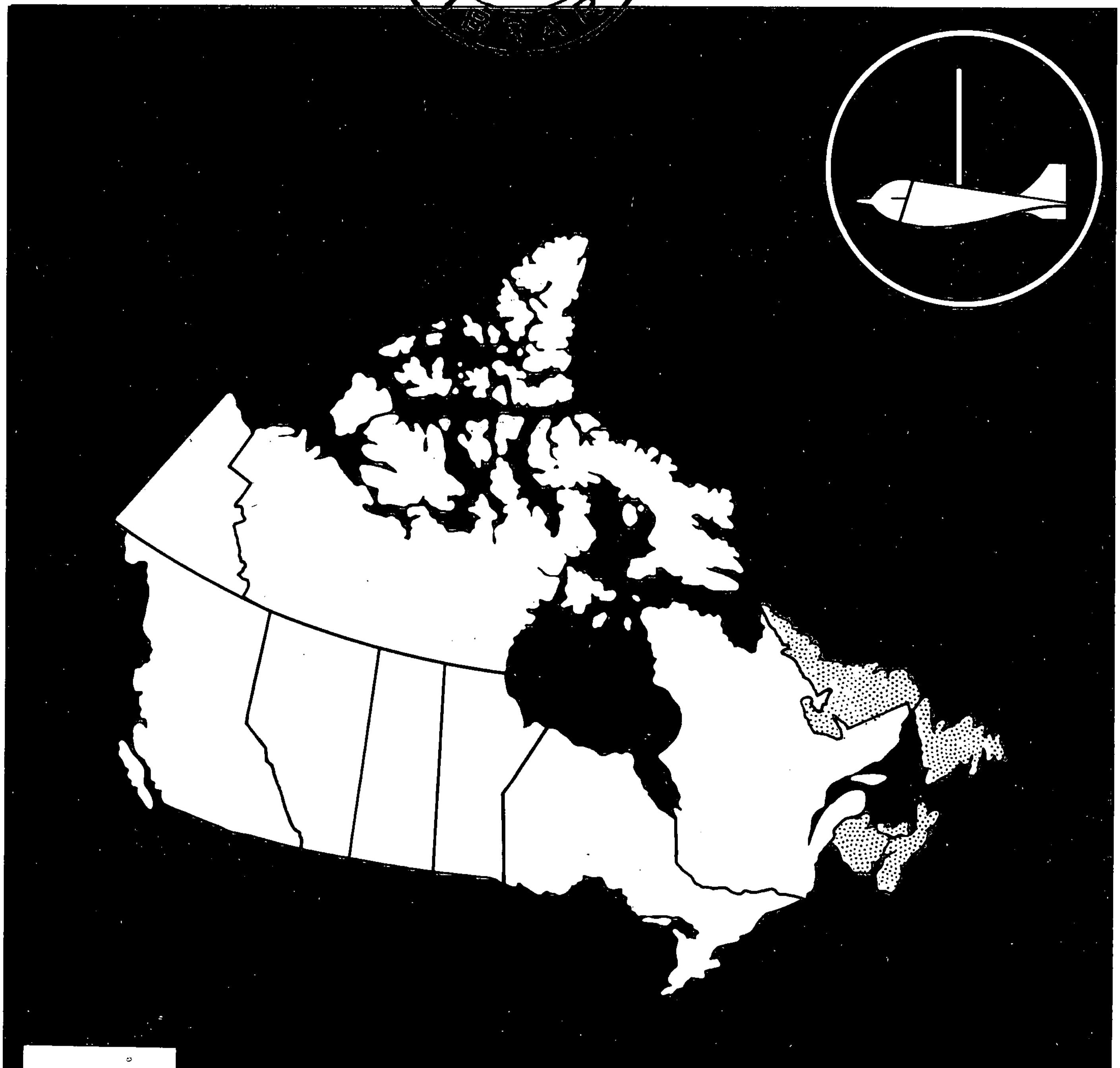
Canada. IWD/Atlantic Region
Water Resources Branch
88-137

INTERPRETATION OF SEDIMENT DATA 1972 - 1985 WILMOT RIVER PRINCE EDWARD ISLAND

IW/L - AR - WRB - 88 - 137



ESOURCES BRANCH
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DIRECTION DES RESSOURCES EN EAU
DIRECTION GÉNÉRALE DES EAUX INTÉRIEURES ET DES TERRES

ATLANTIC REGION

These Stereoscopic Pairs of Aerial Photographs (Source L.R.I.S.) Provide a Partial Overview of the Wilmot River Basin Topography

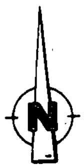

Plate a. The arrow locates the junction of Highways 1a and 107 and the Wilmot River estuary below the gauge.

Scale
1:35,000

Plate b. The arrow locates the Wilmot River near Wilmot Valley gauging station.

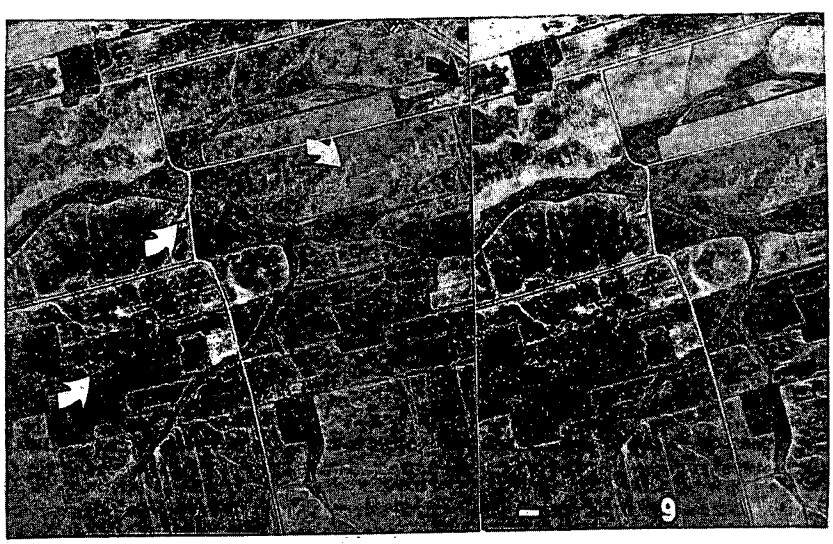

Plate c. The top (black) arrow locates an extraction site near Norboro above the gauge.

INTERPRETATION OF SEDIMENT DATA

1972 - 1985

WILMOT RIVER

PRINCE EDWARD ISLAND

IW/L-AR-WRB-88-137

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ABSTRACT

Sediment data have been collected at the hydrometric gauging station site, Wilmot River near Wilmot Valley, Prince Edward Island from 1972 to the present as part of the ongoing Water Resources Branch National Sediment Surveys Program. This report deals primarily with suspended sediment data collected during the period 1972 to 1985, inclusive, and presents the collected data in various tabular, graphical and statistical formats. It also contains a basin description and a section on land use and river sediments. The suspended sediment program, operated by the Water Survey of Canada Division, Water Resources Branch, is evaluated and recommendations are presented. This material is intended for the Federal/Provincial coordinators of the cost shared Water Quantity Surveys, Water Survey of Canada staff and users of sediment data.

The analyses and interpretations of the sediment data are for the purpose of assessing if sufficient data exist for load determinations. The interpretation of the suspended sediment data set showed that our knowledge of mean characteristics of the sediment regime can be improved only slightly by further sampling. The Wilmot River sediment station is one of two sediment stations in the most active agricultural zone of the province. The Wilmot gauge has more accurate sediment data relative to the other sediment gauge. Therefore, it is recommended that the detailed sediment sampling on the Wilmot River be continued for at least another five years.

RESUME

Des données sur les sédiments ont été collectionnées à la station hydrométrique Wilmot River près de Wilmot Valley, Ile-du-Prince-Edouard à partir de 1972 jusqu'à présent comme composante du Programme national des relevés des sédiments de la Direction des ressources en eau. Ce rapport, qui s'occupe principalement des données sur les sédiments en suspension obtenues pour la période de 1972 à 1985 inclusivement, les présente sous divers formats tabulaires, graphiques et statistiques. Ce rapport contient aussi une description du bassin de même qu'une section sur l'utilisation des terres et les sédiments de rivière. Le programme de sédiments en suspension, opéré par la Division des relevés hydrologiques du Canada, Direction des ressources en eau, est évalué et des recommendations sont présentées. Ce matériel fut préparé pour les coordinateurs d'ententes féderales-provinciales à frais partagés sur les Relevés de la quantité des eax, pour les employés de la Division des relevés hydrologiques du Canada et pour les utilisateurs des données sur les sédiments.

Les analyses et les interprétations des données de sédiment ont pour but d'évaluer s'il existe suffisamnent de données pour déterminer les débits solides. L'interprétation des données sur les sédiments en suspension nous indique que nos connaisances en termes de caractéristiques moyennes du régime sédimentologique ne s'améliorerait que peu avec de l'échantillonage additionnel. La station de sédiment de Wilmot River est une des deux stations de sédiment dans la zone agricole la plus active de la province. Parce que la jauge de Wilmot River a des données de sédiment plus exactes relativement aux autres jauges de sédiment, il est recommandé que l'échantillonage intense sur la rivière Wilmot soit continué pour au moins cinq ans.

ACKNOWLEDGEMENT

Thanks are expressed to Dave Wilson of the Lands Division of the Water Planning and Management Branch of Inland Waters/Lands, Atlantic Region who accompanied the author on a tour of the Wilmot River watershed. Mr. Wilson took most of the photographs of the sediment sources in the basin and he also prepared the section on "Land Use and River Sediments" found in this report.

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INTERPRETATION OF SEDIMENT DATA
1972 - 1985
WILMOT RIVER
PRINCE EDWARD ISLAND

1.0 INTRODUCTION

1.1 Historical Perspective

Suspended sediment data have been collected on the Wilmot River near Wilmot Valley, Prince Edward Island, since January of 1972. Hydrometric data have been collected at this location for the same period. The sediment program was originally required to study the effects of agricultural practices and soil movement (Pol, 1976). The data were used for Federal/Provincial Programs. The Water Survey of Canada Division of the Water Resources Branch of Environment Canada has the responsibility for collecting the sediment data.

Figure 1 shows the location of the Wilmot River in Prince Edward Island. There are approximately 14 years of suspended sediment data available for interpretation on this river.

The term "sediment" is used herein to mean the characteristics of the suspended sediment regime, e.g., means, ranges, and variability of concentrations and loadings on various time scales.

1.2 Objectives

The objectives of the study are to:

1. Analyse and interpret the 1972 to 1985 sediment record for the purpose of assessing if sufficient data exist for load determinations.

2. Make recommendations concerning future data collection at this site.

These objectives comprise the mandate of the Hydrology Division of the Water Resources Branch. The information contained in the large data files created by the Water Survey of Canada Division is made more usefull when analysed and presented for subsequent decision making. At the same time, the analysis provides insight into the sampling program and allows for recommendations to be given to the Water Survey of Canada Division.

1.3 Report Format

This report is modelled on the existing series of sediment station analysis reports, issued by the Water Resources Branch, Environment Canada (Day and Spitzer, 1985).

2.0 BACKGROUND

2.1 Hydrometric Station Description

The Wilmot River near Wilmot Valley gauging station has been operated on a continuous basis since 1 January 1972. This station consists of a stilling well with an A-35 Stevens strip chart recorder. The instrumentation is housed in a metal shelter on the left bank and on the downstream side of the road bridge. The bridge is upstream of the dam. Streamflow measurements during high stages are taken from the bridge. Low and medium water and ice cover discharge measurements are made by wading, or through the ice, in the vicinity of the gauge.

The stage-discharge relationship for this station has been fairly stable, although, the control has shifted over the years. A total of seven curves have been used since 1972. The bed material is composed of a sandstone material with a sandy-gravel texture. The stability of the measurement section is documented in Figure 2, where several cross-sections over the period of 1972 to 1984 are superimposed.

The Wilmot River near Wilmot Valley has natural flow.

2.2 Basin Description and Hydrology

The Wilmot River flows in a westerly direction into the Bedeque Bay, which forms a part of the Northumberland Strait. The hydrometric gauging station is situated approximately 3 km above the dam at Wilmot Valley.

In general, groundwater is effluent to rivers on Prince Edward Island. The movement of groundwater is permitted both by intergranular permeability of the soils and interjoint flow in the bedrock.

The soils in the Wilmot River Basin are podzols, i.e., strongly leached soils, comparatively low in plant nutrients and acid in reaction. The basin is made up of a number of ground moraines with a clay-sand till. The average land slope varies between zero to four percent. The topographic features of the basin included in order of magnitude are: cultivated vegetation, woodland, and urban centers.

The climate (Brandon, 1966) is described as humid and temperate. There is a long and fairly cold winter, a cool summer with a relatively long frost-free period, and frequent precipitation. The mean annual precipitation is 42.3 inches (1074 mm). The main months of snowfall are from December to March. Break-up occurs during April.

The Wilmot River to the hydrometric gauge near Wilmot Valley, which drains an area of some 45.4 km^2, has a circular shaped watershed approximately 32 km in circumference. There are no lakes of any consequence in the Wilmot River Basin.

The main physical features and runoff characteristics of the Wilmot River above the Wilmot Valley hydrometric gauging station are presented in Table 1.

