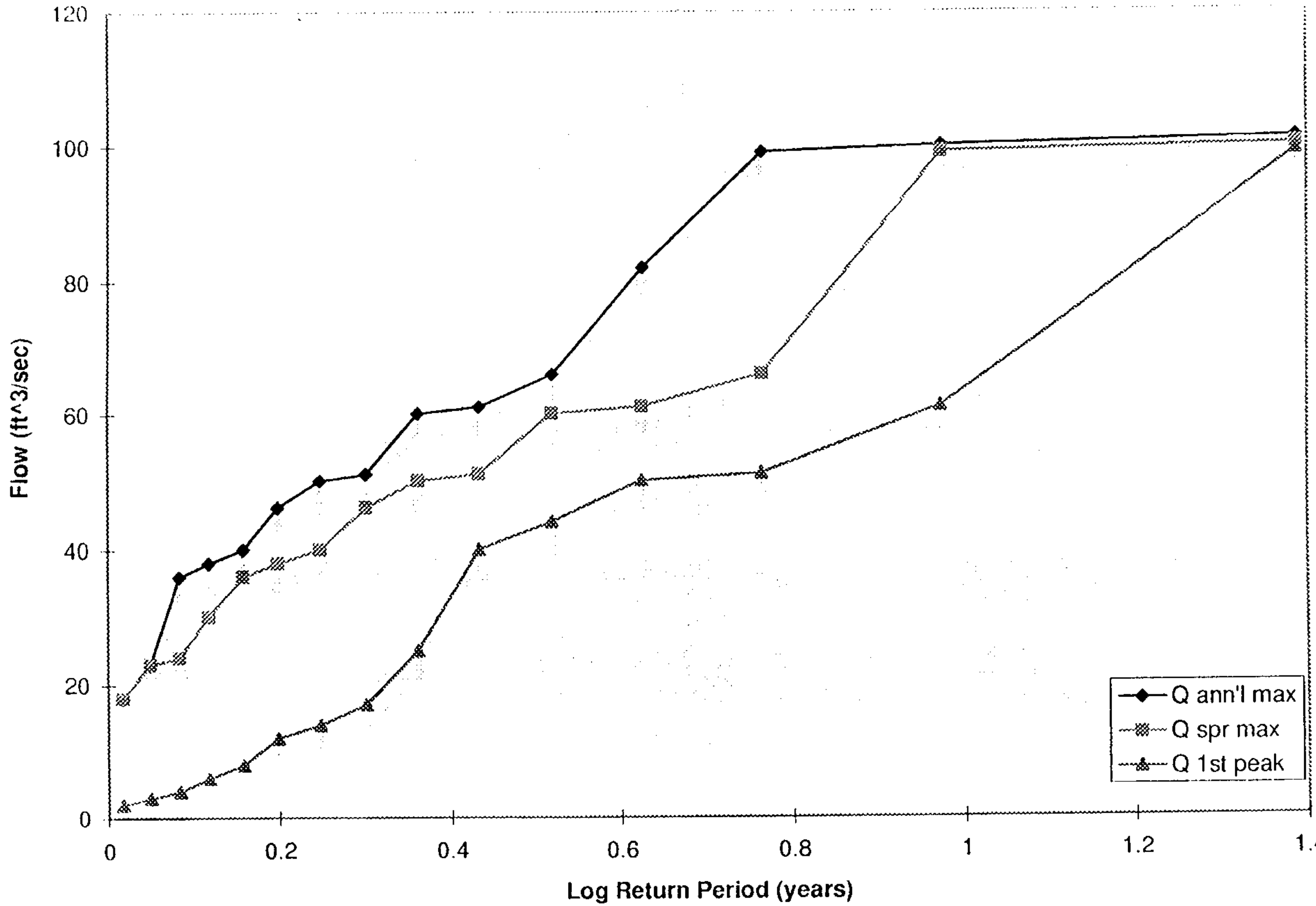
Boulder Creek (18 years of data)

Figure 2d



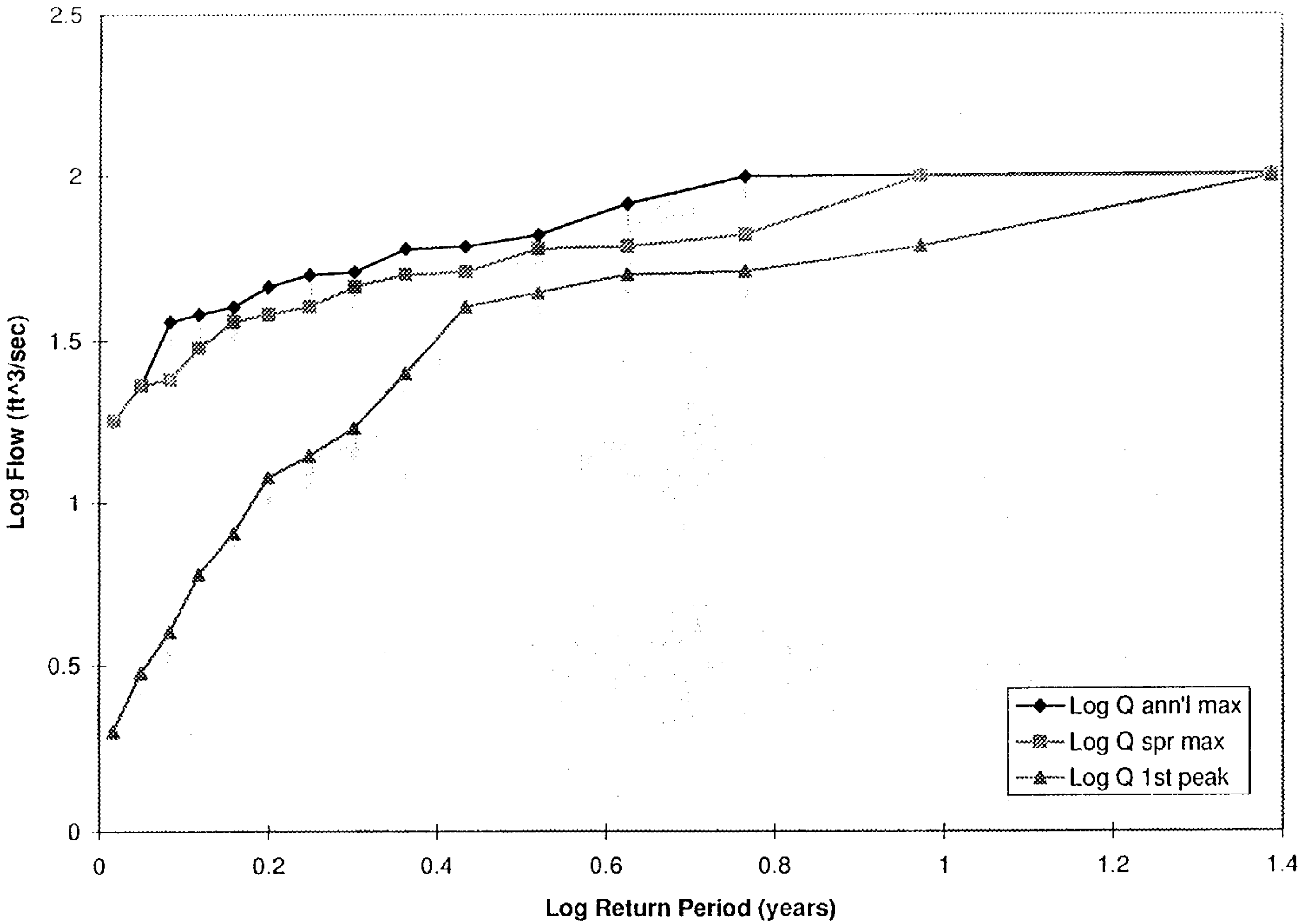
Caribou Creek (15 years of data)

Figure 3a



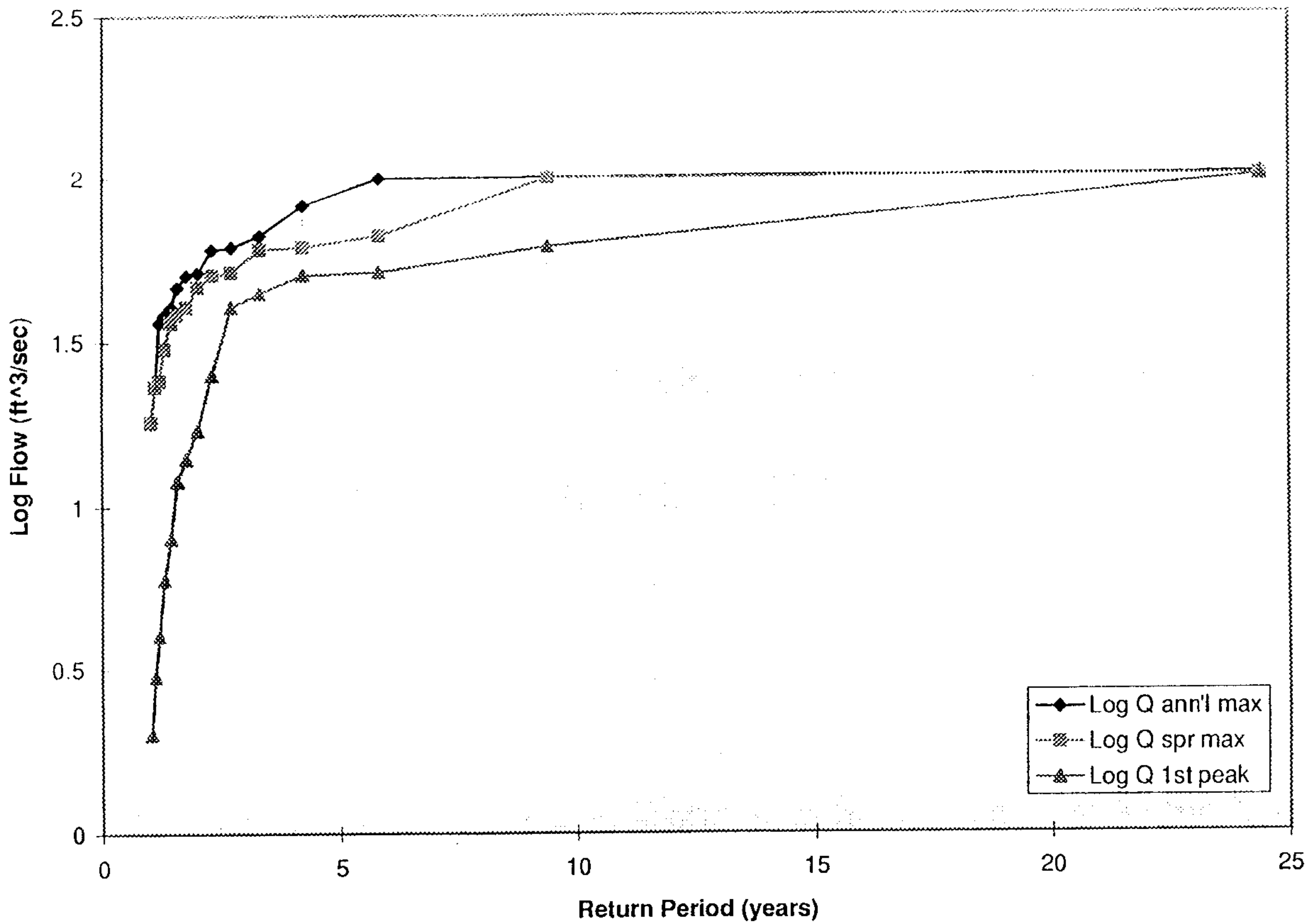
Caribou Creek (15 years of data)

Figure 3b



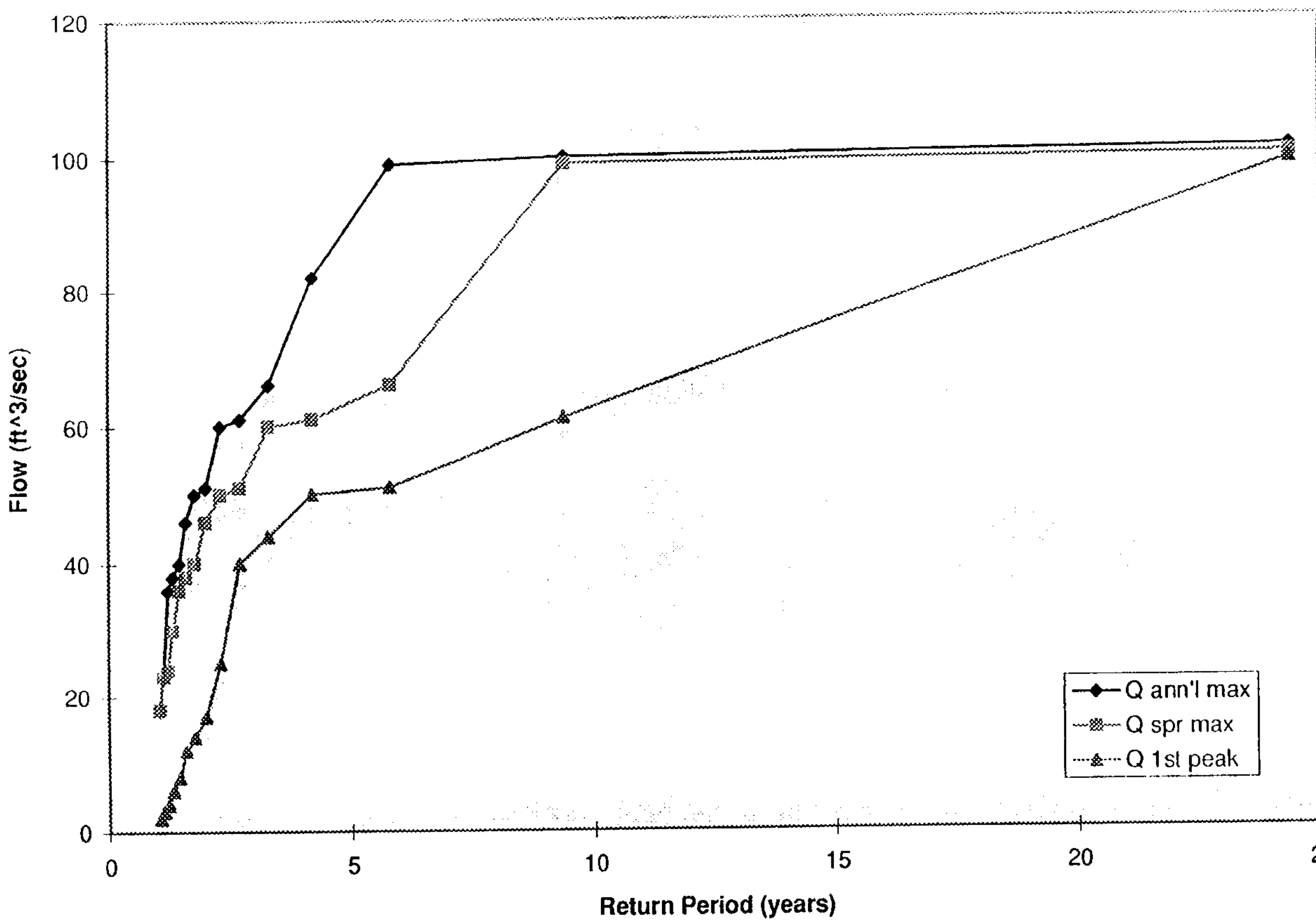
Caribou Creek (15 years of data)

Figure 3c



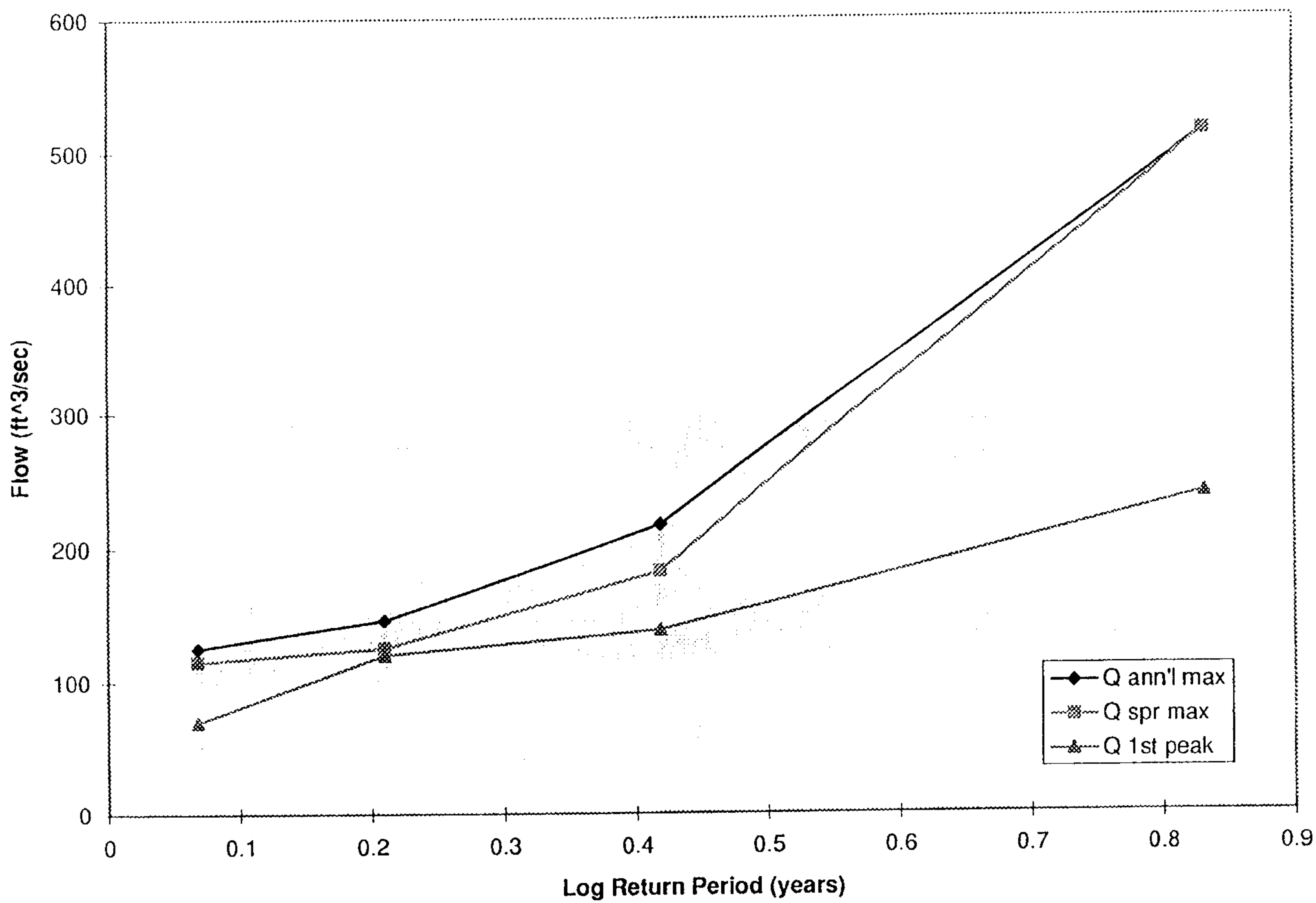
Caribou Creek (15 years of data)