2.3 Land Use and River Sediments

Although, in previous sediment studies there where a variety of land use factors contributing to stream sediment conditions at the hydrometric gauge sites, in the Wilmot basin, agricultural activity is the dominent land use.

Land use, which includes land activity and land cover, for the majority of the area above the gauge (a sub-basin of 3,518 ha of the 4,540 ha covered by the gauge) has recently been completed under contract for the Technology Development Program of the Canada-Prince Edward Island Subsidiary Agreement. The following is an adaptation of a land use table from the contract completed by Marenco Engineering Ltd. and represents conditions in 1986 for the sub-watershed.

Agricultural Land Use	Area (ha)	% of Sub-watershed
Grain	1,030	30
Potatoes	638	18
Hay & pasture	613	17
Rye grass & peas	179	5
Soybeans	150	4
Bare soil (recent)	119	3
Idle land (1986 growing season)	27	1
Subtotal	2,756	78
Non-agricultural Land Use		
Urban (transportation residental & commercial)	244	7
Forest	511	15
Water & wetland	7	0*
Subtotal	762	22
Total	3,518	100

* Value rounded to the nearest whole number.

From the previous information, 74% of the sub-basin is under agricultural crop and it is likely the other 3% of bare soil is associated with agricultural activity. Also of interest is the intensive use made of the land in the basin as indicated by the lack of idle land (1%) in the sub-basin.

Various experiments, such as the one to determine soil runoff from various land covers shown in Plate 1, illustrate an increasing amount of concern on the subject of erosion in the province. This is one of four long-term test sites noted on a field trip in October, 1987. All photographs shown in this report, unless otherwise stated, where taken in the fall of 1987 field trip. The wide profile tires on the vehicle spreading lime in Plate 1, is one form of remedial action taken to reduce detrimental soil compaction/erosion in the basin.

Some of the land use practices linked to the amount of suspended sediments reaching drainage channels and observed in the basin are as follows: crop types that are prone to soil erosion, expanded field size with the removal of windrows which lead to increased soil transport to water courses by the wind and the use of heavier farm machinery which compacts the soil resulting in reduced infiltration and a corresponding increase in runoff transporting soil. A potato harvest operation at Paynter (Plate 2) is representative of the landscape found in the Wilmot basin.

Of particular interest are the estimates linking land use and soil loss based on specific crops, derived from the Universal Soil Loss Equation (U.S.L.E.) by Marenco, for 100 sample points within the upper Wilmot basin. It should be stressed that U.S.L.E. use is for modelling purposes and has not been interpolated for the exact area covered by the gauge. Certainly the total loss per year appears to be higher than the total interpreted from the sediment samples taken at the gauge site.

Somewhat of a surprise, having observed what appeared to be a dense cover of litter on harvested soybean fields during the field trip, was the fact that soybeans had the highest estimates of calculated yearly soil loss of the land covers sampled as shown in the land use table by Marenco Engineering Ltd. At 16.58 tonnes/ha/year, this crop surpassed average soil loss from potato fields (11.20 tonnes/ha/year) followed by "bare soil" at 8.29 tonnes/ha/year. Runoff from potato fields, due to the area planted and the relatively low loss from fields planted to grain (6.05 tonnes/ha/year), accounts for the greatest calculated soil loss in the sub-basin sampled (36.6%). Soybean fields are concentrated roughly midway between Baldwin and Summerfield.

To follow are photographs documenting various land activities and land covers that affect stream sediment loadings. Soil compaction on a harvested potato field is evident in Plate 3 as is the down slope direction (northwest) of the past crop rows. One means of conserving soil is to employ contour and cross slope cultivation practices as shown by the arrow in Plate 4 near Summerfield.

Although historically farm consolidation has occurred, generally holdings of the majority of farm owners (52%) fall into individual units of less than 40 ha. As well there tends to be a lot of renting and short-term exchanges of fields between individual land owners.

From an environmental point of view it is difficult to determine land cover trends needed to establish long-term non-point sources of sediment. Fields, many of which are widely scattered, tend to destort crop rotation patterns based on land tenure thus making it harder to establish remedial soil conservation measures.

Also from an environmental point of view when considering runoff/erosion, is the flatness of the terrain (see Plate 2) which is also advantageous to farm producers. The average land slope is but 0.8% and over 90% of the sub-basin has a slope of less than 5% according to the Marenco report.

The stereoscopic pairs of aerial photographs (taken May 2, 1985) shown in Plates a,b, & c, located on the inside front cover, provide a partial overview of the Wilmot basin topography. For the reader equipped with a stereoscope, note the internal field surface drainage patterns in these three plates. Plate b shows the lack of protective tree cover in the fields above and below the Wilmot gauge (arrow in Plate b). A fringe of cover along the river banks is present to stabalize banks and provide improved fish habitat. Plate c, centred two kilometres southwest of Norboro, emphases the factors that affect the sediment regime of the basin. Included in this photograph are an area of heavy soil erosion from a steeper slope (1 km southwest of Norboro, top white arrow); an old extraction site adjacent to the main stem of the Wilmot River (centre white arrow and shown in Plate 5) and cutting in a woodlot upslope (bottom white arrow). The white areas in these photographs, for example, the white area northeast of the gauge site (Plate b) represents an area of deposition (crusting) of fine grained materials eroded from the upper slopes.

Several surface extraction sites adjacent to streams were noted during the fall field trip. The use of recreational vehicles at this site in Plate 5 (the arrow shows the tire tracks) is retarding the establishment of a protective vegetative cover. In another case, an active pit one kilometre east of Baldwin threatens to undermine a tributary of the Wilmot River located in the alder shrubs in the upper right of Plate 6.

Bank slumping was evident one kilometre southwest of Summerfield. Direct access to a relatively long portion of the river bank of the Wilmot by cattle is one cause of the increased slumping as illustrated in Plate 7. Here, there is a lack of a protective fringe of vegetation and the river proved turbid during the fall field trip. Such a vegetated fringe is evident in Plate 8 which is situated immediately north of the gauge site adjacent to Highway #110. On the other hand, the soil in a field at the eastern end of the basin, between Summerfield and Springfield (Plate 9), is not protected from runoff by a grass channel or by an uncultivated fringe of other vegetation, the arrow shows the unprotected gully running through the field.

As already noted there are not a lot of ponds and wetlands in the basin. Most ponds are man-made such as this one, with a fish ladder, at Mill Valley (Plate 10). These ponds tend to collect sediment from upstream locations.

Lime is trucked into the Wilmot basin from outside of the province. The lime in the hopper of the truck in Plate 11 originated in Saint John, New Brunswick. Lime is applied to the fields at a rate of 4 to 5 tonnes/ha (Personal commmunication, N. Stuart of P.E.I. Agriculture) and indirectly assists in maintaining water PH suitable for sustaining an inland fishery. Where there was a cover over the streams (bridge,alders,culvert, etc.) trout were observed in many locations, indicating at least a relatively good level of water quality.

Two additional observations were noted for which their effect on sediment in the Wilmot River have not been determined. One is the effect of "tile-drainage" as indicated by the white pipe, the triangular sign and the raised ridges in the field in the background in Plate 12 north of Mill Valley. The sediment deposit (see arrow) at the base of the pipe may have come from the pipe and/or the ditch to the right. The other observation involved chemical cans (bottom arrow, Plate 13) noted at the gauge site, indicating that agricultural applications may have been mixed there. Also, at this site there is evidence that sediment reaches the river from the road ditch. The dense cover of alders in which the gauge house is situated (upper, shorter arrow) help stabilize the river bank, but the leaning spruce tree (longer arrow) is an indicator that the bank has been eroded.

In conclusion, it is believed that most of the river sediments in the Wilmot basin are produced by the agricultural activities and by stream bank erosion. It should be noted that with the establishment of at least four long-term erosion test sites in the triangle formed by Paynter-Springfield-Norboro, much needed additional information on the sources of sediments in the Wilmot basin will be realized.

3.0 SEDIMENT TRANSPORT DATA

3.1 Data Collected

The available data set for the Wilmot River near Wilmot Valley consists of the following:

1. suspended sediment concentrations of depth-integrated samples;

2. suspended sediment loads;

3. particle size analyses of suspended sediment of depth-integrated samples;

4. particle size analyses of bed material samples;

5. dissolved solids concentrations;

6. water temperatures.

In this report only the first two data sets outlined above are considered. It was not thought appropriate to interpret the other data or to draw any conclusions due to the limited amount of information available in the other sets.

3.2 Sampling Procedures and Equipment

Table 2 shows the number of days in each month when sample concentrations were collected, over the period 1972-85. These samples were collected using manual sampling and continuous operation for the entire period of record. The sampling effort is more or less evenly concentrated throughout the year, whereas, the high sediment loads occur in the period December to May. Figure 3, a flow duration curve and sediment sampling bar chart, also shows that the sampling effort is evenly spread out during the year, although, the greatest number of samples were taken in the highest 10% flow interval. Figure 3 shows, for example, that 38.1% of the samples were collected during the higher flows (0.9 m^3/s or greater) that occurred over 30% of the time. The sediment loadings that occurred over 30% of the time have a magnitude of 0.8 tonnes per day or greater (Figure 4).

The sediment samples are taken by an observer using a wading-type hand sampler (DH48). The single sampling vertical is referenced as one quarter the distance from the left bank (1QLB) in the vicinity of the gauge.

Bed material samples were taken from this site in 1974 and 1978.

3.3 Data Presentation

Calculated daily mean concentrations, suspended sediment loads, and grain size analyses of bed material and of suspended sediments are contained in the annual sediment data publications for Canada, issued since 1965, e.g., "Sediment Data, Atlantic Provinces, 1984" Inland Waters Directorate, Water Resources Branch, Water Survey of Canada, Ottawa, Canada, 1986 (Environment Canada, 1965 to 1985). The Wilmot River data set starts in the 1972 issue.

Table 3 presents a summary of the flow and suspended sediment data by year. Monthly and annual sediment loads are listed in Table 4 for the period of record to 1985.

3.4 Representativeness of Sediment Record Period

Frequency plots of annual maximum daily discharge and annual flow volume for the 1972 to 1985 hydrometric record are shown in Figure 5. The hydrometric and sediment program both started in 1972 at this site, hence, the sediment program operated throughout the range of discharges shown in Figure 5. Although the range in flows is good, it by no means covers the entire range of flows possible at this site. The annual maximum daily sediment load and total annual load are also shown in Figure 5. It should be noted that the fit of the three parameter log-normal distribution to the sediment data is not as good as that of the discharge data set. Note, when there was no three parameter log-normal solution the log-normal distribution was used.

Another method of illustrating the representativeness of the period of record to the long-term conditions is shown in Figure 6. The sediment program began during a period in which the flow was at its long-term condition and the suspended sediment load was well above its mean. From that point onward, the flow and suspended sediment data sets do not appear to show trend or of being anomalous in the statistical sense. Owing to the shortness of records this diagram only shows the variability of flow and sediment characteristics within the period of record.

3.5 Other Sediment Information Available

The other information that is available for this station, for completeness, is presented in Figures 7 to 9. Figure 7 shows a composite plot of grainsize distribution curves for all depth-integrated samples analysed. Figure 8 shows similar information for the bed material samples.

The rating relationship of dissolved solids versus daily mean discharge is presented in Figure 9. It is interesting to note that the curve has a negative slope, i.e., as the discharge increases the dissolved solid concentration decreases. This could be due to the fact that groundwater is effluent to streams on Prince Edward Island.

4.0 INTERPRETATION OF SEDIMENT DATA

4.1 Suspended Sediment Loads

The annual flow volume in cubic decametres recorded at the Wilmot River gauge is shown on Figure 10. A mean value of 30,100 dam^3/year is shown on this figure for the period 1972 to 1985. By dividing by the drainage area in square kilometres the mean depth of runoff over the basin is found to be 663 mm. Figure 10 also displays the suspended sediment load in tonnes passing by the Wilmot River station each year. The mean value of 1,730 tonnes/year is seen on this figure for the period 1972 to 1985. Assuming, like the above data, that the production of suspended sediment is uniform over the basin a unit value of 38.1 tonnes/km^2/year is calculated. However, sediment production is more likely to be from relatively few areas and most probably the river banks themselves. Therefore the unit value must be taken with this qualified assumption at all times. The annual data sets used to produce Figure 10 are tabulated in Tables 4 and 5.

From Table 4, the range of annual suspended sediment data is seen to vary from a low of 399 tonnes in 1985 to a high of 4,120 tonnes in 1979. This range represents a ten fold variation from the lowest to highest values. Comparing the range in flow volume over the same time period shows only a two fold variation. This leads to conclude that more than runoff influences the suspended sediment movement. The numerous physical characteristics, some static some dynamic, are influening the sediment movement at times more than the basin runoff. The suspended sediment movement within a year varies considerably. From Figure 11, it can be seen that most sediment moves during the December to May, inclusive, time period. Higher flows also occur during this period. The lines showing sediment concentration and discharge on Figure 11 are the means of all daily values in the years 1972 to 1985, inclusive.

The amount of flow or suspended sediment in any month can be expressed as a percentage of the annual value. Figure 12 shows the relative percentages for each month. The dominant sediment related flow characteristics are the winter and spring months when approximately 88% of the sediment load is discharged passed the Wilmot River station. On average, sixty-eight percent of the total annual discharge passes the gauge during this same period.