Figure 3d



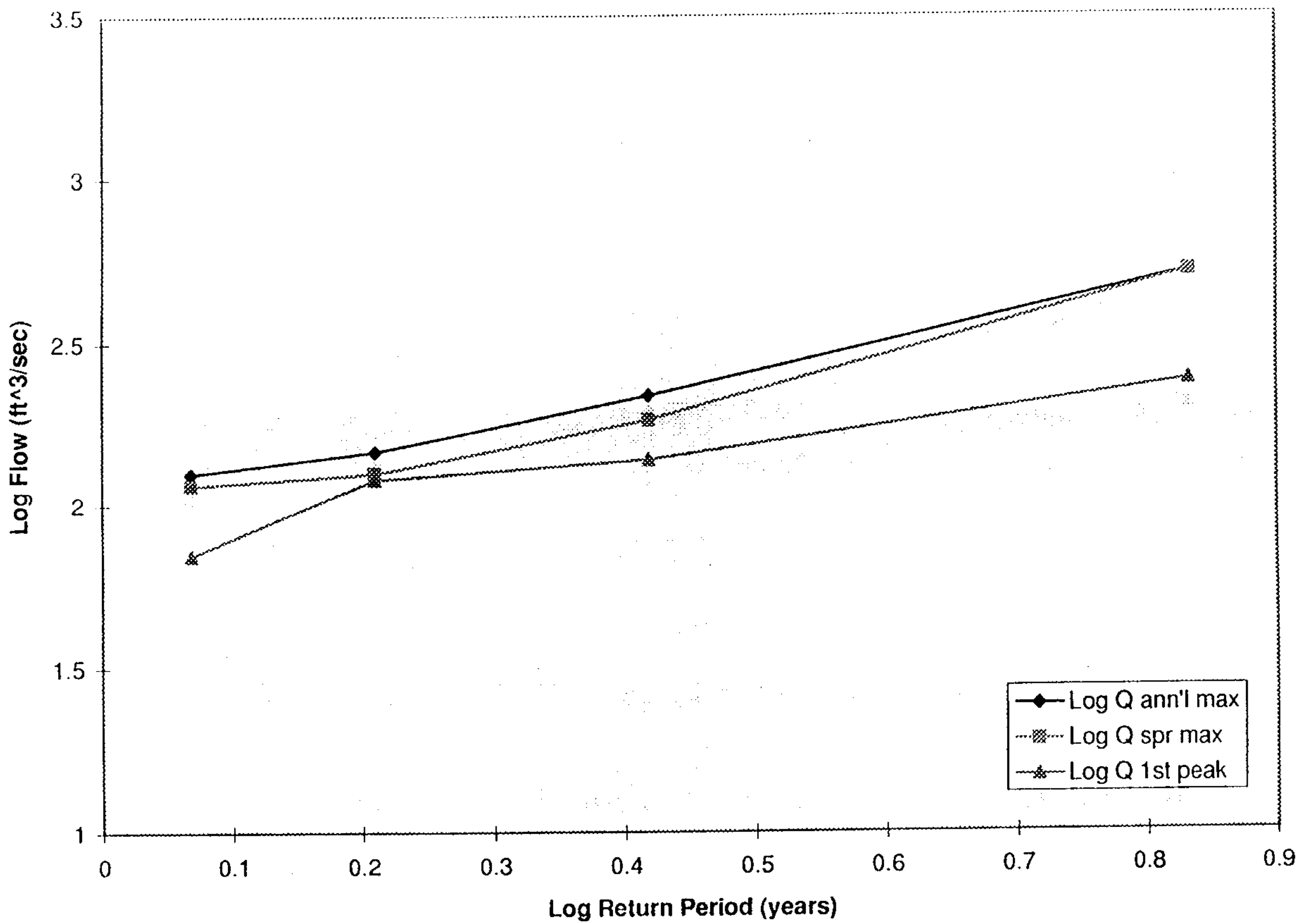
Chena Slough (4 years of data)

Figure 4a



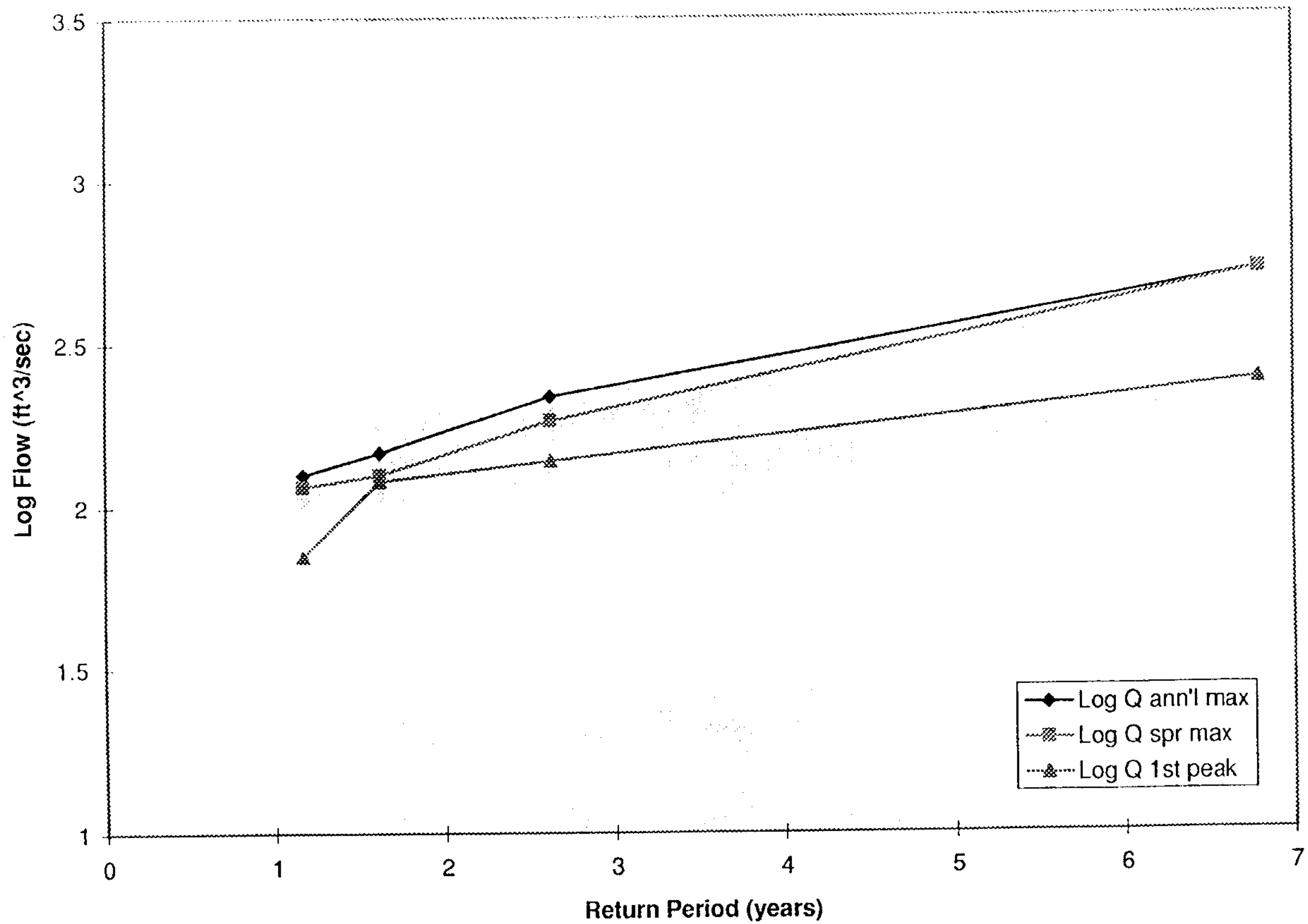
Chena Slough (4 years of data)

Figure 4b



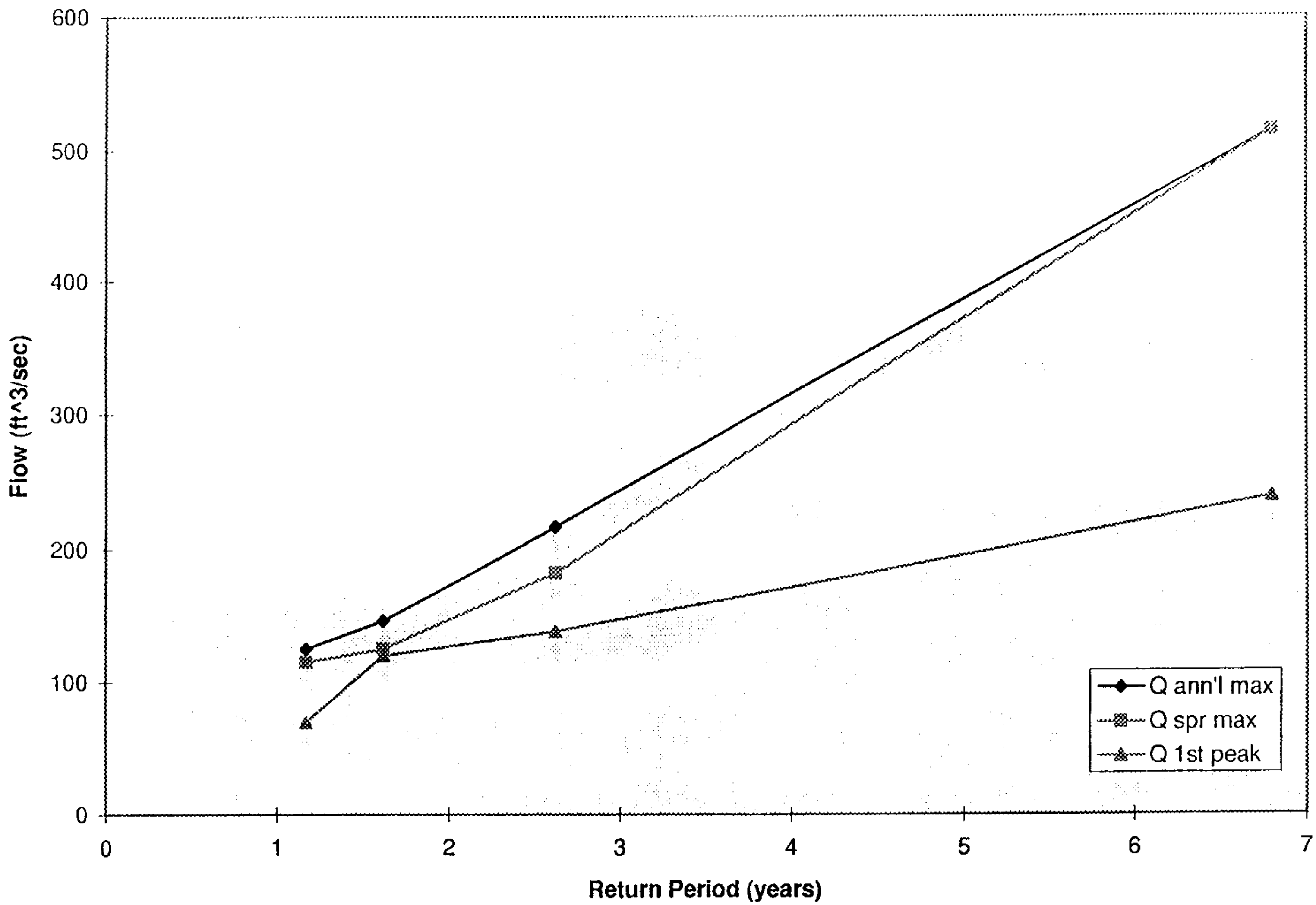
Chena Slough (4 years of data)

Figure 4c



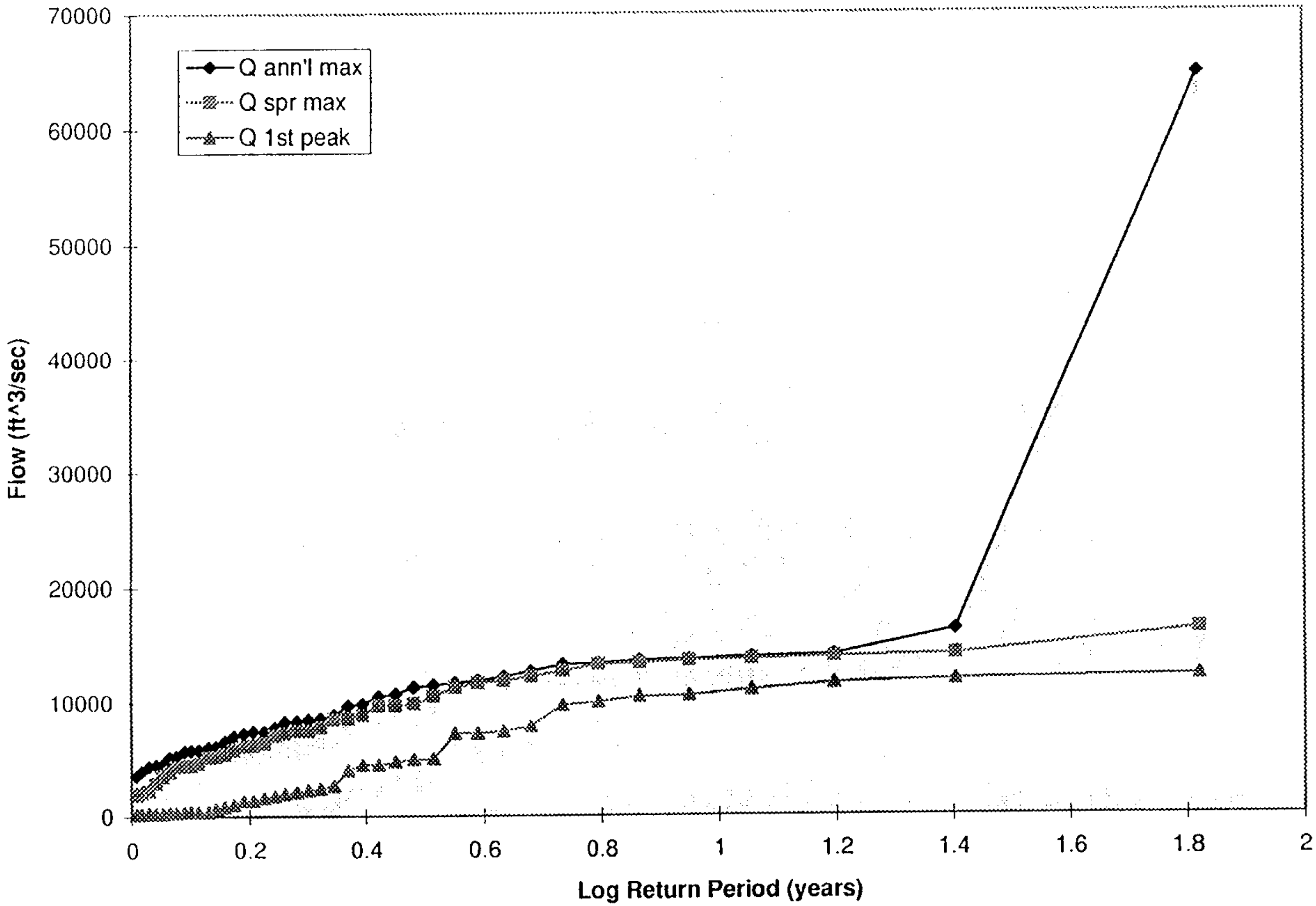
Chena Slough (4 years of data)

Figure 4d



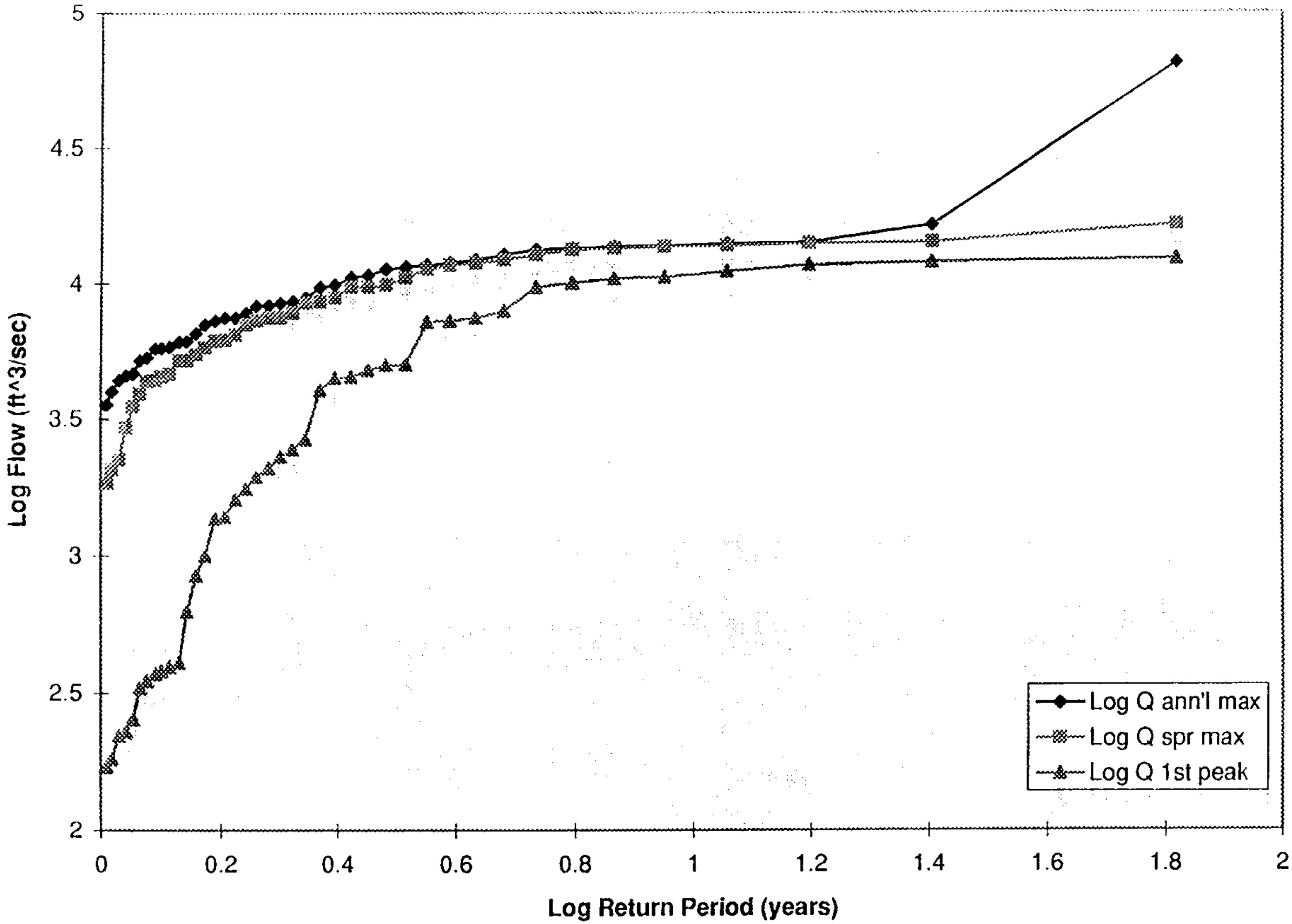
Chena River (41 years of data)

Figure 5a



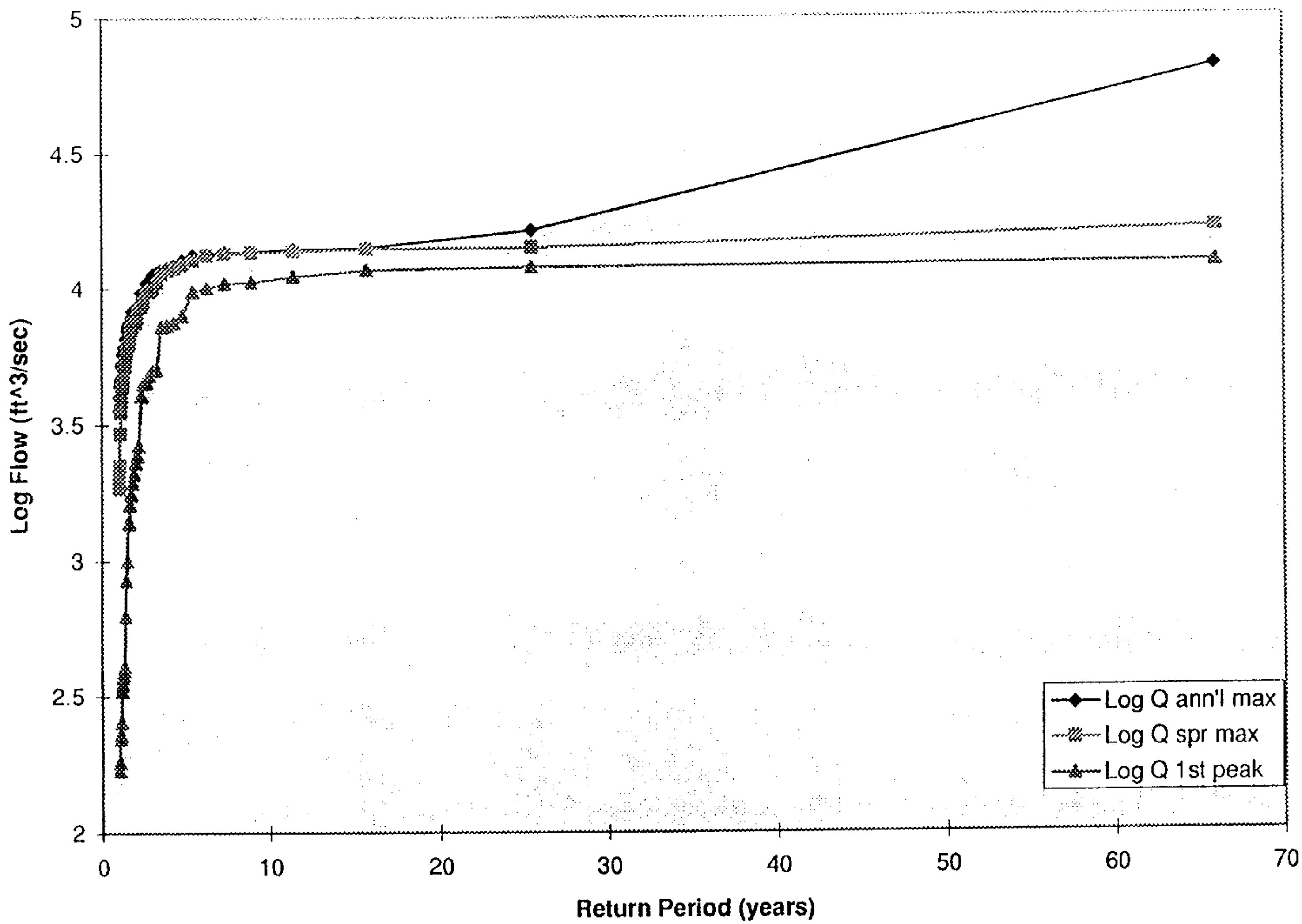
Chena River (41 years of data)

Figure 5b



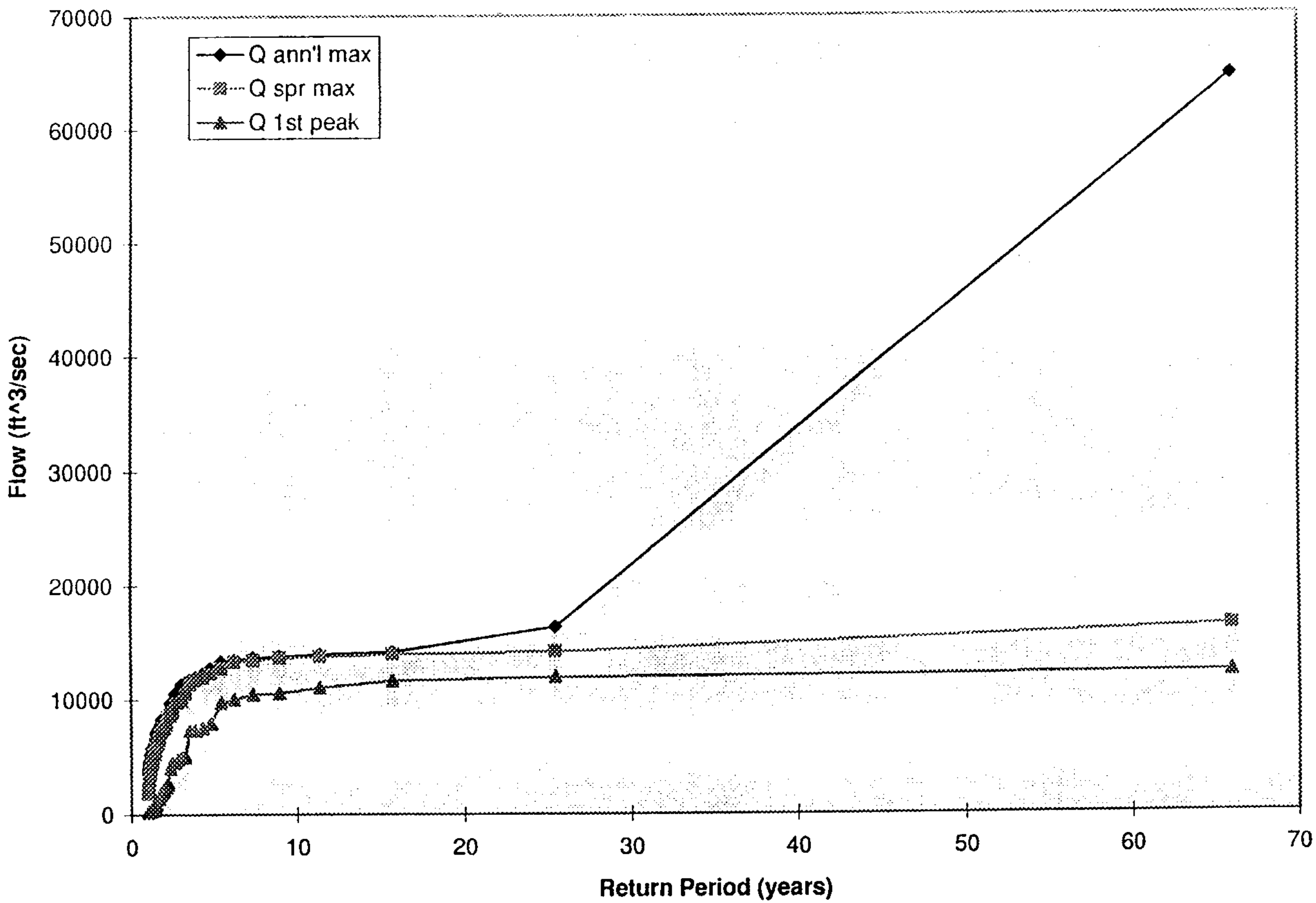
Chena River (41 years of data)

Figure 5c



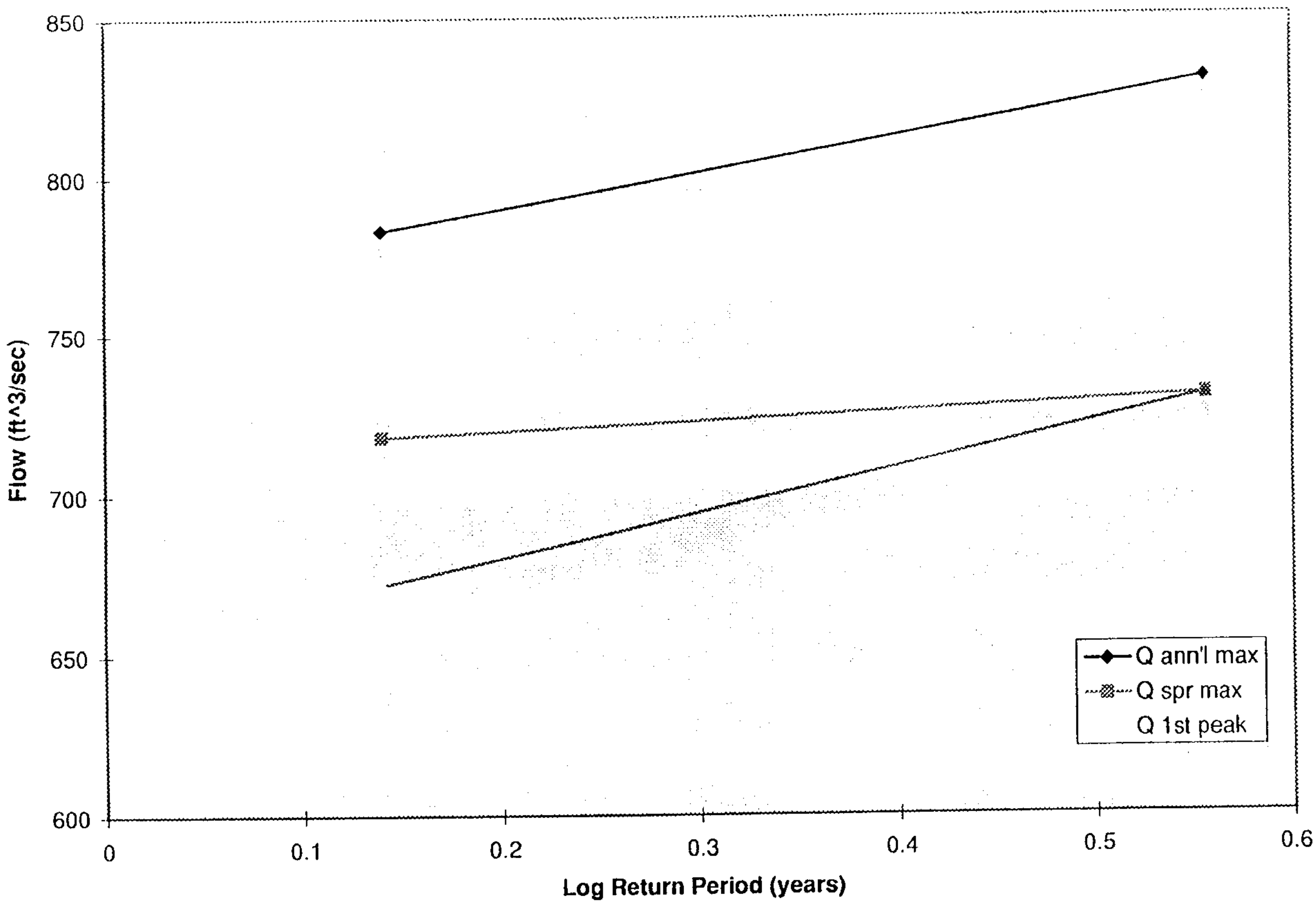
Chena River (41 years of data)

Figure 5d



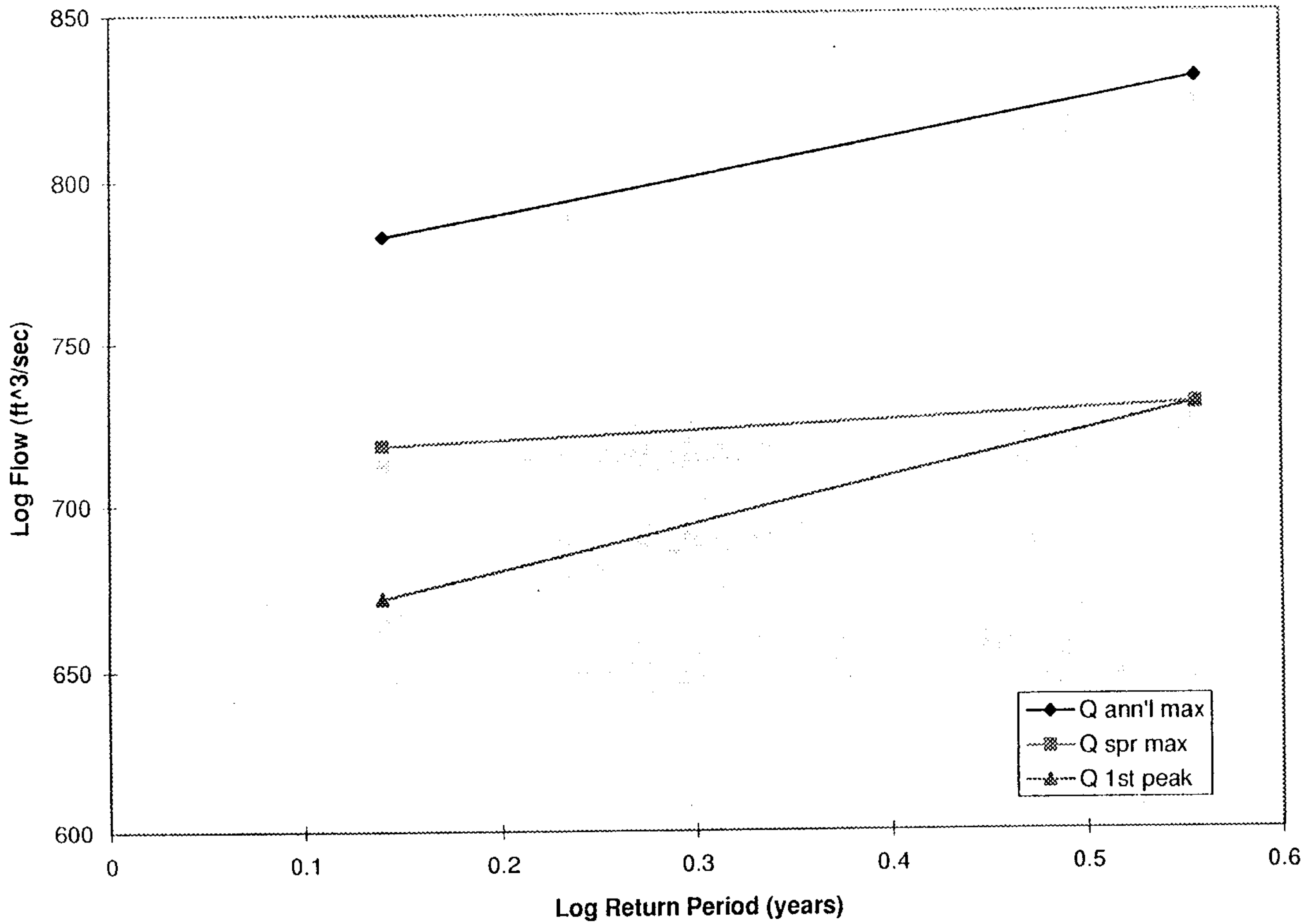
ClearWater River (2 years of data)