Natural variation from year to year gives scatter to a time series, however, at times change may tend to go in one direction more often. Mass curves are useful to show if trends are occurring. Figure 13 is a plot of cumulative sediment and flow data. There is insufficient record length to determine if the variability in this diagram signifies any nonstationarity. Further tests were done on the data sets using non-parametric tests to look for trend, homogeneity, etc. These tests did not detect any presence of trend, etc., in the flow or sediment data sets.

Annual sediment loadings are not from a smooth production throughout each year. A large fast runoff could produce most of the years sediment. Figure 14 illustrates how short duration events can include a significant proportion of the seasonal and therefore annual loadings. This plot shows the annual total discharge and the annual total load for the period 1972 to 1985. The maximum loads occurring in the 1% and 10% of the annual period, 3.7 and 36.5 days, respectively, are also shown. On average, the maximum 3.7 day load carries 28% of the annual total load. The maximum 36.5 day load carries about 58% of the annual load. Total discharge ranged between 7% and 26% of the total annual for the 1% and 10% of period, respectively. Figure 15 also illustrates that the majority of the sediment load carried by the Wilmot River for the period 1972 to 1985 occured over a short period of higher flows. It can be seen that 80% of the total suspended load was carried in about 5% of the time (Figure 16).

The limited record length affects the precision of the long-term estimates of mean conditions, i.e., discharge, load and concentration. As each year of successive data are gathered more of the variability is seen in the long-term data set. The relationship between the standard error of estimate for total annual discharge and record length is shown in Figure 17. The same diagrams for total annual load and mean annual concentration are shown in Figures 18 and 19, respectively. After fourteen years of sediment and discharge records the standard error of the mean is reduced to about 5% for flow and about 10 to 15% for sediment. The percentage gain in the standard error of the mean discharge, load or concentration for each additional year of record is less than 1%. An extension of these data indicates that further data would not substantially improve the standard errors of estimate for mean annual discharge, load, or concentration.

A relationship exists between the sediment movement and basin runoff. Figure 20 shows the relationship between daily mean discharge (m^3/s) versus daily mean suspended sediment (mg/l) for all days sampled in 1984. Table 6 presents the same information for other selected years. The average standard error of estimate obtained for these relationships was about ±90%. Table 6 also presents instantaneous discharge versus instantaneous sediment for the 1984 sampling year for various time periods. The standard error of estimate ranged from ±141% for the April to June period and ±57% error for the October to December period.

Figure 21 depicts the rating relationship of total annual discharge (dam^3) versus total annual suspended load (tonnes). Figures 22 to 24 present similar information but, on a monthly and mean monthly basis. Figure 23 presents the rating of monthly mean discharge in m^3/s and monthly mean sediment in mg/l. Table 7 summarizes the rating relationships. It would appear, judging by the standard errors of estimate, that none of the ratings gave satisfactory results. The discharge alone does not provide enough information to estimate suspended sediment in the Wilmot River.

5.0 PROGRAM EVALUATION AND RECOMMENDATIONS

The suspended sediment data collection program at the Wilmot River at Wilmot Valley hydrometric gauging station represents sediment loadings and yield from an agricultural environment. It is believed that most of the river sediments are produced by the agricultural activities and by stream bank erosion.

For the 1972 to 1985 period of record, the mean annual sediment load was 1,730 tonnes. The annual loads have varied by a factor of ten between the smallest to largest annual total loads. Over the same period, the annual flow volume varied by a factor of two. More than 88% of the sediment load is transported during the six months of December through May.

The findings of this interpretation indicate that the data collected to date are sufficient to define the present-day suspended sediment regime of the Wilmot River. In particular, the analyses indicate the following:

(1) the range in the data is good, i.e., it covers the range of recorded flows, for the period 1972 to 1985

(2) estimates of the <u>mean</u> characteristics of the suspended sediment regime can be improved only slightly, if basin use does not change

(3) annual variability is well documented, for the period 1972 to 1985

(4) any presence of trend in the data set is not noticeable, for the period 1972 to 1985.

Although our knowledge of how representative these data are of long-term conditions is incomplete, a lengthier program to address only this aspect cannot be justified. Furthermore, for most anticipated engineering design needs sufficient mean annual and monthly data now exist.

It is also realized that the Wilmot River at Wilmot Valley station is one of two sediment stations within the same sediment zone as outlined by T. Ingledow & Associates Limited in 1970; the Wilmot gauge having the more accurate sediment data. Also, in a recent assessment of sediment issues in the Atlantic Provinces (Washburn & Gillis Associates Ltd., 1985), it was recommended that a basic network of long-term stations be retained.

Other factors must be considered in recommending the future management of this station. The Wilmot River Watershed has the highest proportion of land use in agriculture than any other basin on Prince Edward Island. It is for this reason that leads the author not to discontinue this station. Research into decreasing sediment movement by altering farming practices is ongoing and its success can be quantified by continued monitoring. Therefore it is been recommended:

(1) That the sediment program for the Wilmot River be continued in its present state for at least another 5 years.

(2) Research involving multiple regression techniques relating sediment loadings to watershed physiographic and hydrologic parameters is needed. The relationships developed only between total flow and total sediment are considered to be adequate, but it would be more accurate to relate sediment movement to physical and climatic parameters (slope, soil type, rainfall intensity, etc.) in addition to the flow parameter. The existing data set (suspended sediment loads) from the Wilmot River would provide a good basis for this research.

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APPENDIX A
(Tables)

TABLE 1

Runoff Characteristics of the Wilmot River near Wilmot Valley
Period 1972 to 1985

Drainage Area (km^2)	45.4
Length (Meander) to Mouth (km)	19
Area of Lakes (percentage of D.A.)	0
Recorded Minimum Daily Discharge (m^3/s) (on February 11, 1972)	0.153 B
Recorded Maximum Daily Discharge (m^3/s) (on February 12, 1981)	19.1
Recorded Maximum Instantaneous Discharge (m^3/s) (on February 12, 1981)	29.1
Mean Annual Runoff (m^3/s)	0.955
Mean Annual Runoff (mm)	664
Years of Record	14

B - Ice Conditions

TABLE 2

Summary of Suspended Sediment Sampling Strategies

Showing Number of Days Sampled Each Month

Month

Year	Jan.	Feb.	Mar.	Apr.	May	June	July	Aug	Sept.	Oct.	Nov.	Dec.	Total
1972	0	1	6	5	13	7	6	4	5	5	3	3	58
73	5	3	3	4	5	4	4	3	4	3	2	3	43
74	1	2	2	1	5	8	7	3	3	3	8	3	46
1975	5	4	5	9	7	2	3	4	5	2	4	3	53
76	7	6	5	4	4	5	4	8	8	7	5	4	67
77	4	3	2	5	5	3	2	1	5	7	4	4	45
78	3	4	5	8	7	5	7	3	5	7	3	4	61
79	3	1	4	4	5	4	2	4	2	4	2	3	38
1980	3	2	4	5	2	2	7	4	6	2	4	3	44
81	4	6	2	6	4	2	5	3	4	9	8	5	58
82	3	4	5	11	7	3	4	2	4	2	2	4	51
83	4	3	5	6	7	6	5	9	2	1	3	2	53
84	6	7	9	1	5	8	7	8	5	7	2	4	69
1985	3	5	3	13	10	10	4	6	4	4	2	4	68
Total	51	51	60	82	86	69	67	62	62	63	52	49	754
% of Grand Total	7	7	8	11	12	9	9	8	8	8	7	6	100

Table 3

Summary of the Flow and Suspended Sediment Data Analyses

at the Wilmot River near Wilmot Valley Hydrometric Gauging Station

Annual Statistics

Year	Number of days Sampled	Mean Discharge (m^3/s)	Mean Concentration (mg/l) Cal.[1]	Mean Concentration (mg/l) Ave.[2]	Total Load (tonnes)	Basin Yield ($tonnes/km^2$)
1972	58	0.995	120	28	3 760	82.8
1973	43	0.858	70	18	1 880	41.4
1974	46	0.690	73	29	1 600	35.2
1975	53	0.853	23	11	624	13.7
1976	67	1.02	36	17	1 150	25.3
1977	45	1.21	33	16	1 260	27.8
1978	61	1.09	29	12	1 010	22.2
1979	38	1.14	115	38	4 120	90.7
1980	44	0.692	63	22	1 380	30.4
1981	58	1.10	55	24	1 900	41.9
1982	51	1.04	23	12	735	16.2
1983	53	0.890	69	23	1 950	43.0
1984	69	1.20	64	18	2 420	53.3
1985	68	0.598	21	8	399	8.8
	Mean :	0.955	57	20	1 730	38.1
	Standard Dev. :	0.20	32	8	1 100	24.1

1. Calculated using the function: $c = r/q$ where c = sediment concentration, r = sediment load, and q = flow.

2. Mean of daily concentrations.

TABLE 4

SUMMARY OF MONTHLY AND ANNUAL SUSPENDED SEDIMENT LOADS
WILMOT RIVER NEAR WILMOT VALLEY

	TOTAL LOADS IN TONNES												
YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1972	28	299	918	1060	1310	34	6	9	10	33	32	29	3760
1973	577	479	659	57	21	10	45	10	6	4	4	14	1880
1974	57	118	554	409	31	8	35	11	6	17	189	163	1600
1975	18	6	20	359	71	28	11	8	7	6	9	82	624
1976	183	263	233	51	17	12	14	29	24	39	79	208	1150
1977	76	23	457	408	25	38	21	14	18	79	27	74	1260
1978	379	22	178	329	43	10	8	7	6	14	6	4	1010
1979	1190	582	1110	531	27	11	89	24	16	47	204	288	4120
1980	119	11	671	359	9	6	11	12	6	7	70	100	1380
1981	37	757	53	67	90	148	14	7	5	285	177	265	1900
1982	28	21	101	391	69	51	14	7	9	10	3	30	735
1983	15	24	954	378	43	82	31	277	25	5	7	106	1950
1984	18	145	1690	356	66	54	30	38	5	3	4	9	2420
1985	8	4	67	202	61	15	5	4	2	2	4	23	399
MEAN	195	197	548	354	134	36	24	33	10	39	58	100	1730
S.D.	330	247	493	252	338	39	22	71	7	74	76	96	1100
% of Mean Annual	11.3	11.4	31.6	20.5	7.7	2.1	1.4	1.9	0.6	2.3	3.4	5.8	100

TABLE 5

SUMMARY OF MONTHLY AND ANNUAL FLOWS
WILMOT RIVER NEAR WILMOT VALLEY

MONTHLY AND ANNUAL MEAN DISCHARGES IN CUBIC METRES PER SECOND FOR THE PERIOD OF RECORD

YEAR	JAN	FEB	MAR	APR	MAY	JUN	JUL	AUG	SEP	OCT	NOV	DEC	ANNUAL
1972	0.505	0.665	1.57	2.18	2.93	0.799	0.528	0.425	0.377	0.433	0.717	0.787	0.995
1973	1.68	1.32	1.94	1.10	0.957	0.650	0.607	0.521	0.436	0.390	0.322	0.375	0.858
1974	0.657	0.845	1.18	1.40	0.629	0.500	0.451	0.362	0.330	0.391	0.586	0.962	0.690
1975	0.608	0.370	0.572	2.59	2.42	0.891	0.545	0.450	0.390	0.355	0.346	0.684	0.853
1976	1.21	2.05	1.36	1.02	0.826	0.547	0.454	0.449	0.631	0.730	1.32	1.74	1.02
1977	1.09	0.636	2.65	2.64	1.05	0.964	0.728	0.580	0.538	1.25	1.01	1.31	1.21
1978	2.63	1.11	1.51	3.00	1.59	0.791	0.577	0.465	0.378	0.417	0.356	0.293	1.09
1979	2.34	1.34	2.03	1.14	0.689	0.569	0.625	0.582	0.543	0.863	1.40	1.51	1.14
1980	1.19	0.596	1.38	1.02	0.572	0.434	0.386	0.362	0.345	0.350	0.540	1.11	0.692
1981	0.761	2.39	1.19	1.16	0.889	0.993	0.860	0.590	0.486	0.766	1.37	1.86	1.10
1982	1.27	0.971	1.32	3.08	2.04	0.897	0.621	0.501	0.450	0.413	0.345	0.546	1.04
1983	0.641	0.587	1.68	1.36	1.01	0.997	0.624	0.896	0.674	0.546	0.544	1.09	0.890
1984	0.838	1.84	2.52	2.37	1.66	1.29	0.928	0.742	0.628	0.571	0.513	0.507	1.20
1985	0.399	0.326	0.962	1.28	0.915	0.815	0.557	0.459	0.382	0.368	0.341	0.358	0.598
MEAN	1.13	1.07	1.56	1.81	1.30	0.796	0.607	0.527	0.471	0.560	0.694	0.938	0.955
% of Mean Annual Total Flow	10.0	8.6	13.9	15.6	11.6	6.9	5.4	4.7	4.1	5.0	6.0	8.2	100

TABLE 6

WILMOT RIVER NEAR WILMOT VALLEY
REGRESSION ANALYSIS
INSTANTANEOUS AND DAILY MEAN VALUES OF DISCHARGE VERSUS CONCENTRATION
ONLY SAMPLED CONCENTRATIONS

Daily Mean Discharge Versus Daily Mean Suspended Sediment

Year	r^2	Standard Error (%)
1972	0.642	± 96
1976	0.364	± 63
1980	0.636	± 96
1984	0.654	± 103

Instantaneous Discharge Versus Instantaneous Suspended Sediment
For The Year 1984

Period	r^2	Standard Error (%)
Jan-Dec	0.674	± 93
Jan-Mar	0.819	± 68
Apr-Jun	0.251	± 141
Jul-Sep	0.636	± 73
Oct-Dec	0.823	± 57

Note: Discharge in m^3/s,
Suspended Sediment in mg/l.