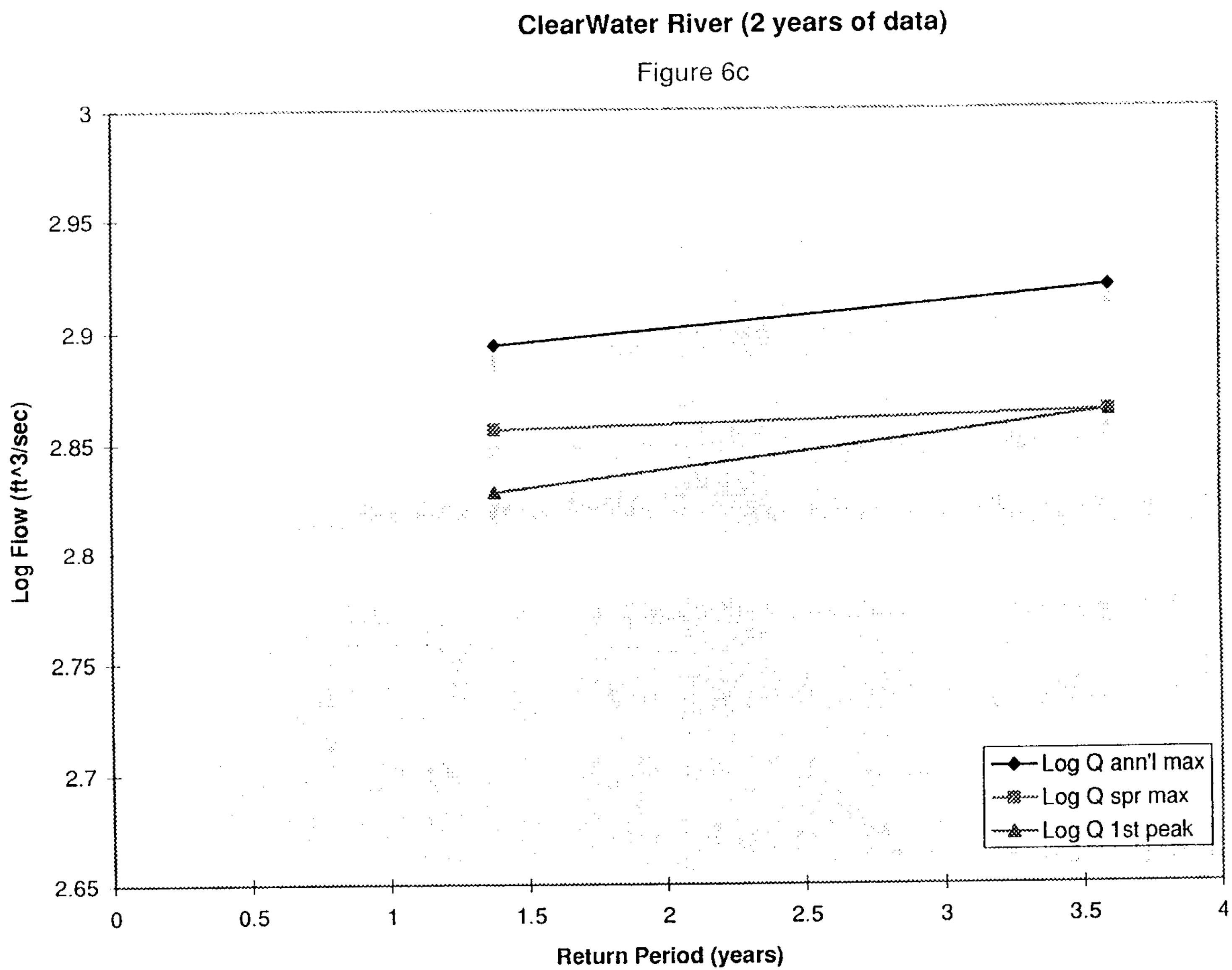
Figure 6a

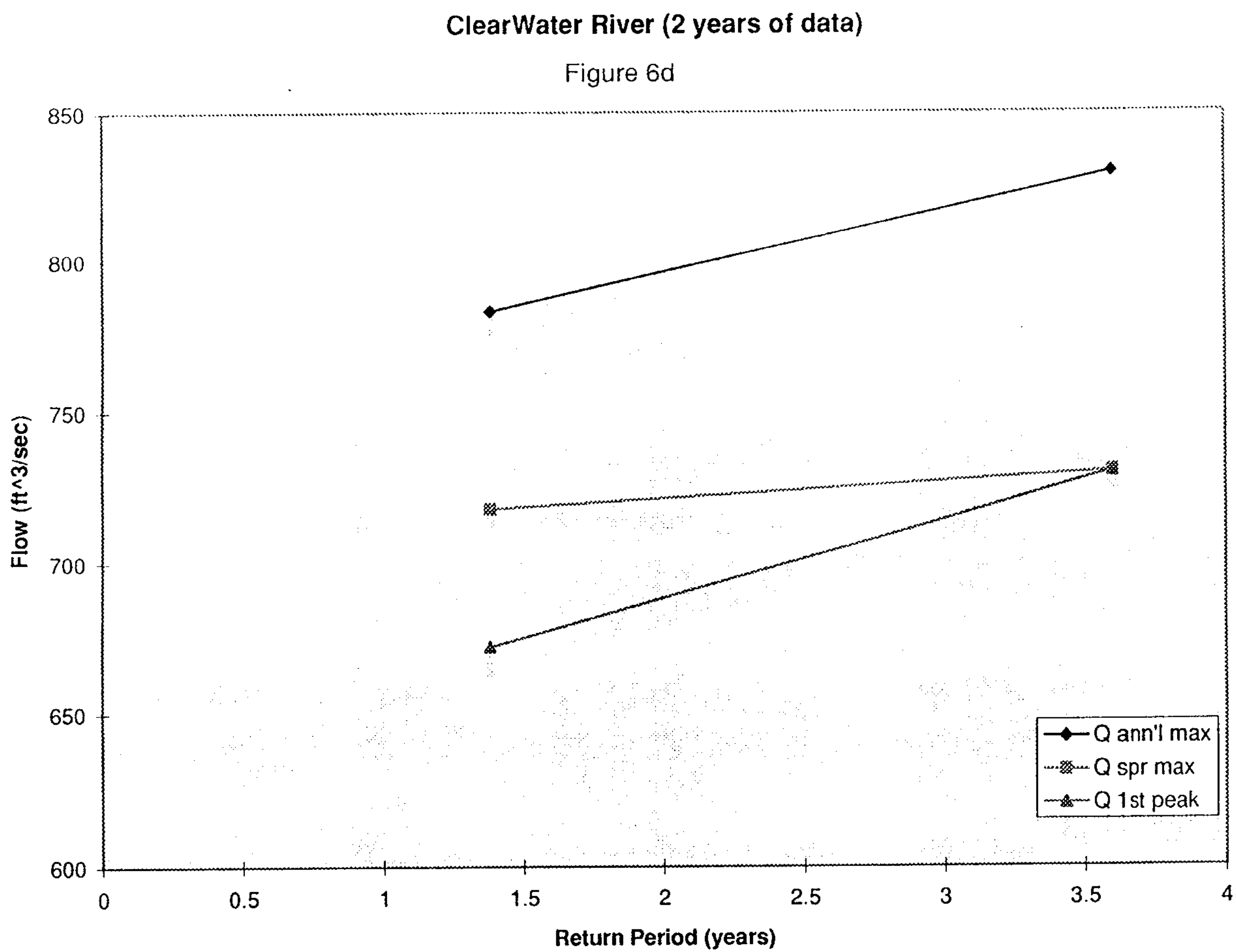


ClearWater River (2 years of data)

Figure 6b

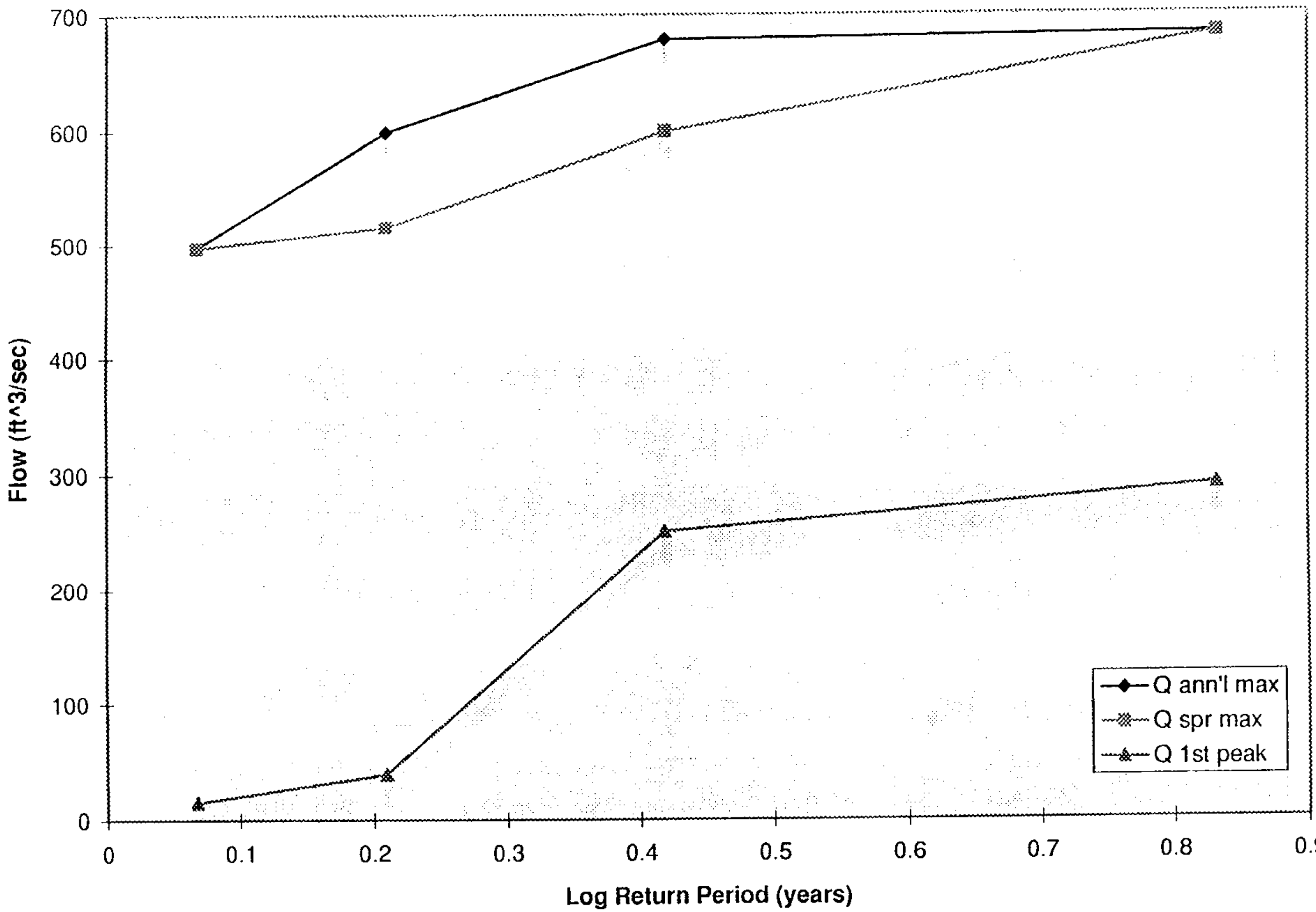


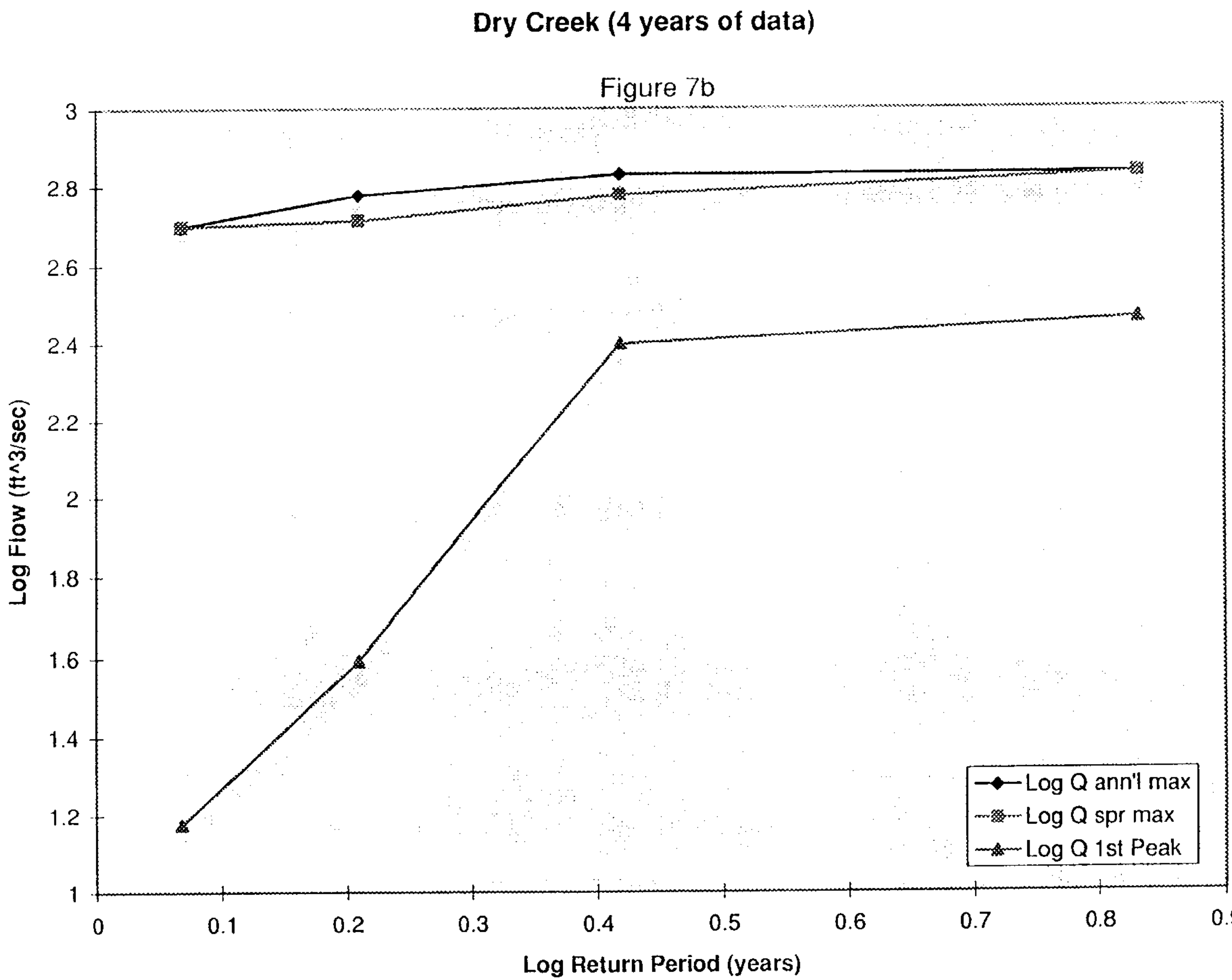

ClearWater River (2 years of data)
Figure 6c
Log Flow (ft^3/sec)
3
2.95
2.9
2.85
2.8
2.75
2.7
2.65
0
0.5
1
1.5
2
2.5
3
3.5
4
Return Period (years)
Log Q ann'l max
Log Q spr max
Log Q 1st peak


ClearWater River (2 years of data)
Figure 6d
Flow (ft^3/sec)
850
800
750
700
650
600
0
0.5
1
1.5
2
2.5
3
3.5
4
Return Period (years)
Q ann'l max
Q spr max
Q 1st peak

Dry Creek (4 years of data)

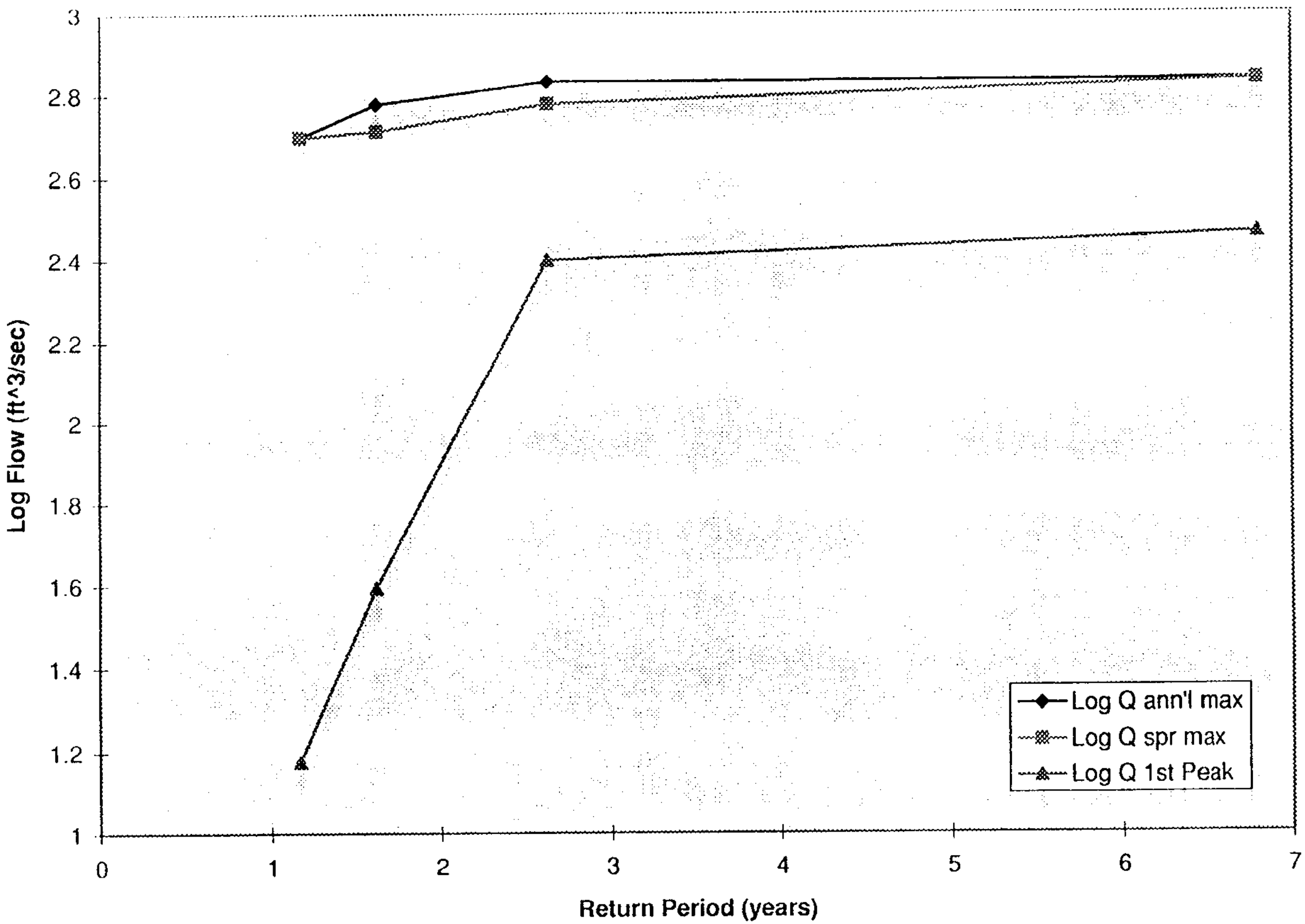
Figure 7a




Dry Creek (4 years of data)
Figure 7b
Log Flow (ft^3/sec)
Log Return Period (years)
3
2.8
2.6
2.4
2.2
2
1.8
1.6
1.4
1.2
1
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9
Log Q ann'l max
Log Q spr max
Log Q 1st Peak

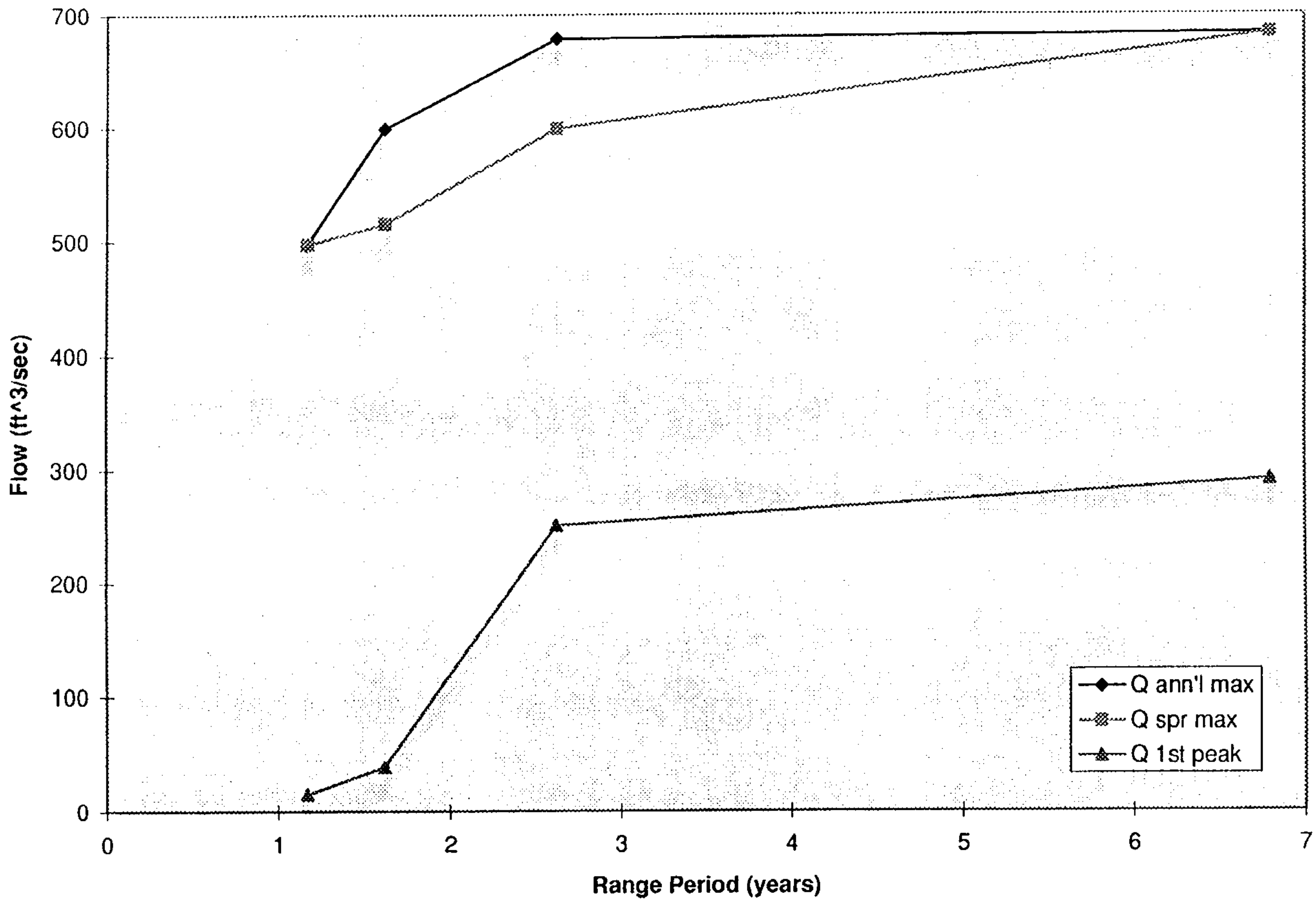
Dry Creek (4 years of data)

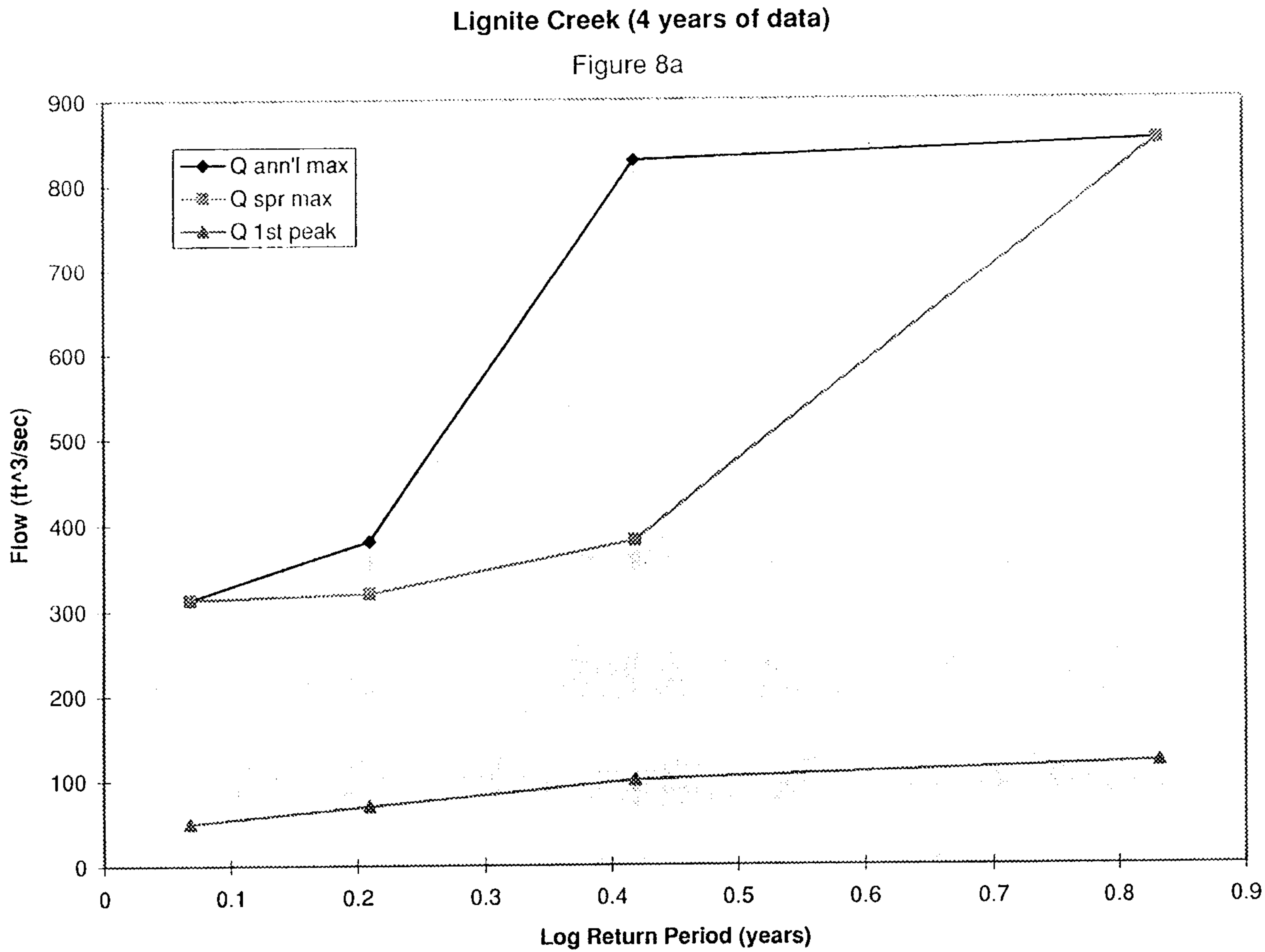
Figure 7c



Dry Creek (4 years of data)

Figure 7d

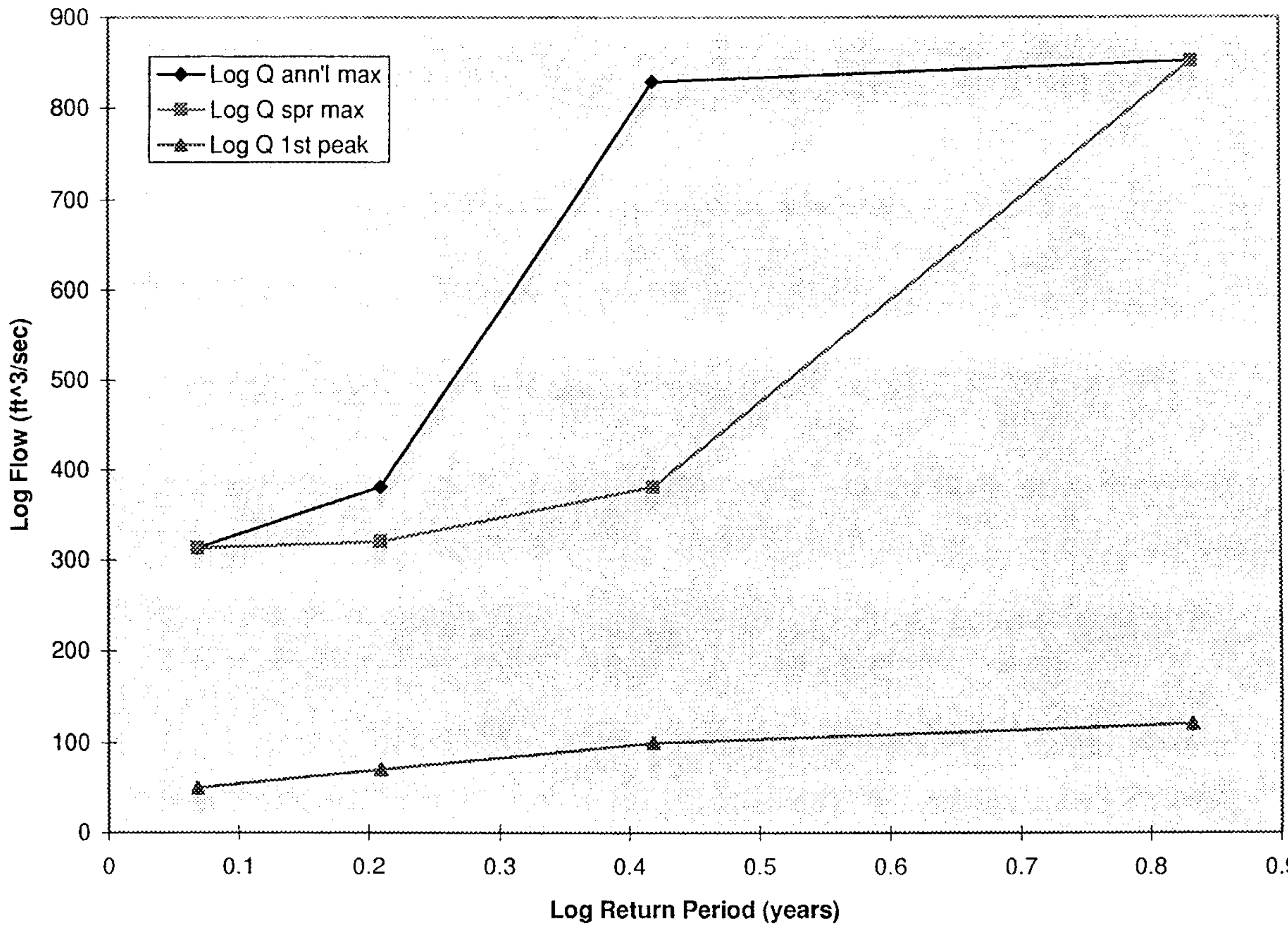




Lignite Creek (4 years of data)
Figure 8a
Q ann'l max
Q spr max
Q 1st peak
Flow (ft^3/sec)
Log Return Period (years)
0
100
200
300
400
500
600
700
800
900
0
0.1
0.2
0.3
0.4
0.5
0.6
0.7
0.8
0.9

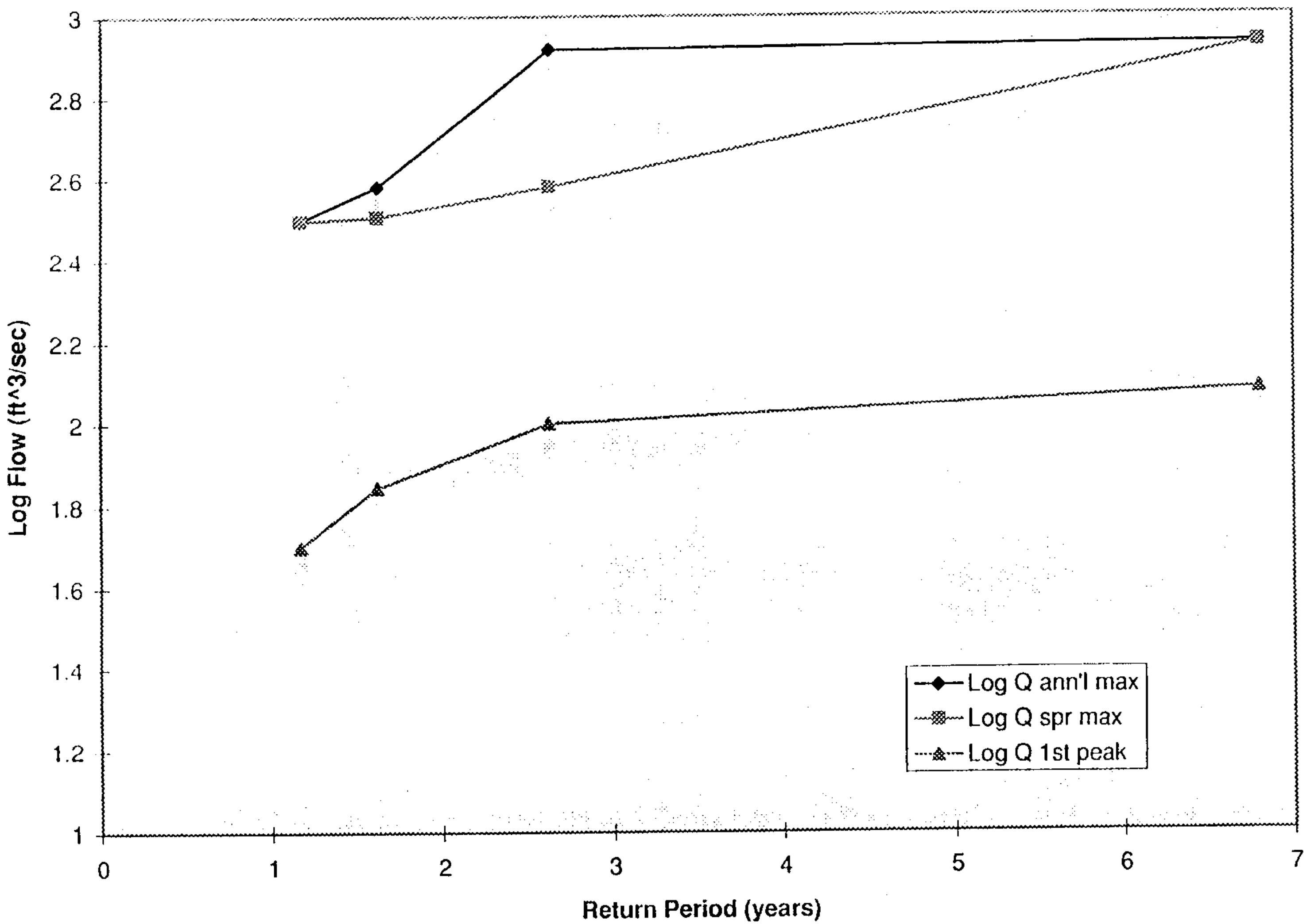
Lignite Creek (4 years of data)

Figure 8b



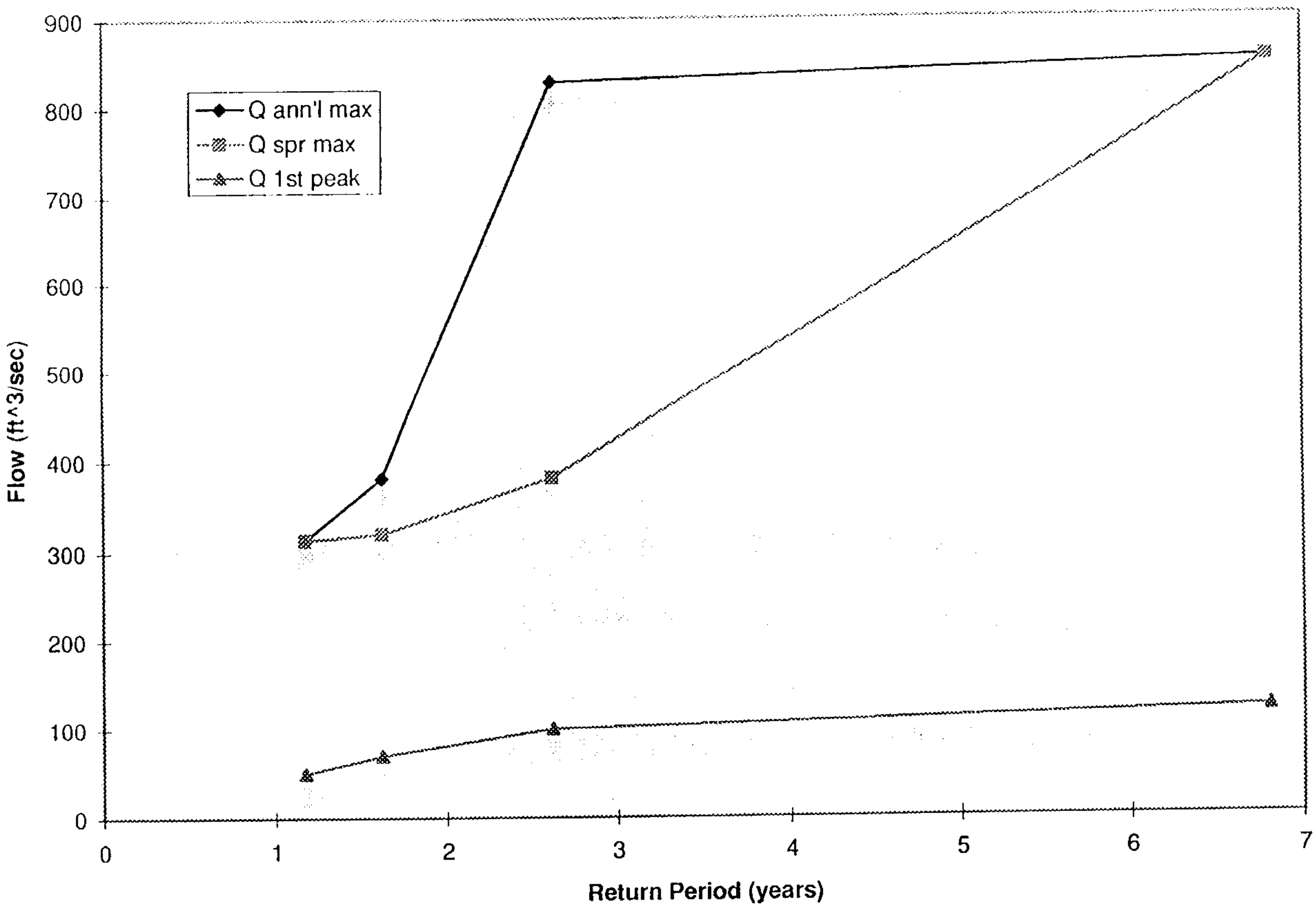
Lignite Creek (4 years of data)