TABLE 7

ANNAPOLIS RIVER AT WILMOT
REGRESSION ANALYSIS
MONTHLY AND ANNUAL VALUES OF DISCHARGE VERSUS SUSPENDED SEDIMENT

Quantity	r^2	S_e (%)
1. Total Annual Discharge (dam^3) vs. Total Annual Sediment Load (tonnes) Period 1972 to 1985	0.208	± 60
2. Monthly Total Discharge (dam^3) vs. Monthly Total Sediment Load (tonnes) Period 1972 to 1985	0.724	± 103
3. Monthly Mean Discharge (m^3/s) vs. Monthly Mean Suspended Sediment (mg/l) Period 1972 to 1985	0.471	± 69
4. Mean Monthly Total Discharge (dam^3) vs. Mean Monthly Total Sediment Load (tonnes) Period 1972 to 1985	0.883	± 43

APPENDIX B
(Figures)

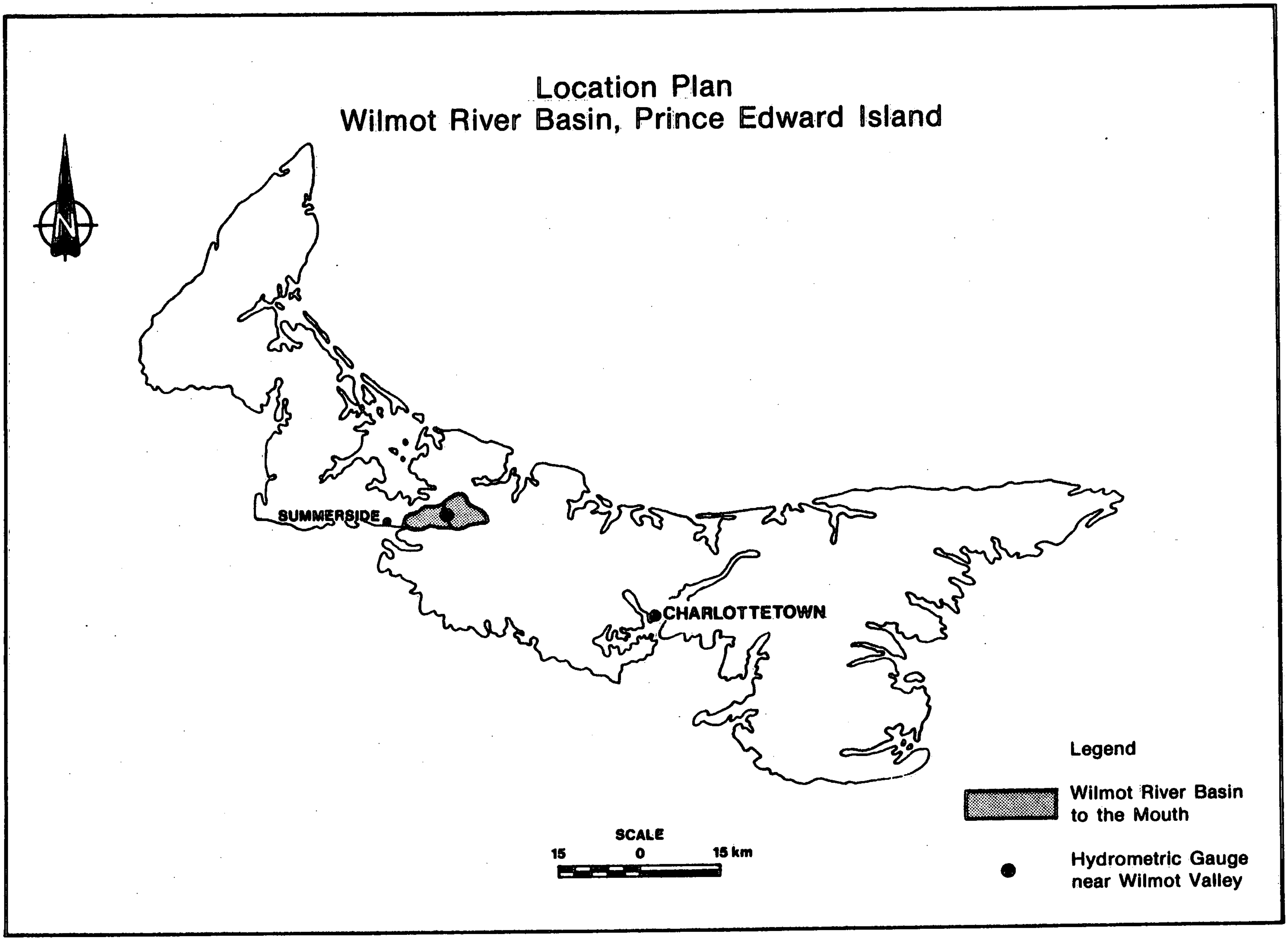

Location Plan
Wilmot River Basin, Prince Edward Island
N
SUMMERSIDE
CHARLOTTETOWN
SCALE
15
0
15 km
Legend
Wilmot River Basin to the Mouth
Hydrometric Gauge near Wilmot Valley

Figure 1

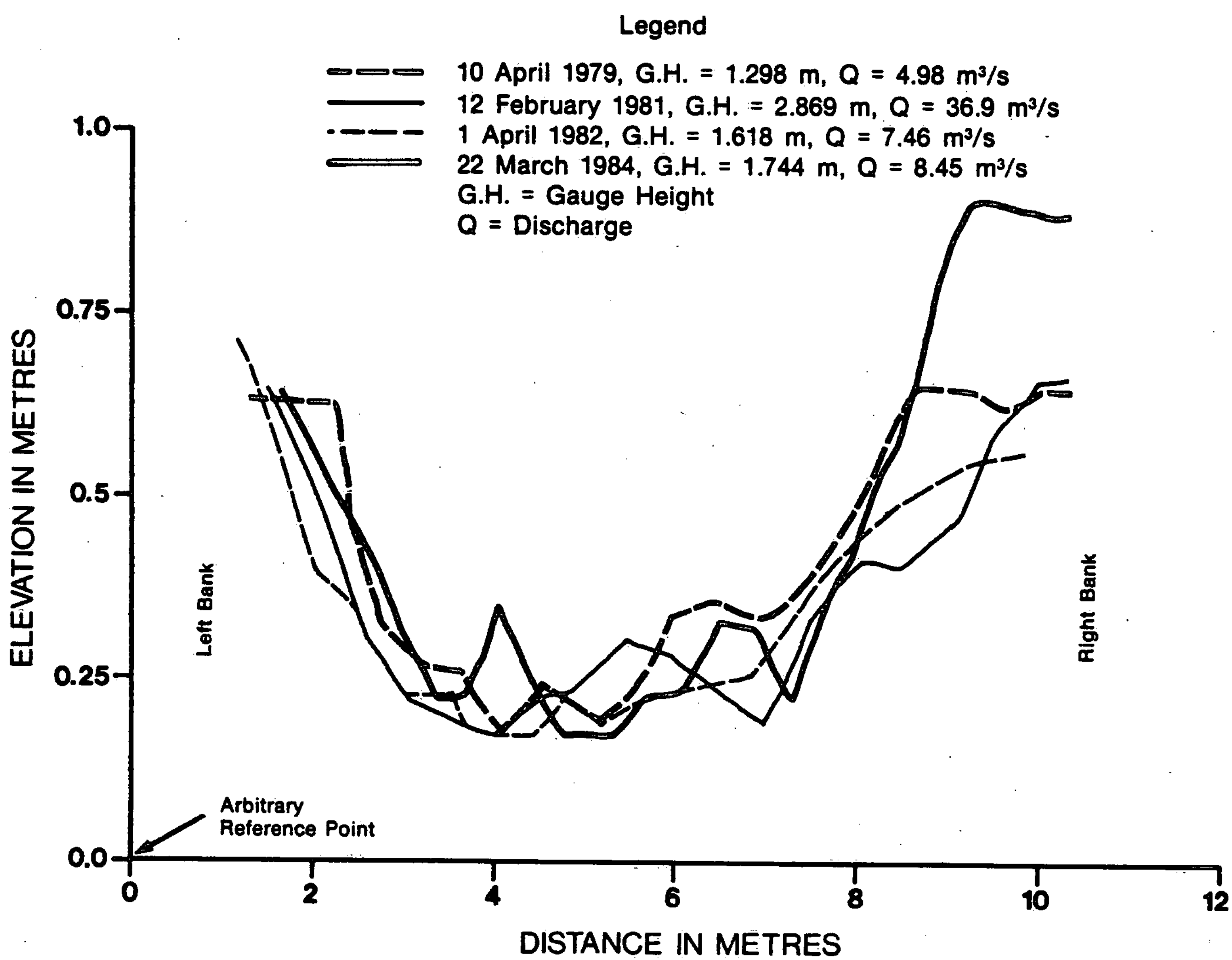


Figure 2 Wilmot River Cross-Sections
Road Bridge near the Gauge

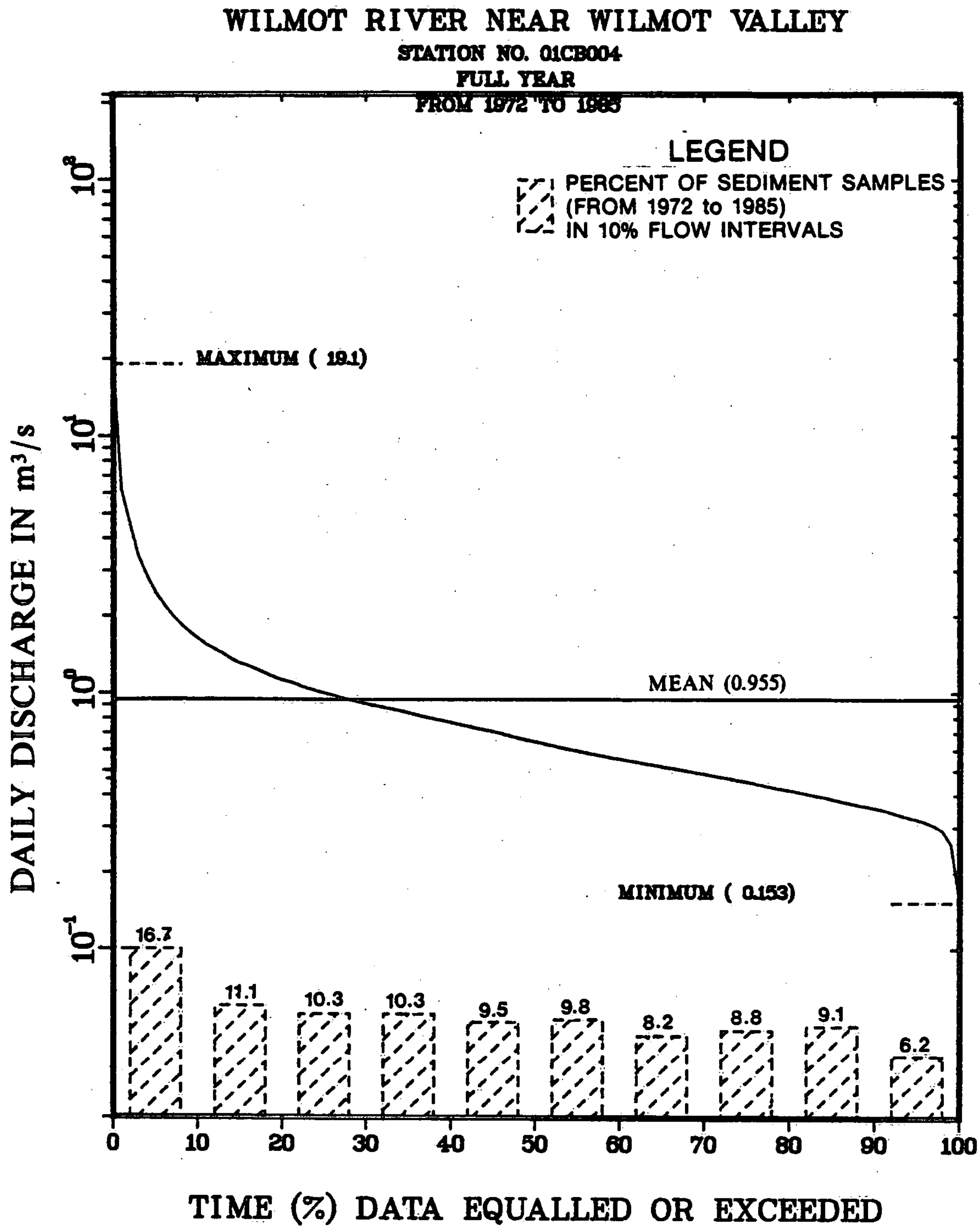


Figure 3 Flow Duration Curve and Sediment Sampling Bar Chart

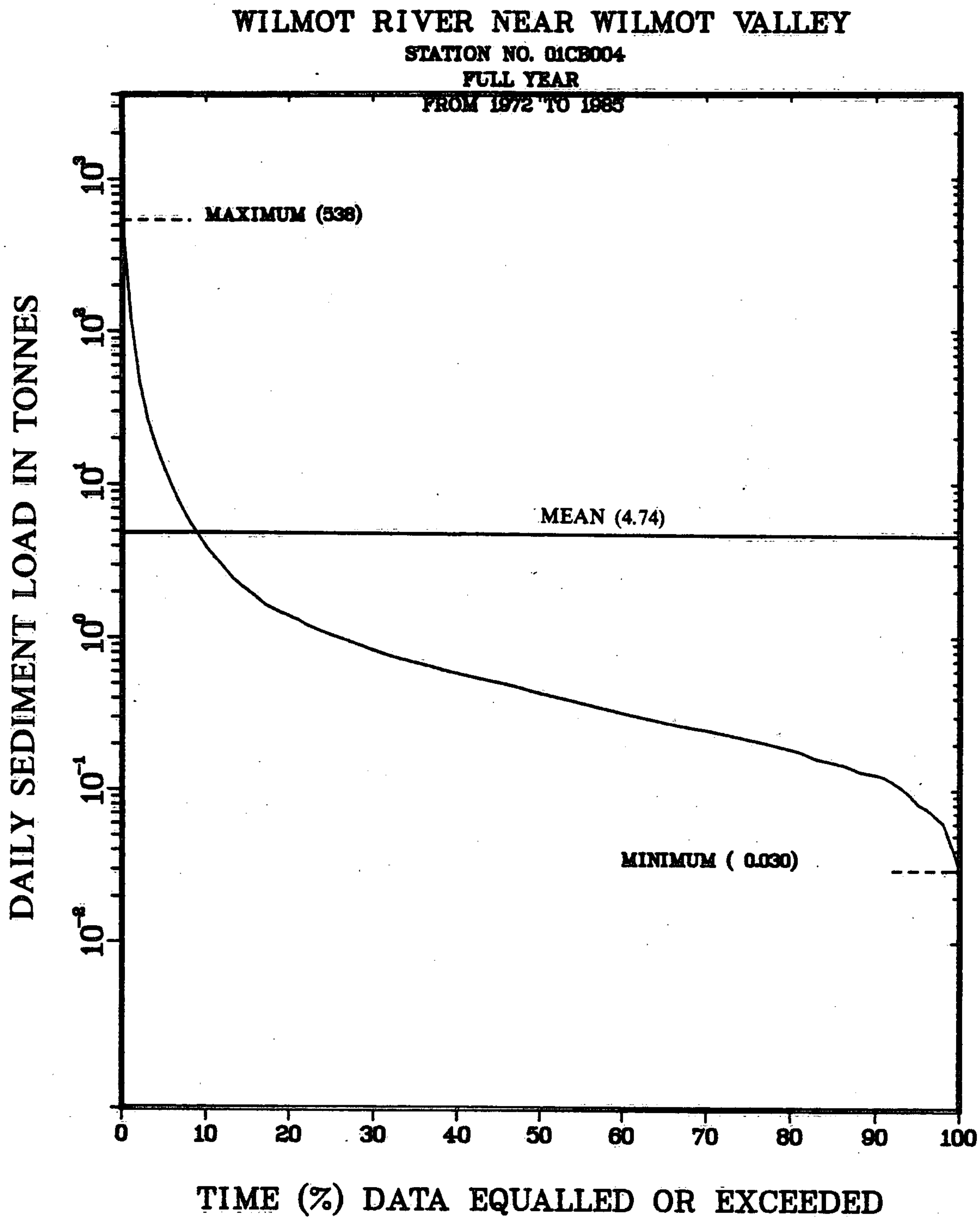
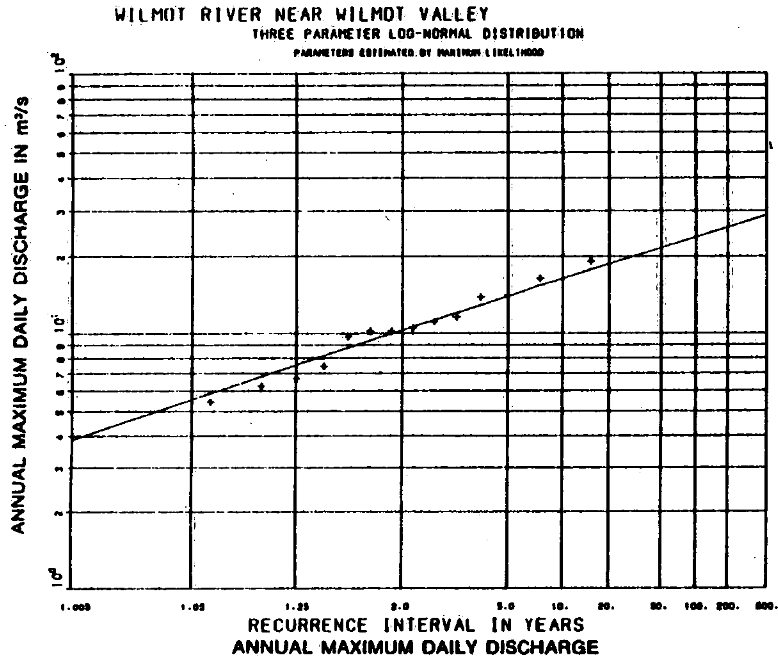
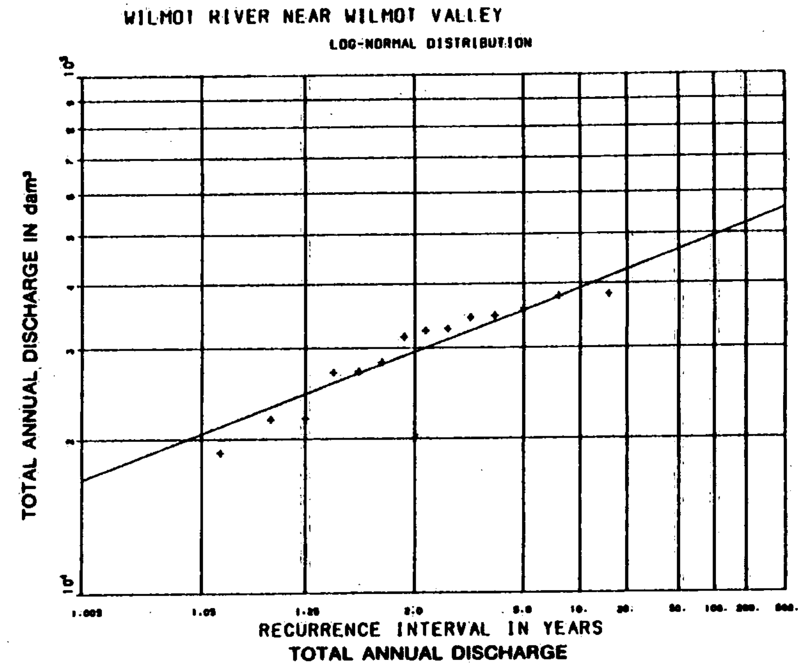
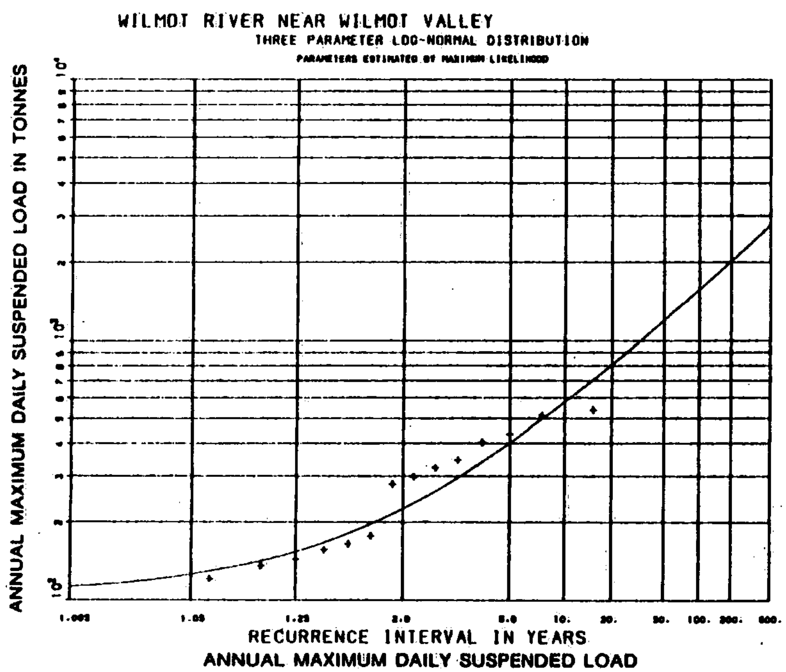


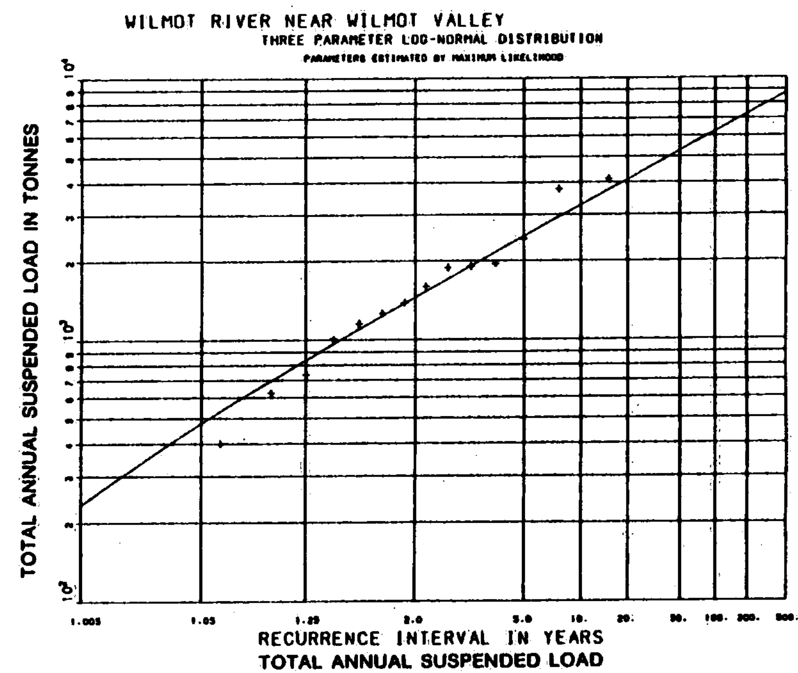
Figure 4 Suspended Sediment Duration Curve