Figure 8c



Lignite Creek (4 years of data)

Figure 8d



Poker Creek (7 years of data)

Figure 9a

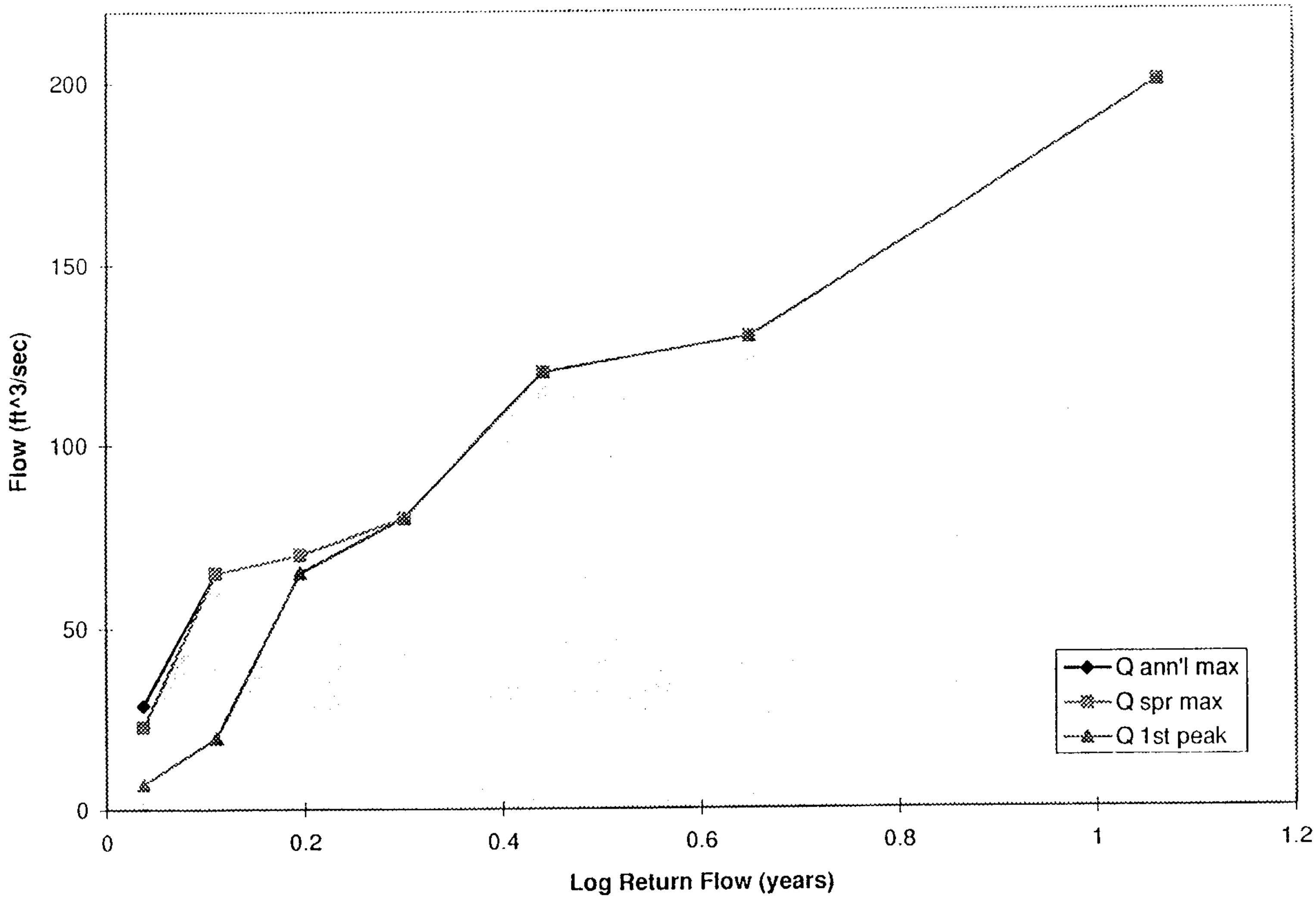
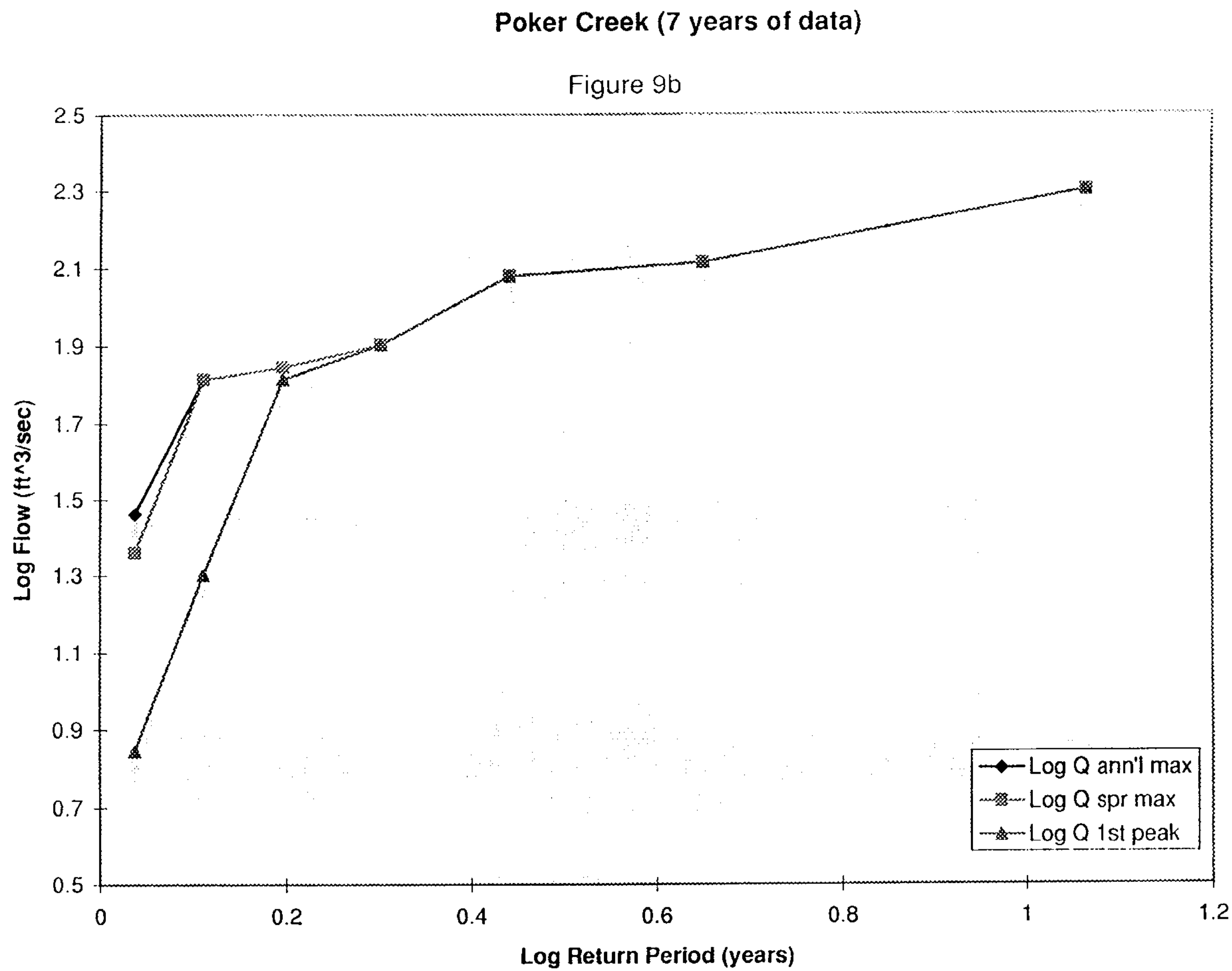
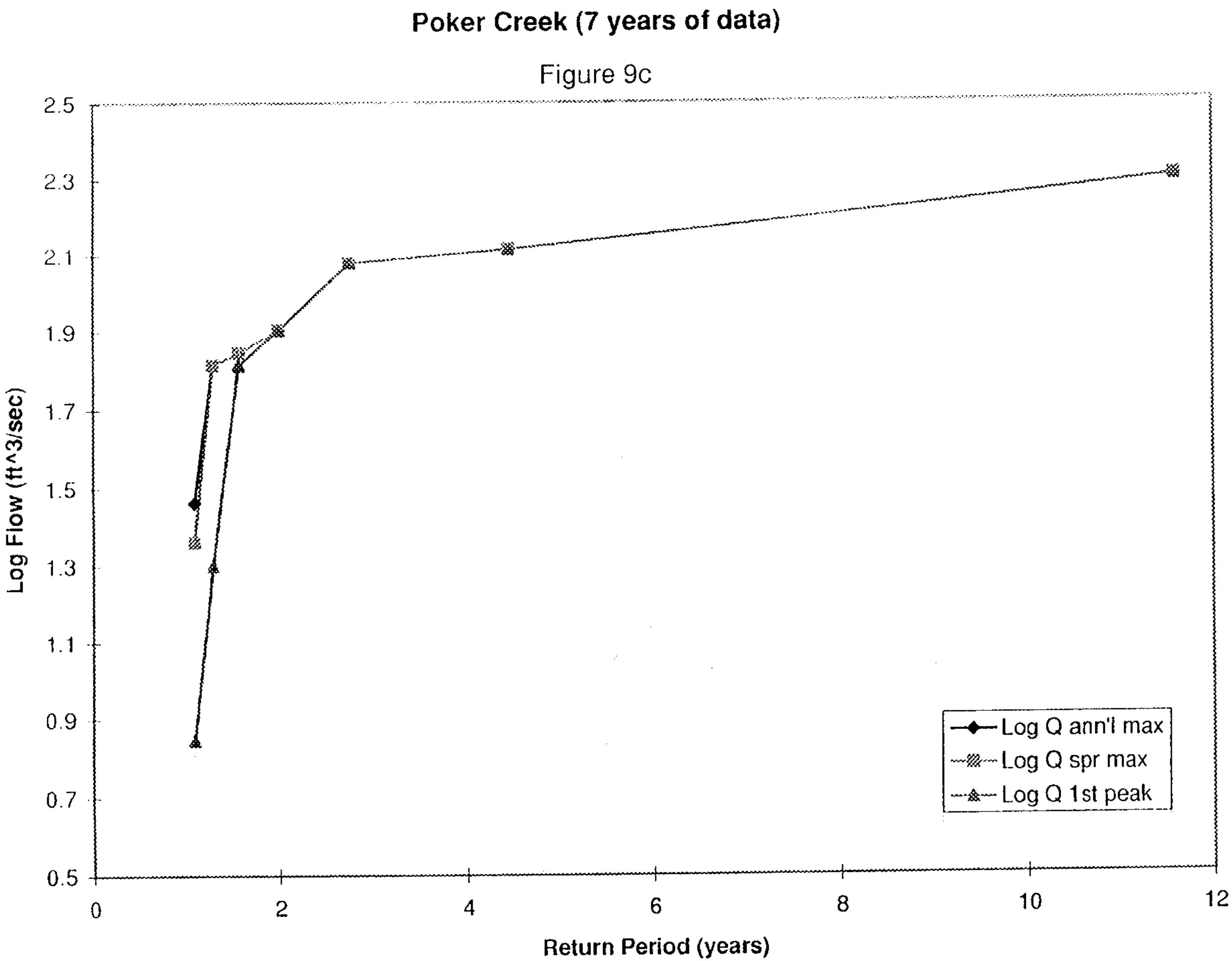


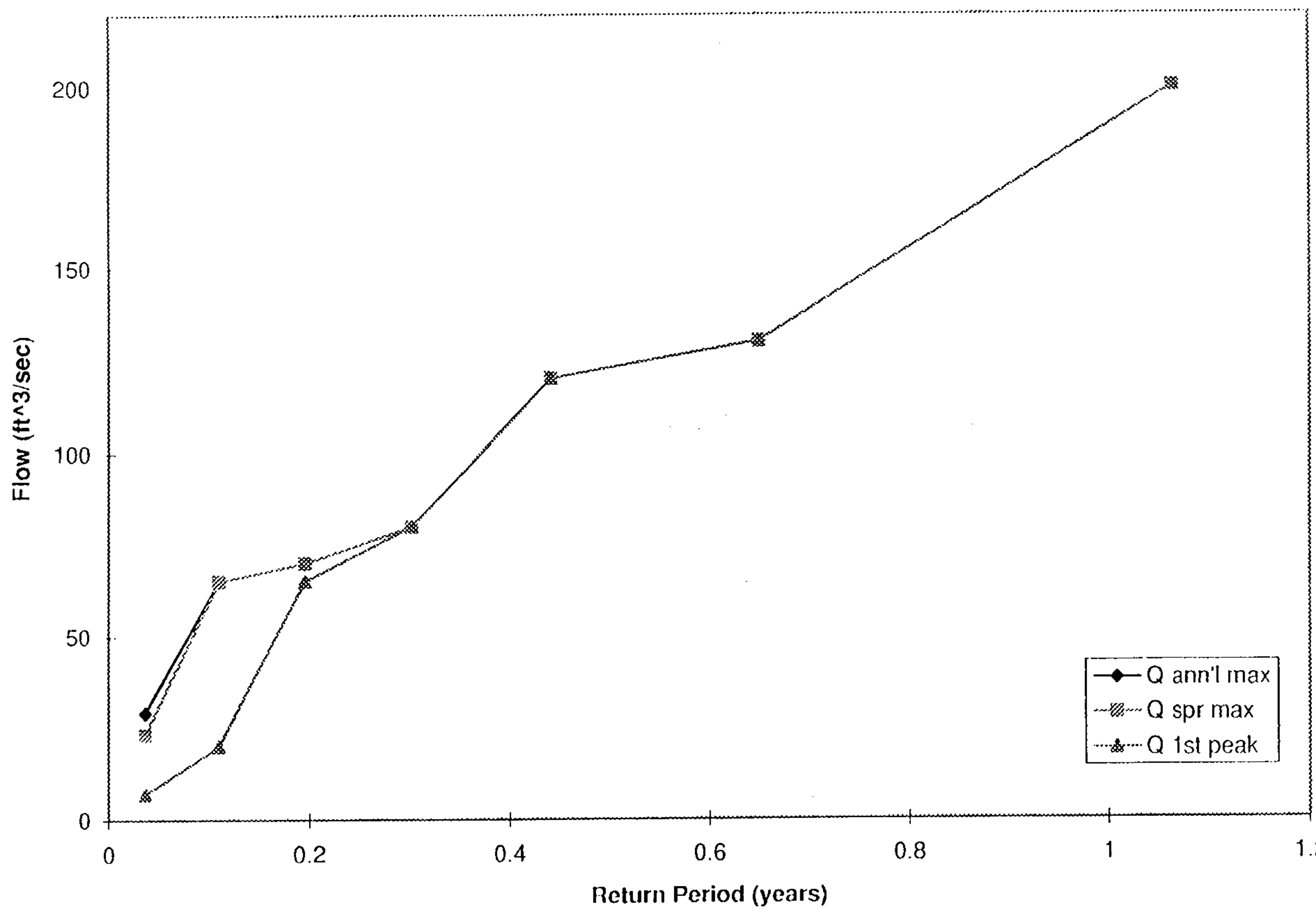
Figure 9b

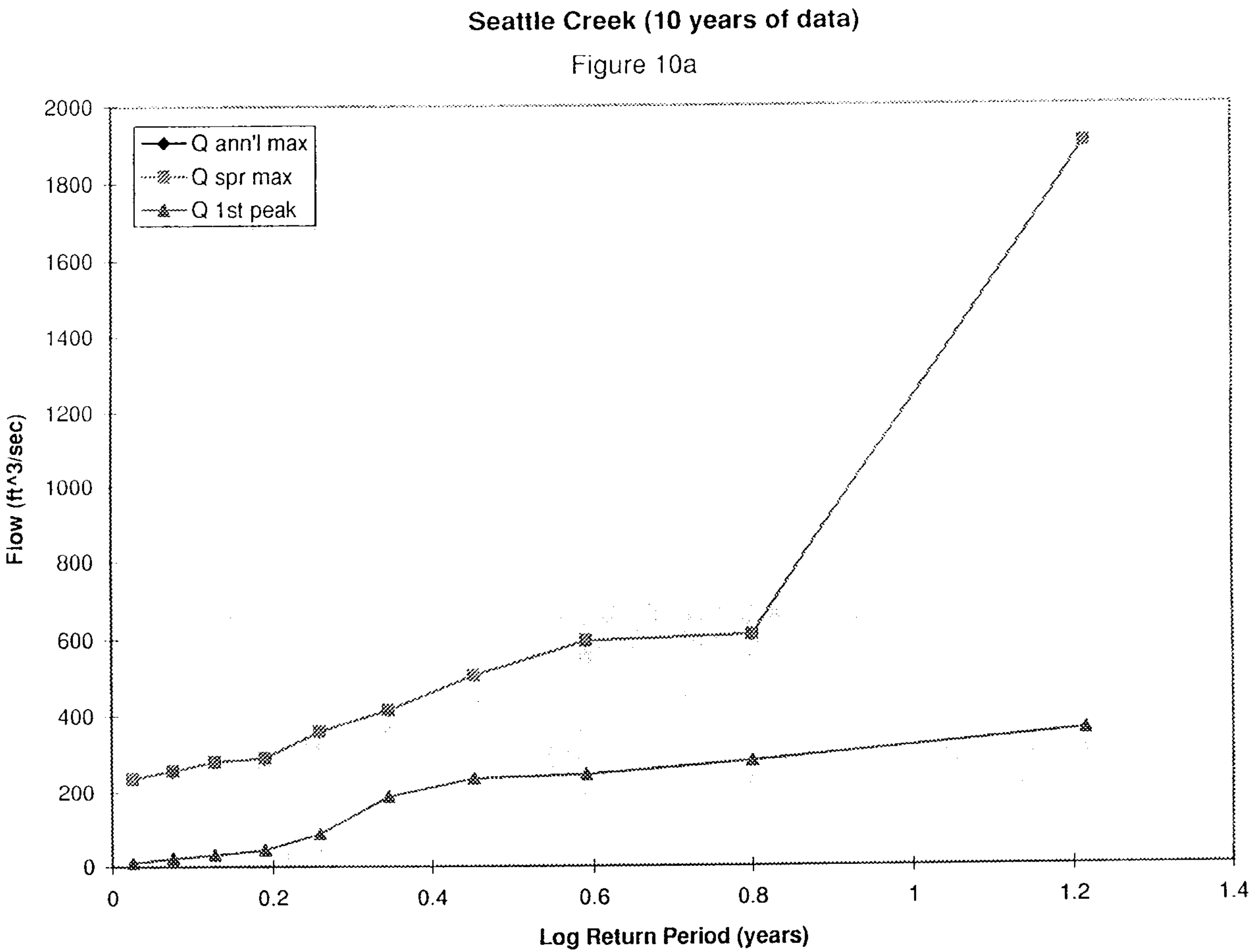

Poker Creek (7 years of data)
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
Log Flow (ft^3/sec)
0
0.2
0.4
0.6
0.8
1
1.2
Log Return Period (years)
Log Q ann'l max
Log Q spr max
Log Q 1st peak