Figure 5 Frequency Plots of Discharge and Suspended Sediment Load









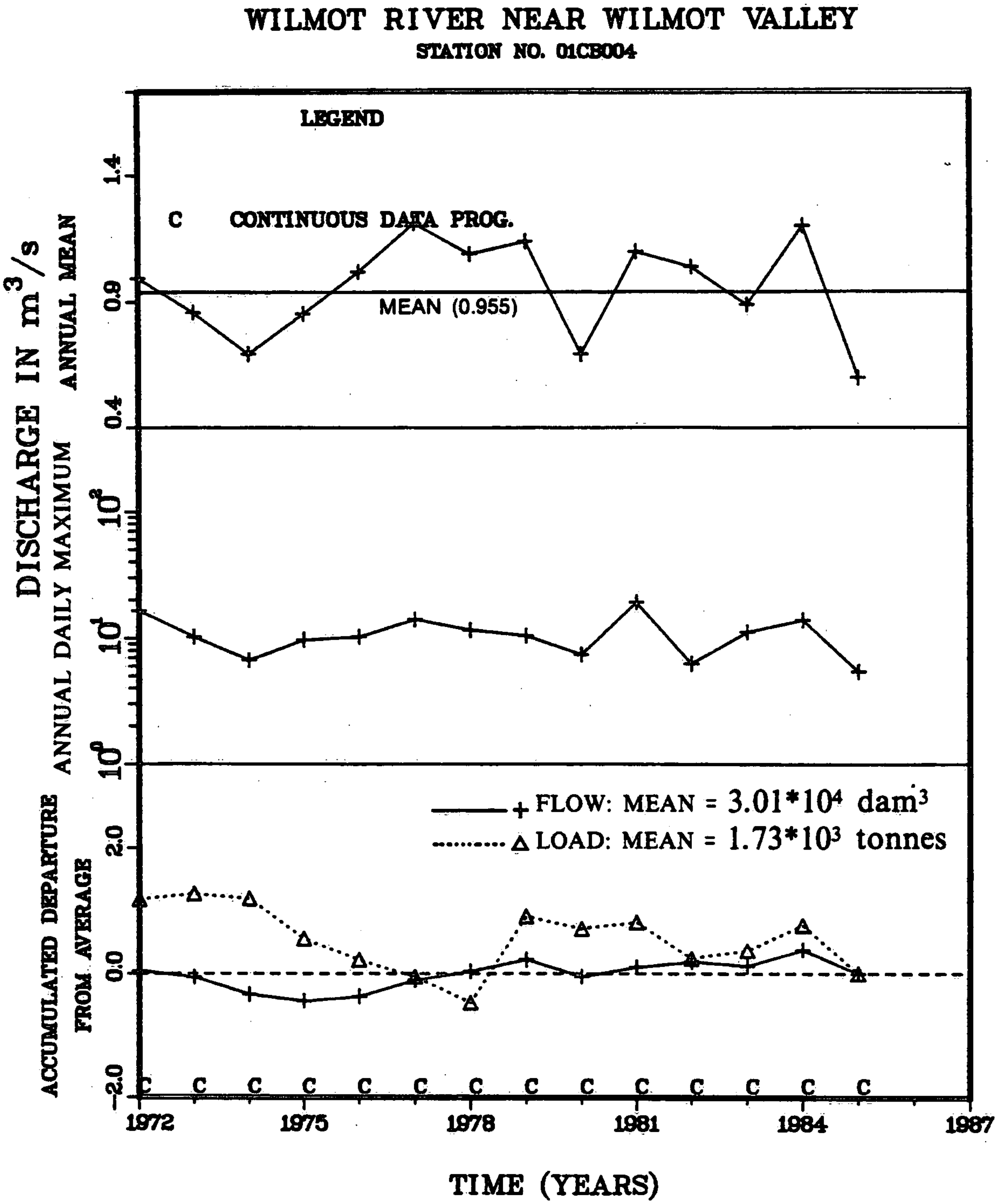


Figure 6 Flow History During Sediment Sampling Program

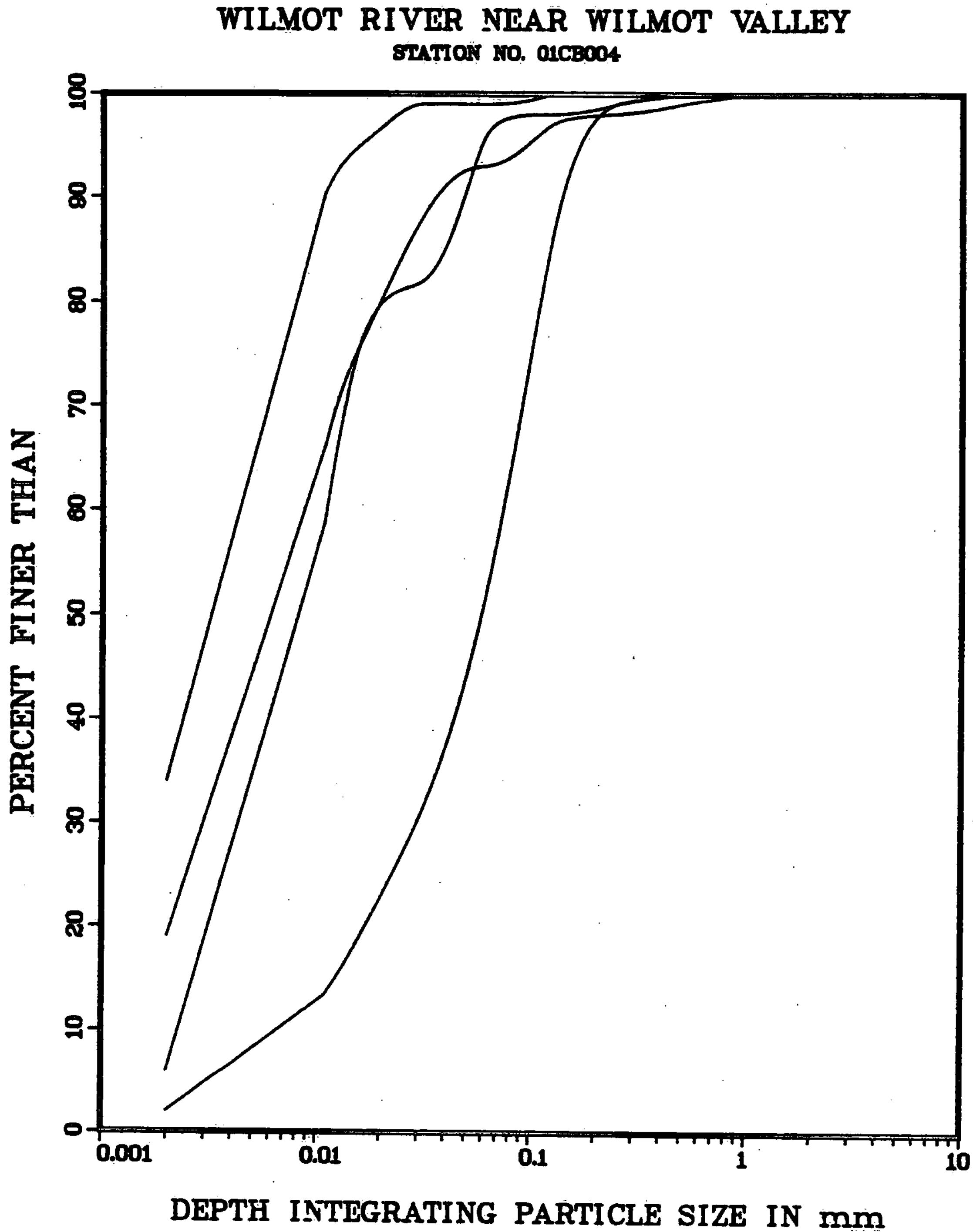


Figure 7 Composite Plot for Depth Integrated Particle Sizes

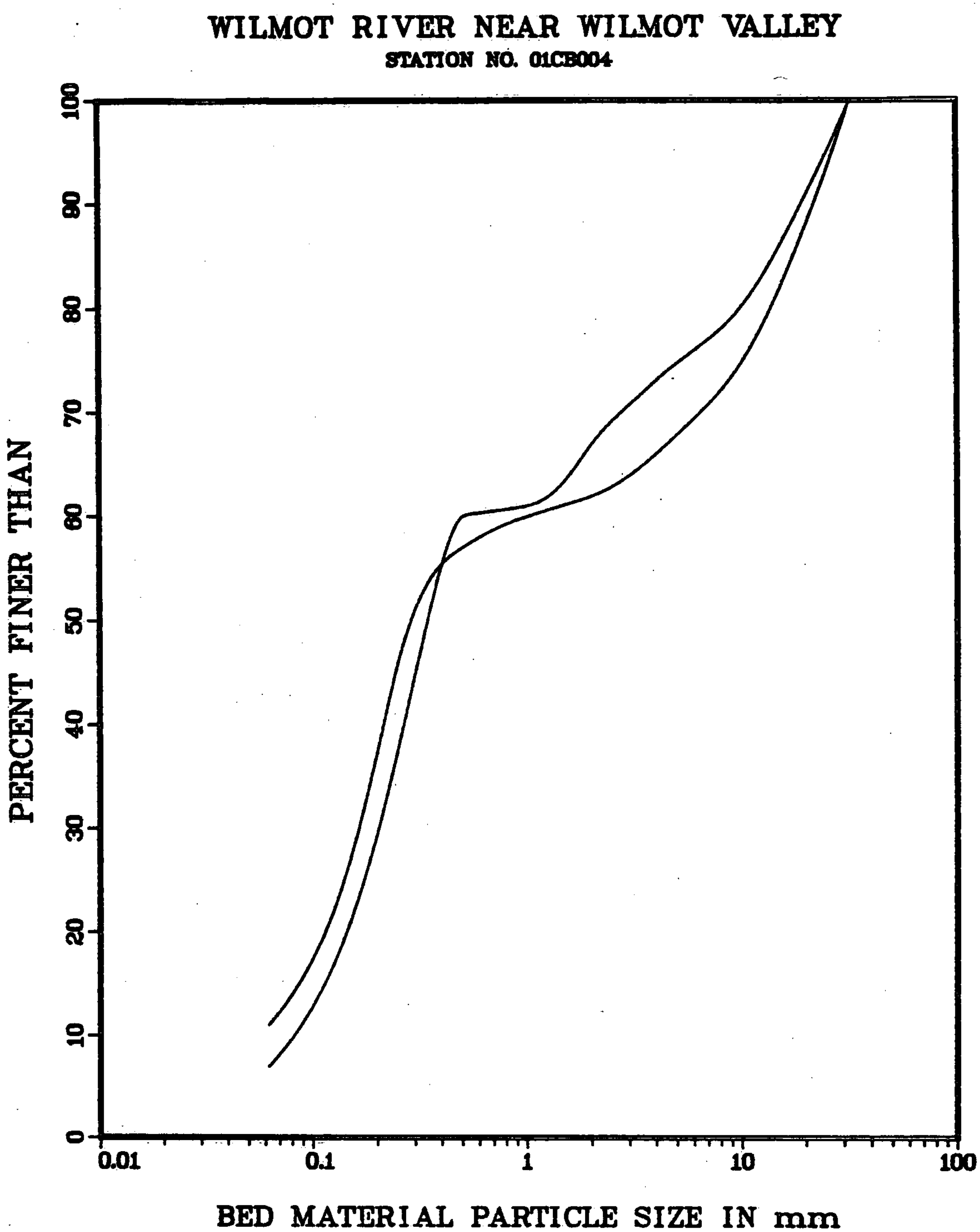


Figure 8 Composite Plot for Bed Material Particle Sizes

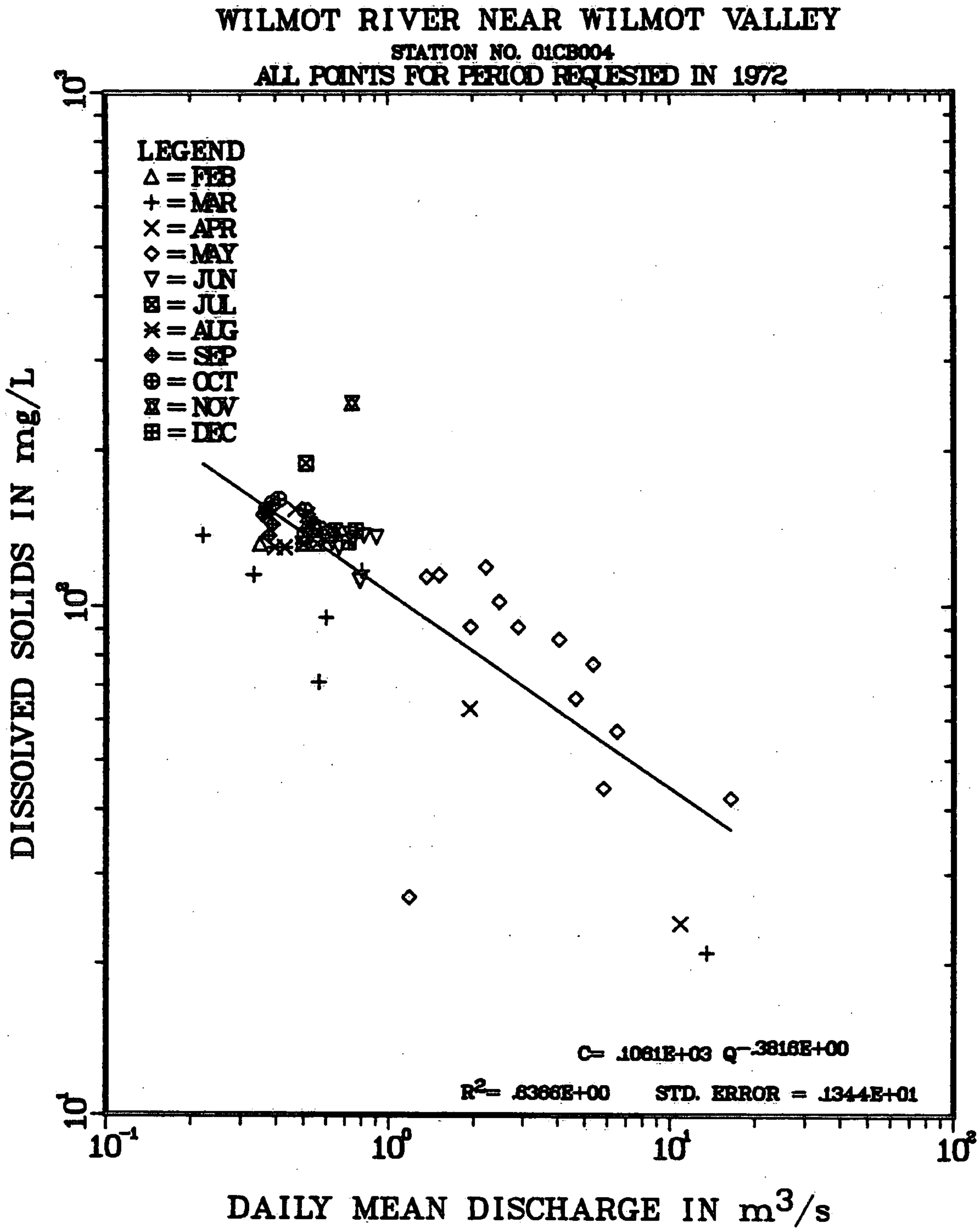
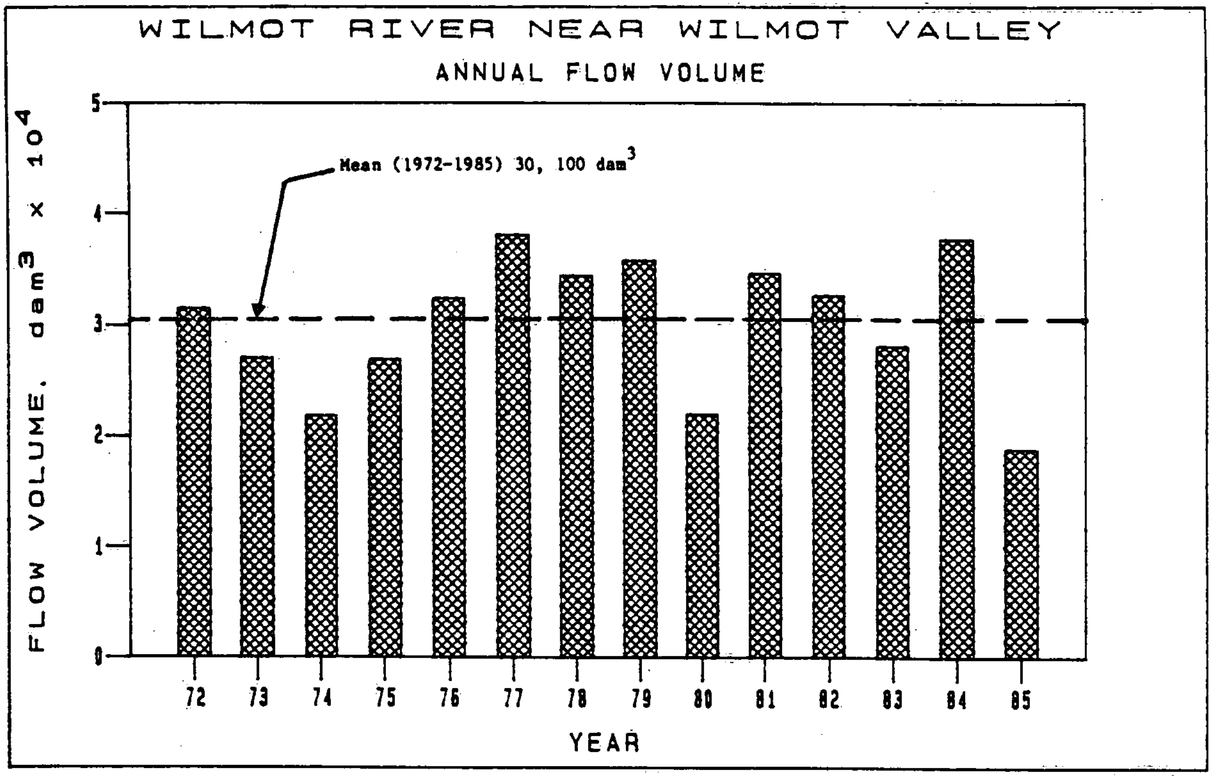