Poker Creek (7 years of data)
Figure 9c
Log Flow (ft^3/sec)
2.5
2.3
2.1
1.9
1.7
1.5
1.3
1.1
0.9
0.7
0.5
0
2
4
6
8
10
12
Return Period (years)
Log Q ann'l max
Log Q spr max
Log Q 1st peak

Poker Creek (7 years of data)

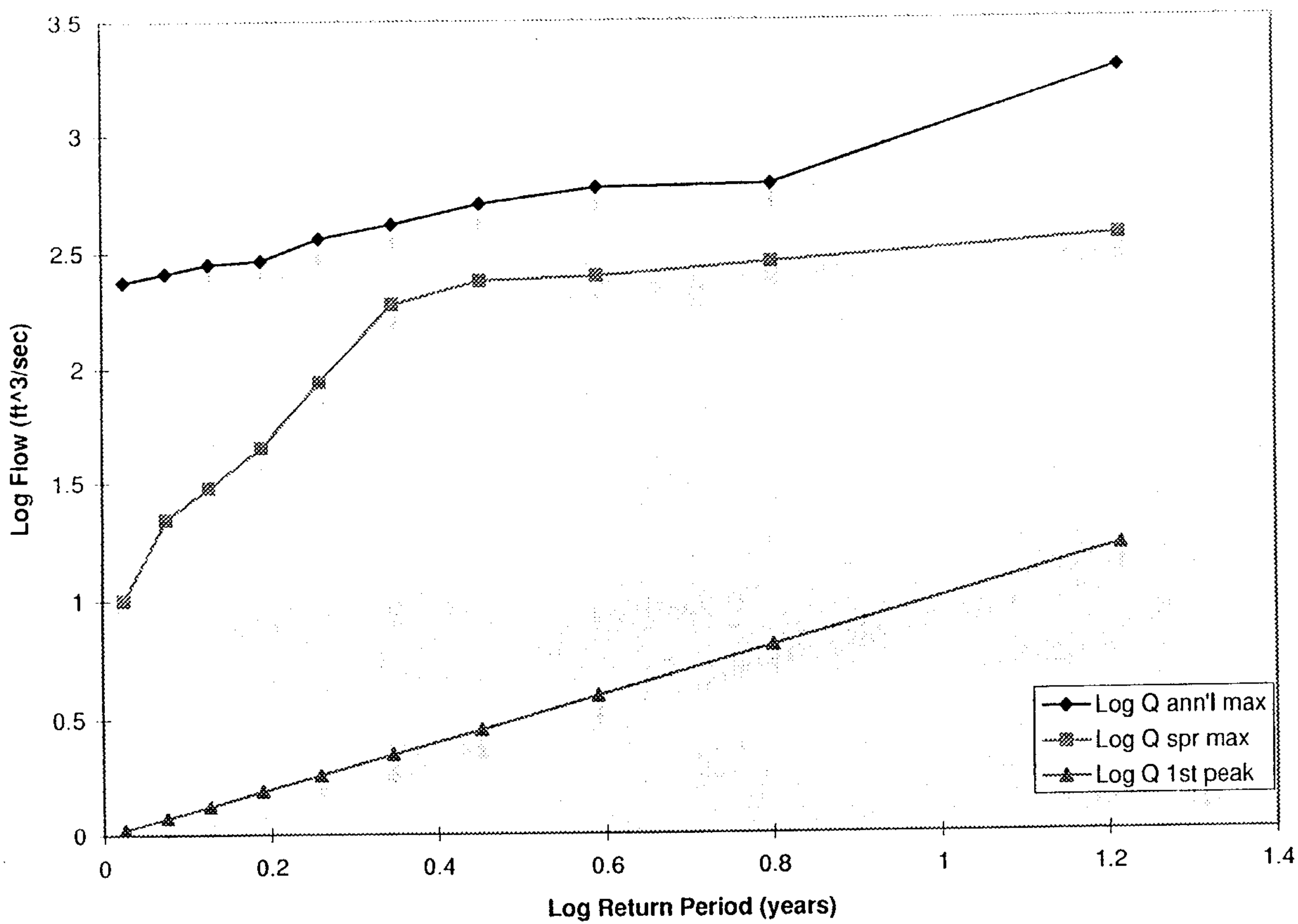
Figure 9d




Seattle Creek (10 years of data)
Figure 10a
Q ann'l max
Q spr max
Q 1st peak
Flow (ft^3/sec)
2000
1800
1600
1400
1200
1000
800
600
400
200
0
0
0.2
0.4
0.6
0.8
1
1.2
1.4
Log Return Period (years)

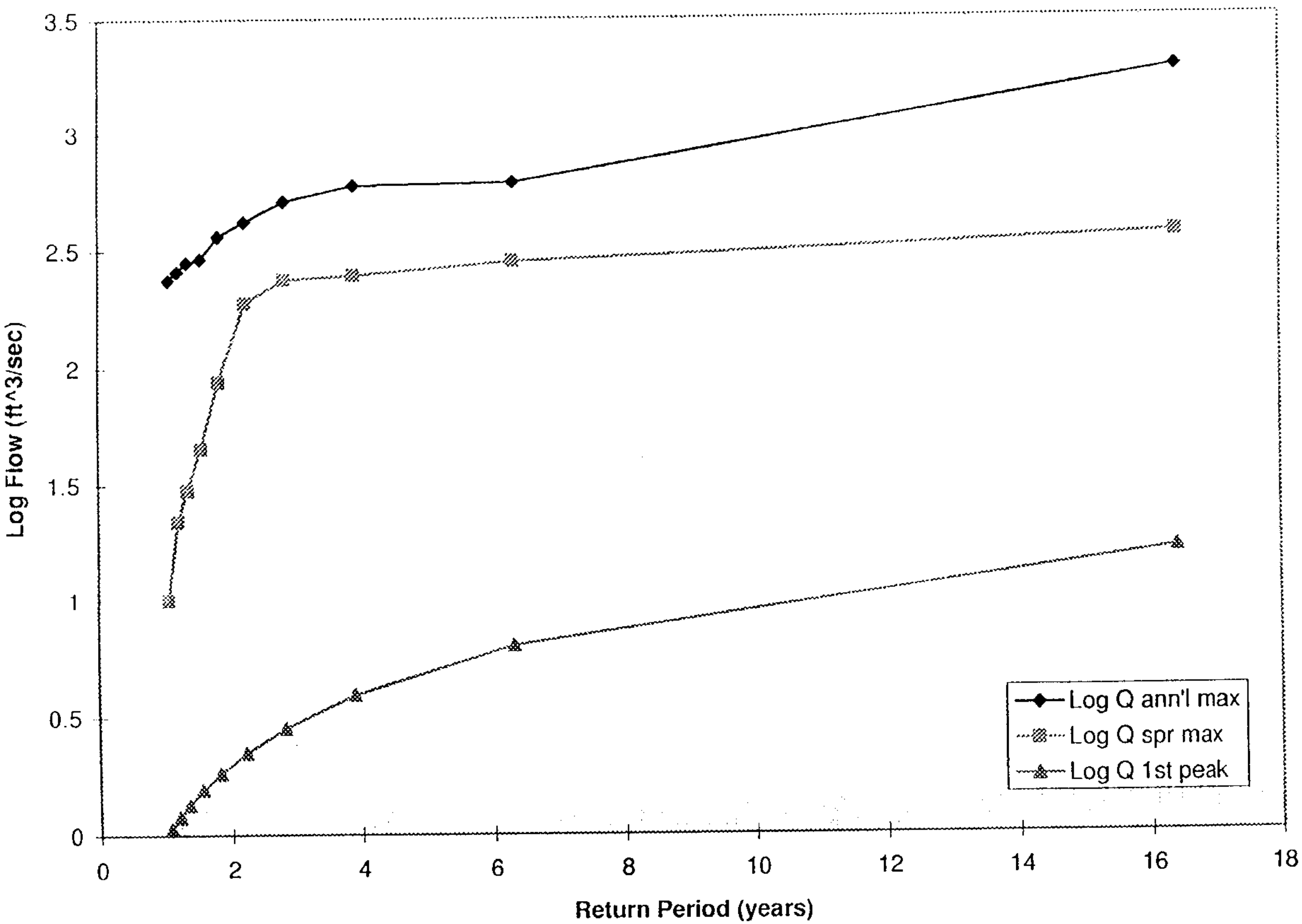
Seattle Creek (10 years of data)

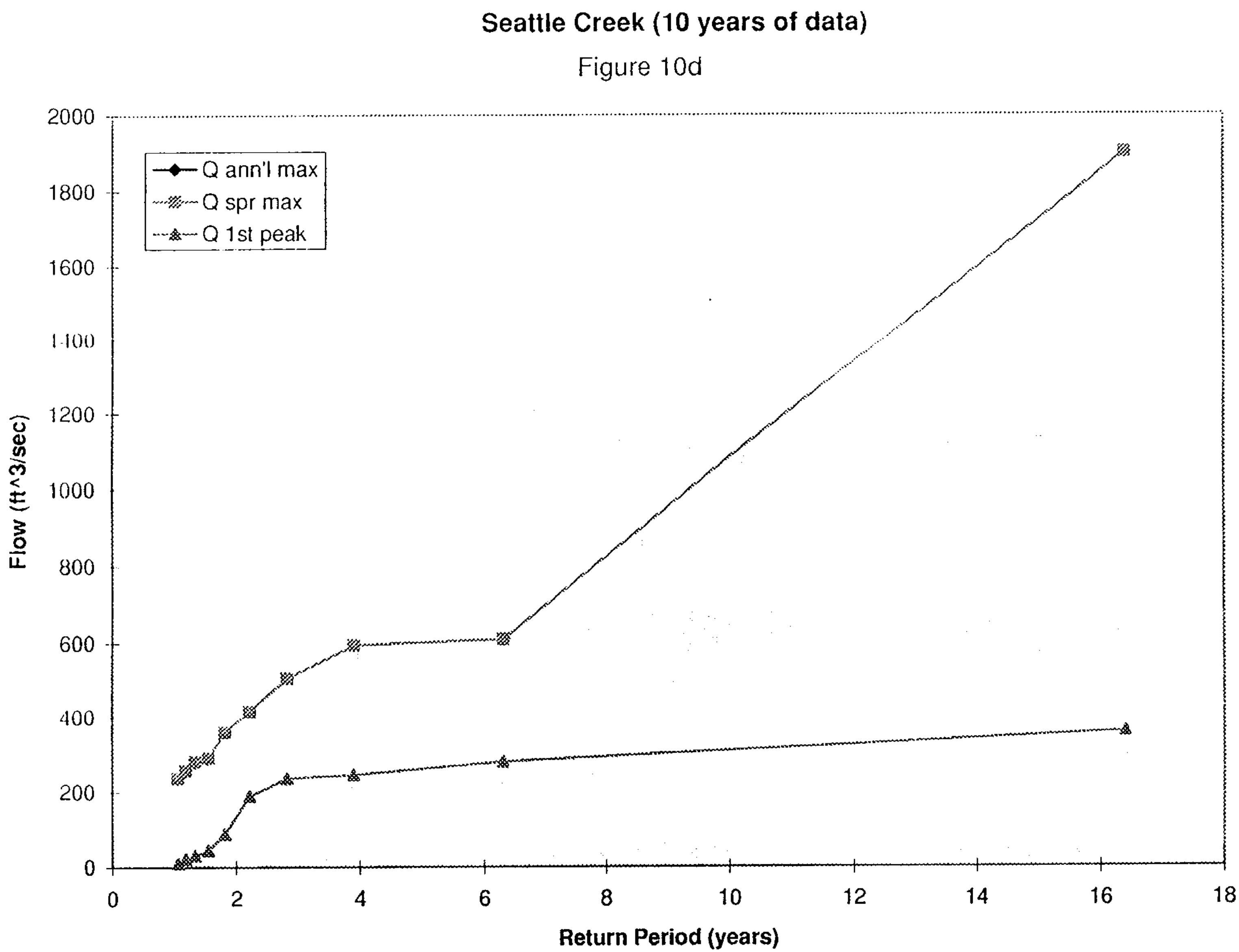
Figure 10b



Seattle Creek (10 years of data)

Figure 10c





Seattle Creek (10 years of data)
Figure 10d
Q ann'l max
Q spr max
Q 1st peak
Flow (ft^3/sec)
Return Period (years)
0
200
400
600
800
1000
1200
1400
1600
1800
2000
0
2
4
6
8
10
12
14
16
18

APPENDIX B

PROJECT TASK REPORTS

ALASKA COOPERATIVE TRANSPORTATION AND PUBLIC FACILITIES RESEARCH PROGRAM (CTPRP)

Project Name:	Determination of Snowmelt Flood Peaks for Highway Drainage Design
Project Number:	SPR-UAF-92-2
Principal Investigator:	Robert F. Carlson Professor of Civil Engineering University of Alaska Fairbanks
Technical Advisor:	Billy Connor ADOT&PF Fairbanks
DOT&PF Project Manager:	David C. Esch

PROJECT REPORT

Task Title: Survey of Present Methods Report

Date: August 2, 1993

Introduction: This report gives the results of the task activity which was aimed at determining the current status of design procedures for snowmelt floods at drainage crossings of highway routes. It includes a brief summary of the current literature and suggestions for the remaining research plan. It is intended to be circulated to ADOT&PF hydraulic engineers for comments and guidance for the remaining research program.

Review of current literature: A search of recent literature revealed several articles which may be of interest to the project. These are briefly summarized below; complete citations, abstracts and articles are available on request:

1. Bengtsson and Westerstrom, Urban Snowmelt and Runoff in Northern Sweden. The main conclusion is that urban watersheds have increased snowmelt rates but less infiltration. Runoff rates are usually higher. Very small drainages used in this study. Sixteen references.

2. Rango and van Katwijk, Development and Testing of a Snowmelt-Runoff Forecasting Technique. They have developed the Snowmelt-Runoff Model (SRM) to estimate snowmelt and subsequent runoff from mountain basins where snowmelt is the major source of streamflow. The main application has been to water supply forecasts in western U.S. mountain regions. SRM requires remote sensing data for parameter development. The model is too complicated for our purposes but contains some useful ideas. Seven references.

3. Rango, Progress in Developing an Operational Snowmelt-Runoff Forecast Model with Remote Sensing Input. This paper reports on an effort to extend the Snowmelt-Runoff Model to operational real time flood forecasting and is of limited use at this time. Ten references.

4. Sogaard and Thomsen, Satellite Data for Monitoring Snow Cover. This effort is very similar to that by Rango et al in No. 2. Again, some interesting ideas but probably no direct application. Eleven references.

5. Bengtsson, Movement of Meltwater in Small Basins. This is a very solid paper on the description of component processes in the snowmelt runoff season. Some ideas could be adapted to the use of HEC-1 for our problem. Eleven references.

6. Buttle and Xu, Snowmelt Runoff in Suburban Environment. Reports on a comparative study of two rural and suburban watersheds which uses both field data and a fairly complex snowmelt runoff simulation model. Probably too complex for our needs but does illuminate the importance of hydrologic processes. Thirty-four references.

7. Martinec, Snowmelt Runoff Models for Operational Forecasts. This report is very similar in direction to those of Rango above. No direct application but maybe we should keep in mind the use of satellite data for our problem. Seven references.

8. Bengtsson, Characteristics of Snowmelt Induced Peak Flows in a Small Northern Basin. Presents the results of several years of study from a small research watershed in northern Sweden. Compares the results of runoff events from snowmelt and rainfall for open and wooded areas. Also has a good discussion of other studies in other countries and of theoretical concepts. Will be useful in an adaptation of HEC-1 to our work. Twenty-six references.

Summary of literature review: This list of references represents the literature available at this time which may be useful to this study. Of the many snowmelt related reports, only a small portion are applicable to engineering design studies for highway drainage crossings. The eight papers referenced will be primarily useful from a conceptual point of view. As we make various decisions and judgements, they will serve as a guide for comparison. At this time we have found no previous work which is directly applicable to our research plan. The literature review will continue throughout the course of the study.

Current research plan: We plan to proceed with the study along the same paths as outlined in the proposal. The plan is as follows:

1) We will try to develop a flood frequency analysis for the spring break-up season of April, May and June. The concentration will be on small basins which would normally be served by culverts. The results will be much like the fish passage flow frequency study which was completed several years ago. A comparison will be made to the annual flood frequency relationship which has been established by the USGS.