Figure 9 Rating Relationship of Dissolved Solids versus Daily Mean Discharge



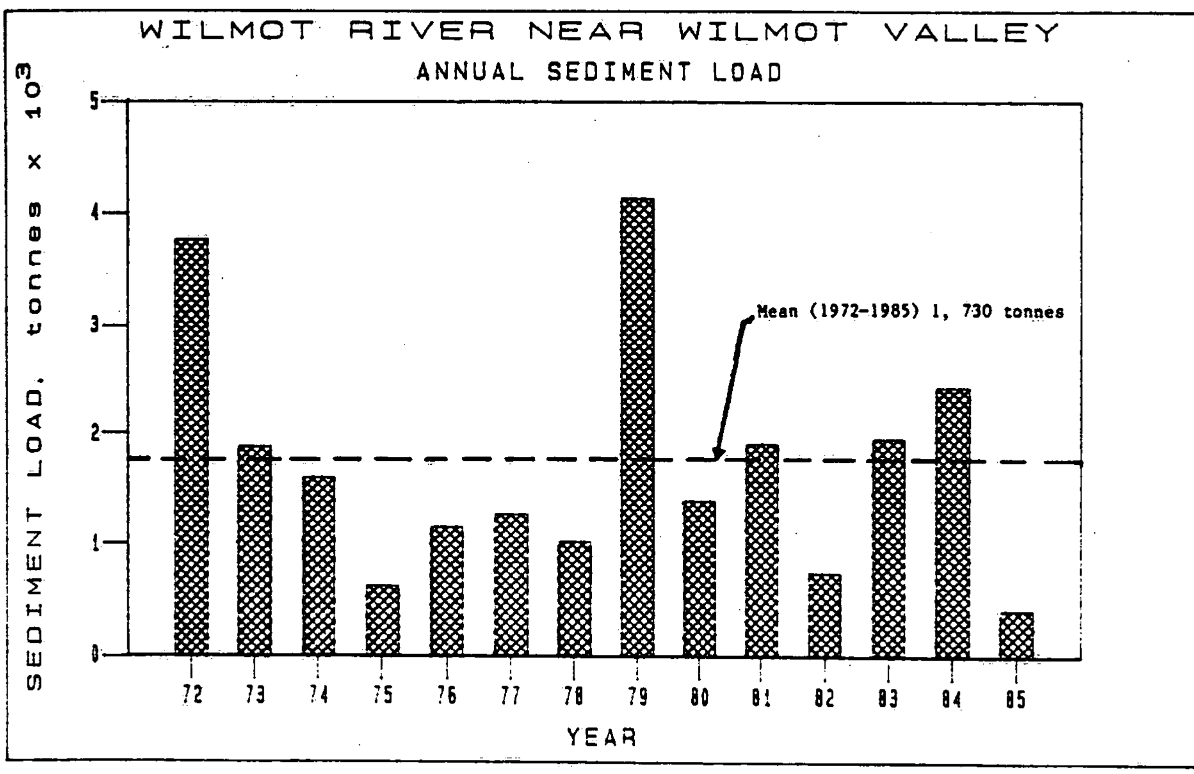
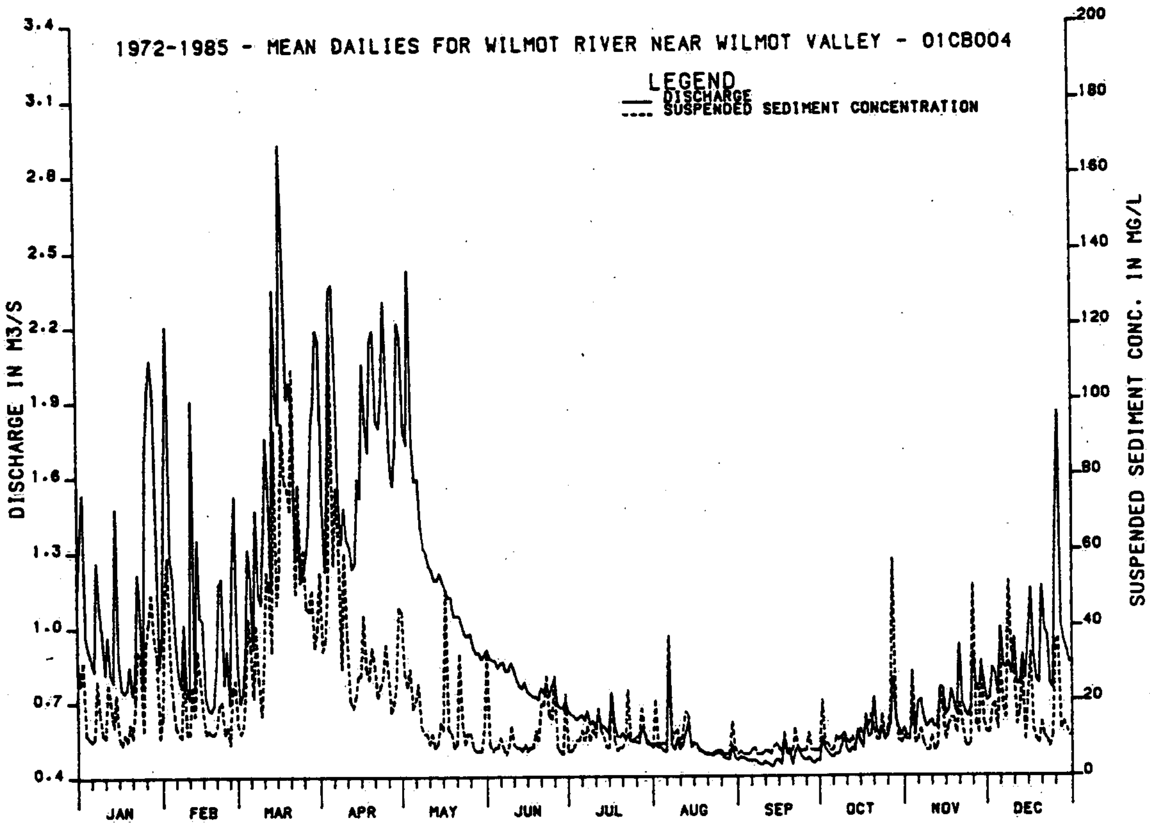


Figure 10 Annual Flow Volumes and Sediment Loads



1972-1985 - MEAN DAILIES FOR WILMOT RIVER NEAR WILMOT VALLEY - 01CB004
LEGEND
DISCHARGE
SUSPENDED SEDIMENT CONCENTRATION
DISCHARGE IN M3/S
SUSPENDED SEDIMENT CONC. IN MG/L
3.4
3.1
2.8
2.5
2.2
1.9
1.6
1.3
1.0
0.7
0.4
200
180
160
140
120
100
80
60
40
20
0
JAN
FEB
MAR
APR
MAY
JUN
JUL
AUG
SEP
OCT
NOV
DEC

Figure 11

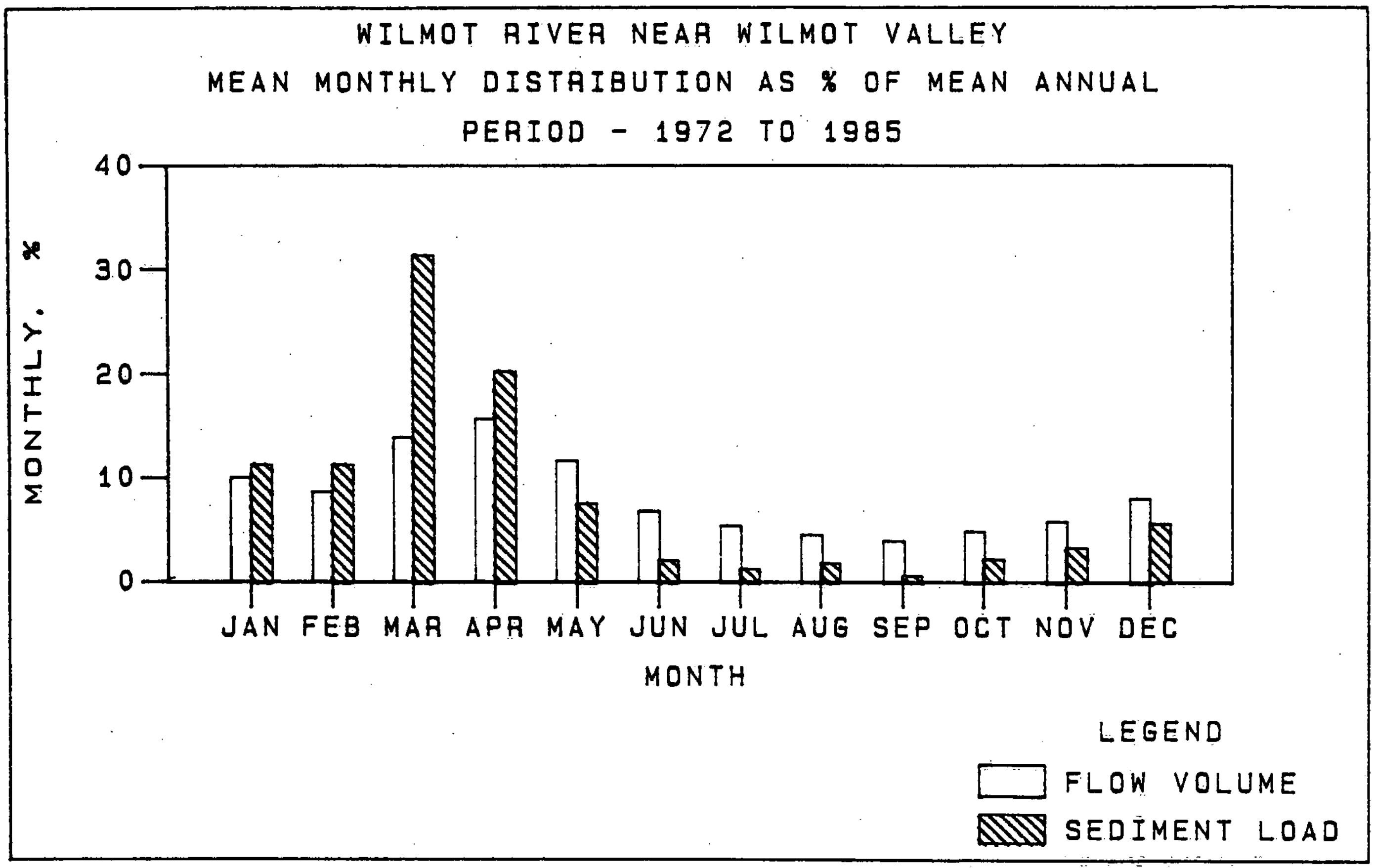


Figure 12 Mean Monthly Flow and Sediment Distribution as a Percentage of the Mean Annual Total