2) We expect that the results from activity no. 1 will be suitable for most design situations. However, we realize more precision could be gained by extracting the peak spring flood flow for each year and subjecting the resulting data series to a standard frequency analysis. This method is more time intensive, as each hydrograph must be visually examined. This method is only possible through the use of the streamflow data on CD-ROM which is available to the project.

3) The project activity will also investigate a method which would be applicable in areas which are outside of the data set on which the two regression methods are available. We will attempt to apply the HEC-1 snowmelt routine to predict spring runoff. The challenge will be to specify the appropriate model parameters and develop a useful frequency relationship.

Each of the three methods will be developed first for several stream basins in interior Alaska and then in south central Alaska. Following this activity, the technical advisor will be consulted and a path chosen for the remainder of the study.

ALASKA COOPERATIVE TRANSPORTATION AND PUBLIC FACILITIES RESEARCH PROGRAM (CTPRP)

Project Name:	Determination of Snow Melt Flood Peaks for Highway Drainage Design
Project Number:	SPR-UAF-92-2
Principal Investigator:	Robert F. Carlson
Technical Advisor:	Billy Connor
DOT&PF Project Manager:	David C. Esch

PROJECT REPORT

Task 4 of 7: Delineate Flow Computation Methodology Report

Date: November 1993

Introduction: This report gives the results of the task activity aimed at experimenting with and defining the best method for developing a design procedures for snowmelt floods at drainage crossings of highway routes. It includes a brief summary of the methods used to date and shows some examples. It is intended for circulation to ADOTPF hydraulic engineers for comments and suggestions on the remaining research program.

In the previous report, Survey of Present Methods Report, we outlined the following research plan:

1) We will try to develop a flood frequency analysis for the spring break-up season of April, May and June. The concentration will be on small basins which would normally be served by culverts. The results will be much like the fish passage flow frequency study completed several years ago. A comparison will be made to the annual flood frequency relationship established by the USGS.

2) We expect that the results from activity No. 1 will be suitable for most design situations. However, we realized more precision could be gained by extracting the peak spring flood flow for each year and subjecting the resulting data series to a standard frequency analysis. This method is more time intensive as each hydrograph must be visually examined. This method is only possible through the use the streamflow data on CD-ROM which is available to the project.

3) The project activity will also investigate a method which would be applicable in areas outside of the data set on which the two regression methods are available. Here we will attempt to apply the HEC-1 snow melt routine to spring runoff predictions. The challenge will be to specify the appropriate model parameters and develop a useful frequency relationship.

4) Each of the three methods will be developed first for several stream basins in interior Alaska and then for areas in south central Alaska. Following this activity, the technical advisors will be consulted and a path chosen for the remainder of the study.

Since that report the study has proceeded with the following items:

1) We acquired a CD-ROM based streamflow data series for all USGS Alaskan surface water data through the 1993 water year. This data base method allows for nearly instant retrieval of streamflow data in the PC computer world. By using the vendor-supplied software with our own, we are able to retrieve data by basin, drainage area size, location, year and season. First we select the desired data base, load it into the Lotus 1-2-3 package, then plot the streamflow hydrographs. The final product is illustrated in Figure 1 (attached). These plots are easy to do and give a good interpretive sense of the nature of the spring runoff compared to other times of the year.

2) We decided to analysis several small basins in interior Alaska for the following data series:

a) The annual flood peak based on the entire water year. This series is the most commonly used and will form a base for comparison with the other two series.
b) The annual flood peak based on the spring quarter of April, May and June. This quarter is probably inclusive for spring runoff for most of the state. However the time period could easily be adjusted to a more suitable period if necessary.
c) The first peak of the spring. This flow determination is new and should be considered experimental. It is fairly easily programmed and gives an indication of the earliest flow which may be significant while the culverts and small bridge openings are still full of ice and snow.

Each of the three data series are extracted for each year of record. The flow determination results are shown for an interior stream in Figures 1 and 2.

3) Once the three data series are formed for each stream, the following analysis steps are followed:

a) The data series is ranked and the return period plotting position is calculated for each value. The flood frequency determination will be based on the log-normal distribution. The theoretical and plotted values will be compared for each of the tree series on a single plot. Other analysis will be conducted to see if there is a consistent ratio relationship between the three data series for various return periods, basin areas and other basin characteristics.
b) The data will be normalized with division by the mean flood value. The normalized data will be compared to determine an appropriate regionalized flood frequency curve. Other regionalization methods will be explored.

The flood analysis procedure as carried out in the Lotus 1-2-3 package is outlined in Appendix A.

Once the analysis is completed for the several streams in interior Alaska, and after consultation with ADOTPF design engineers, the computation procedure will be extended to the rest of the state as is appropriate.

Appendix A: Flood Analysis Procedure

The procedure utilized in analysis of runoff is outlined below:

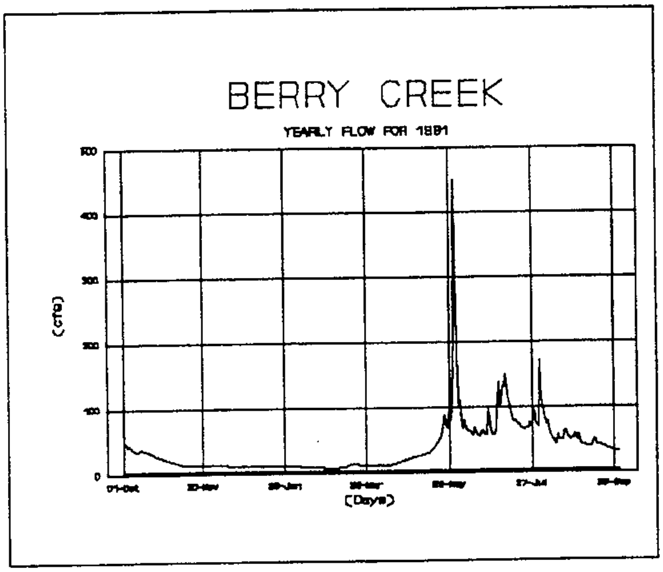
USGS Data Records
The USGS streamflow data is available for all gaging stations in Alaska on CD-ROM. This data can be extracted into a spreadsheet format for all years of record for any particular USGS station Id. The data is next imported into a Lotus 123 master worksheet.

Master Worksheet File
The master worksheet file is subdivided into the following areas:

Master Screen
The master screen area consists of a window area that includes the filename, year of analysis, yearly totals for the highest peak flow with associated date, spring quarter totals for highest peak flow with associated date and first peak flow with associated data. Visual representation of the data is supplied in an adjacent graph window. This window allows the operator to visually analyze the data for accuracy during runtime. The yearly data is graphed first, followed by a graph for the spring quarter. The time allotted to visualize the graphs can also be altered to enhance analysis.

MASTER SCREEN AREA

FileName	BERRY.WK3
Yearly Totals	YEAR
Evaluation Year	1981
Highest Peak Flow	450
Date Highest Flow	02 Jun
	Spg Qtr
First Peak Flow	88
Date First Peak Flow	25-May
Highest Peak Flow	450
Date Highest Flow	01-Jun
First Year of Data	1971
Last Year of Data	1981
Graph Time (sec):	5



Data Base

The imported data is stored in the master worksheet as an internal dBase. The dBase automatically sizes itself to meet the diversity of recorded years from different USGS gage stations. The dbase consists of all streamflow records for the particular station sorted by year and day.

Algorithms

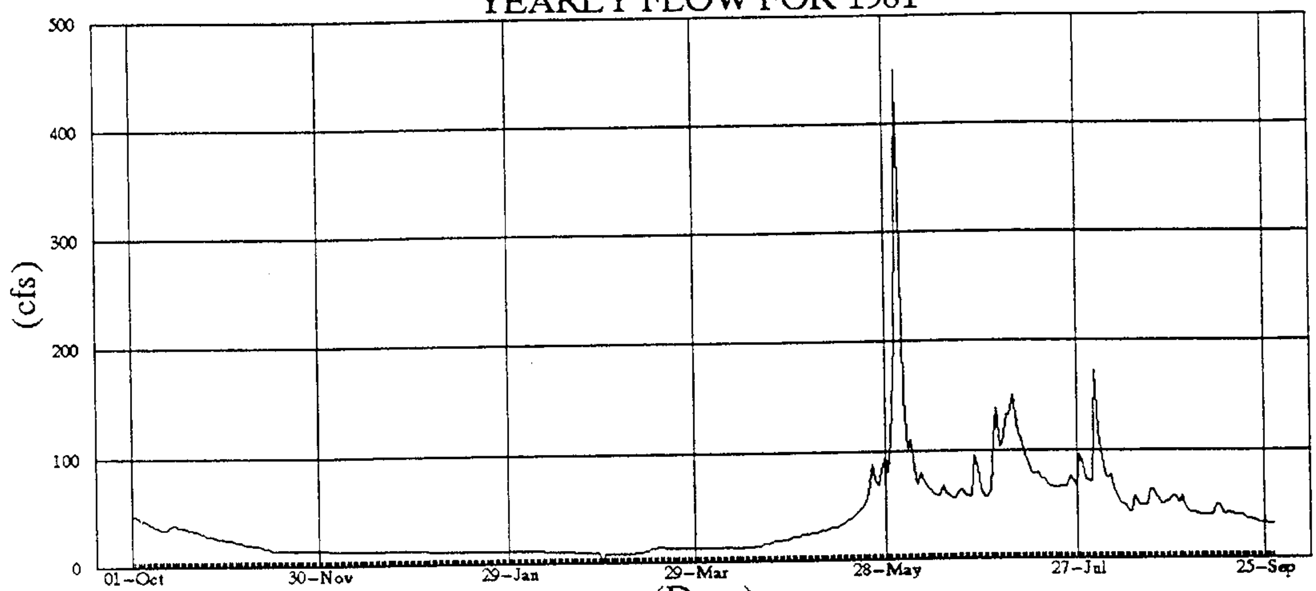
The master worksheet consists of numerous algorithms that analyze for maximum yearly flow rate with associated date, maximum spring quarterly flow rate with associated date, and first spring quarter peak flow rate with associated date. The algorithms include error trapping to prevent erroneous data transfer and lockup of computer hardware.

Reports

The data and graph windows discussed above are named and stored within the masterwork sheet in a report area. This report area can easily be printed for the analysis year. The data is also stored in a summary dBase which allows printing analyzed data for all the record years.

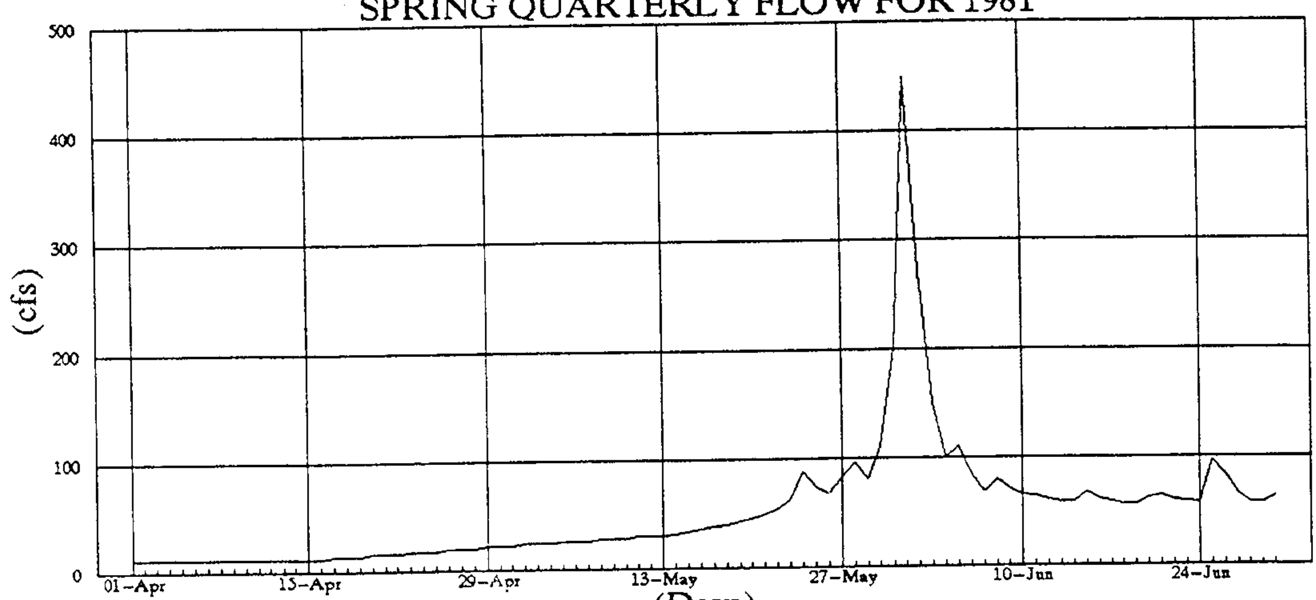
BERRY CREEK

YEARLY FLOW FOR 1981



BERRY CREEK

SPRING QUARTERLY FLOW FOR 1981



FileName:	BERRY.WK3
Yearly Totals	YEAR
Evaluation Year	1981
Highest Peak Flow	450
Date Highest Flow	02-Jun-92
Spg Qtr Totals	
First Peak Flow (cfs)	88
Date First Peak Flow	25-May-92
Highest Peak Flow	450
Date Highest Flow	01-Jun-92

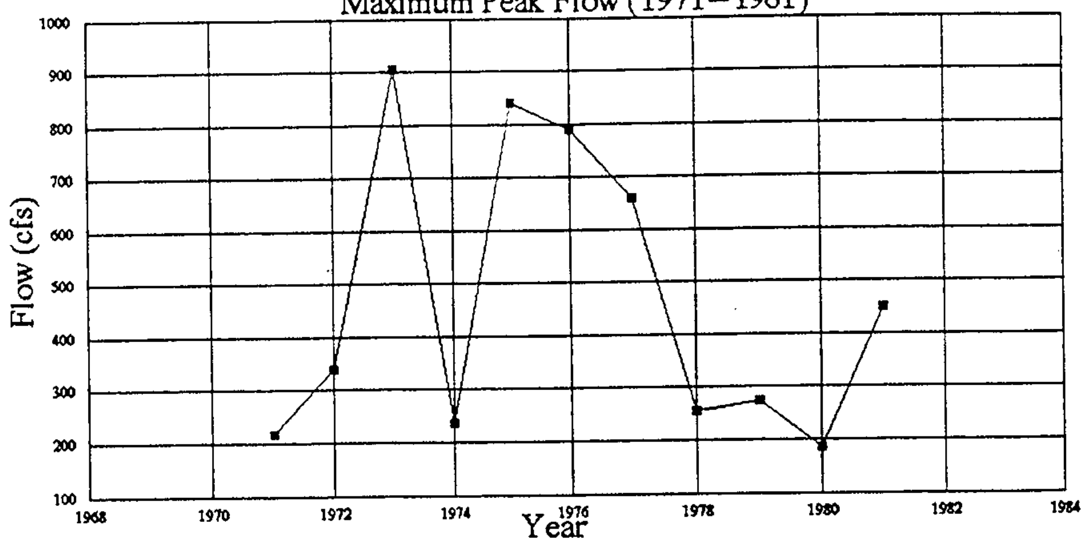
Figure 1

BERRY CREEK ANALYSIS: 1971-1981

Yearly Totals	Evaluation Year	Highest Peak Flow	Date Highest Flow	Qtr	First Peak Flow	Date First Peak Flow
YEAR	1971	217	14-Aug	Spg Qtr	0	NA
YEAR	1972	340	27-May	Spg Qtr	300	20-May
YEAR	1973	904	09-Jun	Spg Qtr	140	06-May
YEAR	1974	235	30-Jun	Spg Qtr	210	22-May
YEAR	1975	841	04-Jun	Spg Qtr	400	22-May
YEAR	1976	790	10-Jun	Spg Qtr	120	02-May
YEAR	1977	659	22-Jun	Spg Qtr	200	18-May
YEAR	1978	256	29-May	Spg Qtr	40	28-Apr
YEAR	1979	274	02-Aug	Spg Qtr	200	03-May
YEAR	1980	185	17-Jul	Spg Qtr	43	28-May
YEAR	1981	450	01-Jun	Spg Qtr	88	25-May

BERRY CREEK

Maximum Peak Flow (1971-1981)



BERRY CREEK

Spg Qtr Max Peak Flow (1971-1981)

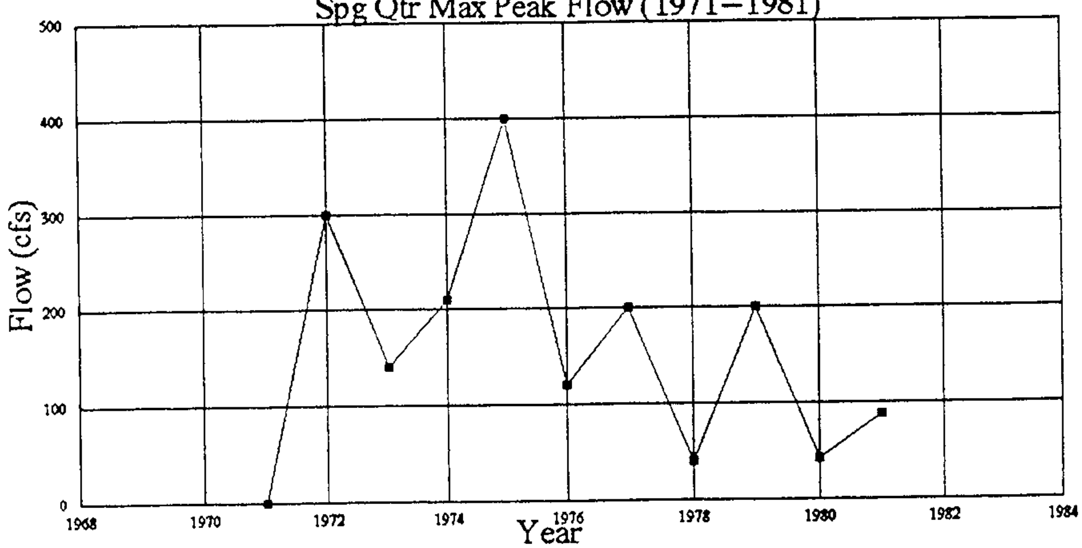


Figure 2