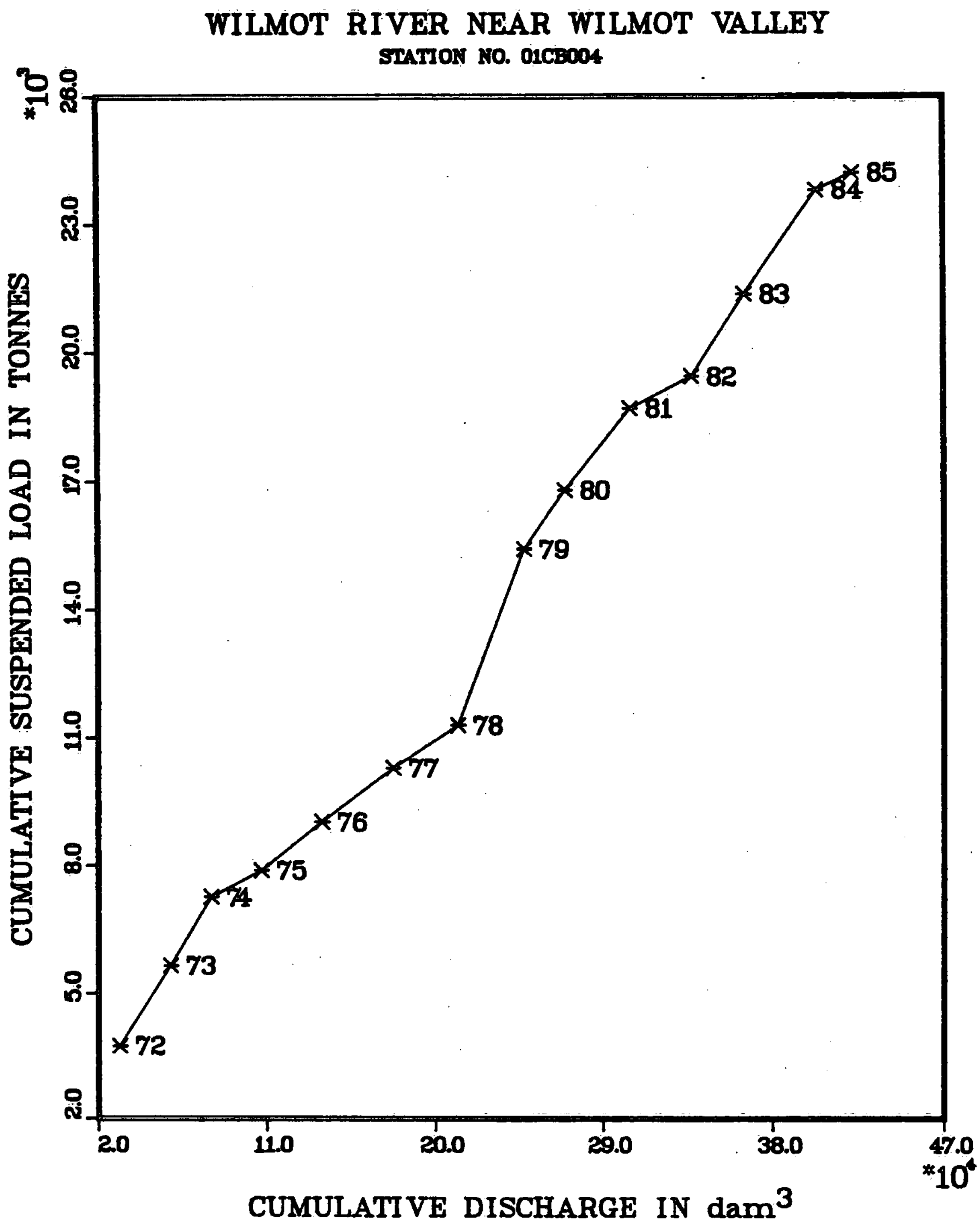
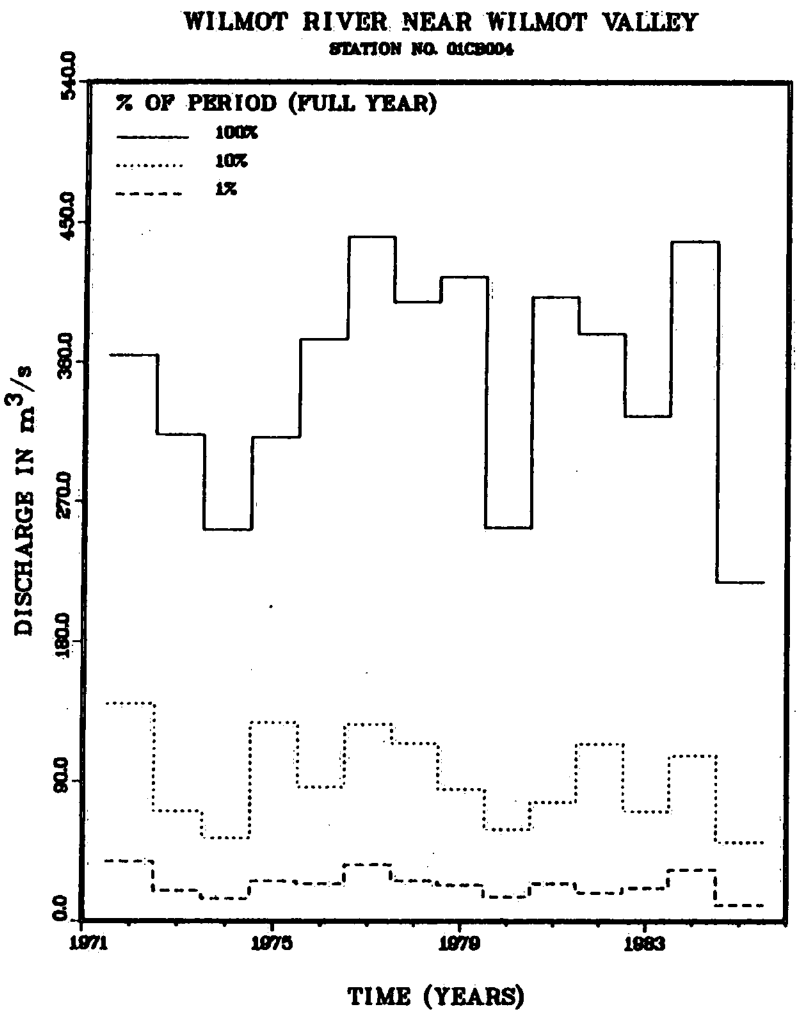


FIGURE 13 CUMULATIVE SUSPENDED SEDIMENT LOAD VERSUS CUMULATIVE FLOW VOLUME, 1972 TO 1985.



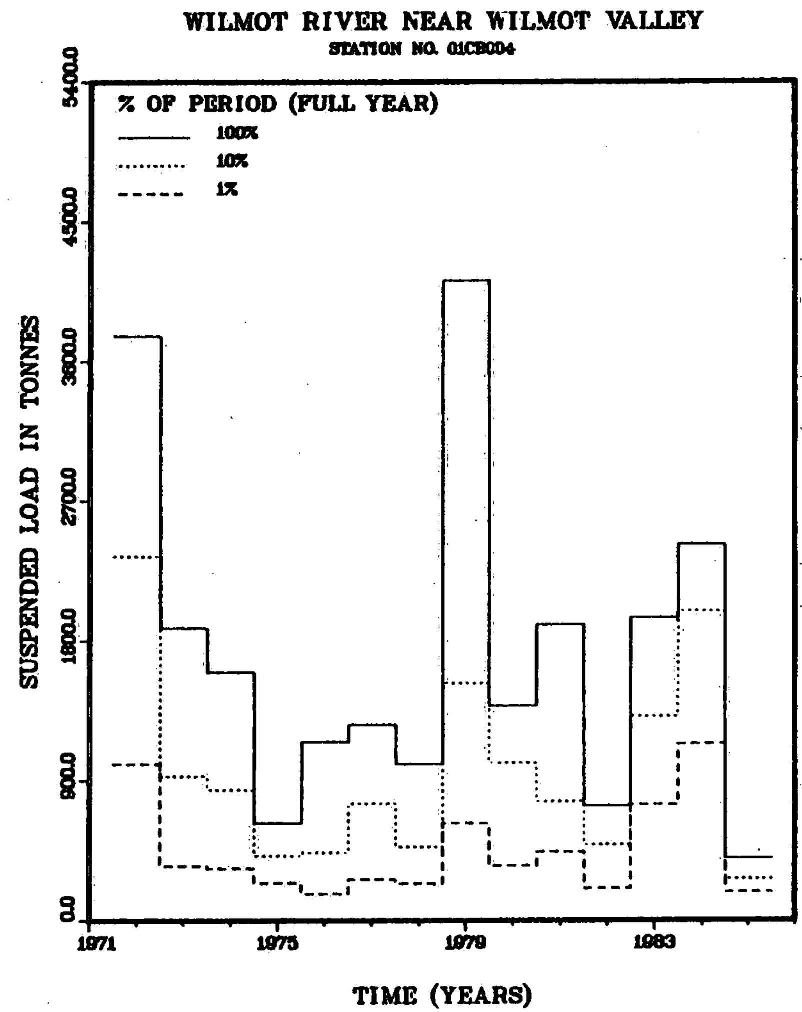


Figure 14 Contribution of Short Duration Events to Annual Discharge and Sediment Load

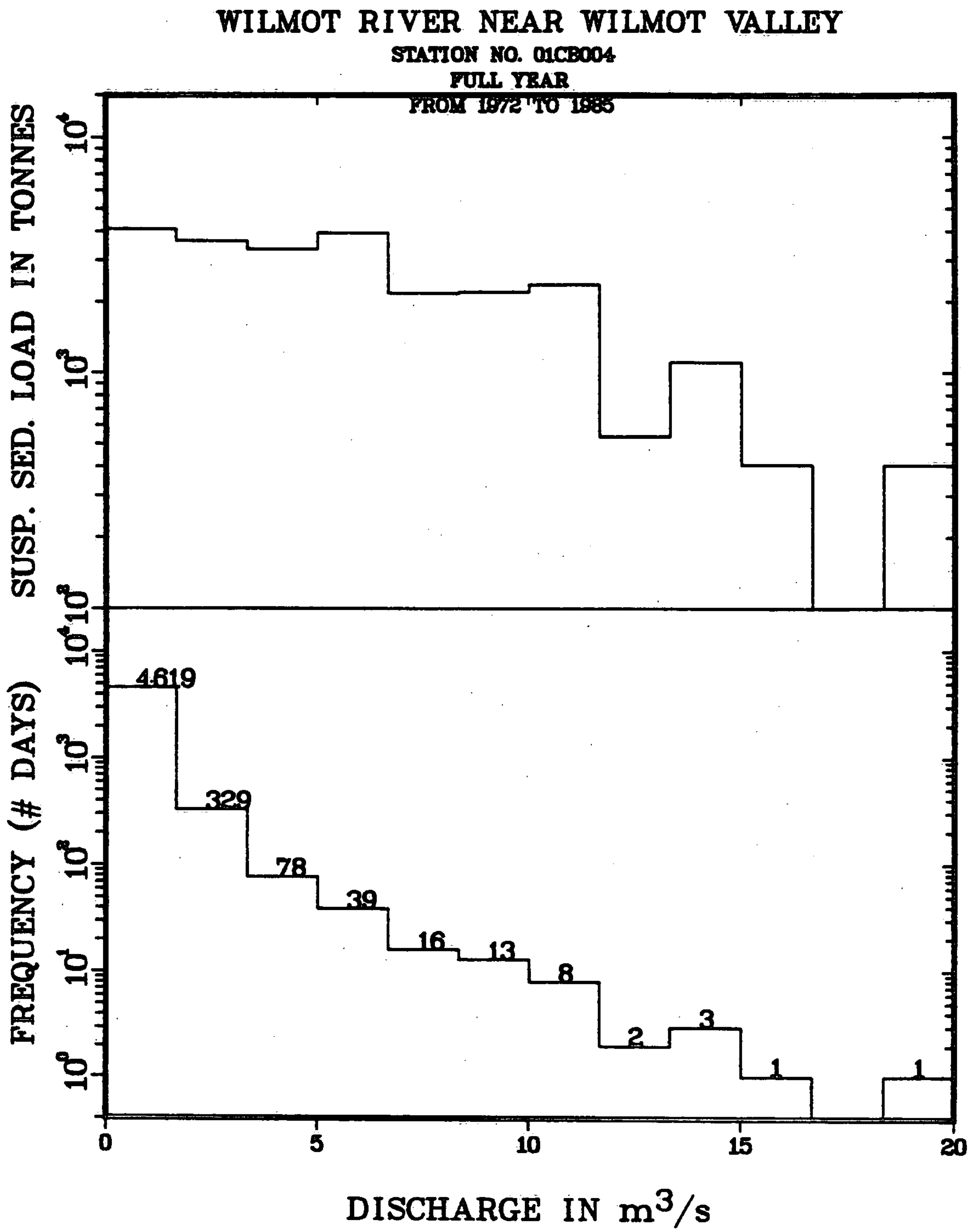


FIGURE 15 FREQUENCY OF OCCURRENCE OF DISCHARGE AND SUSPENDED SEDIMENT LOAD.

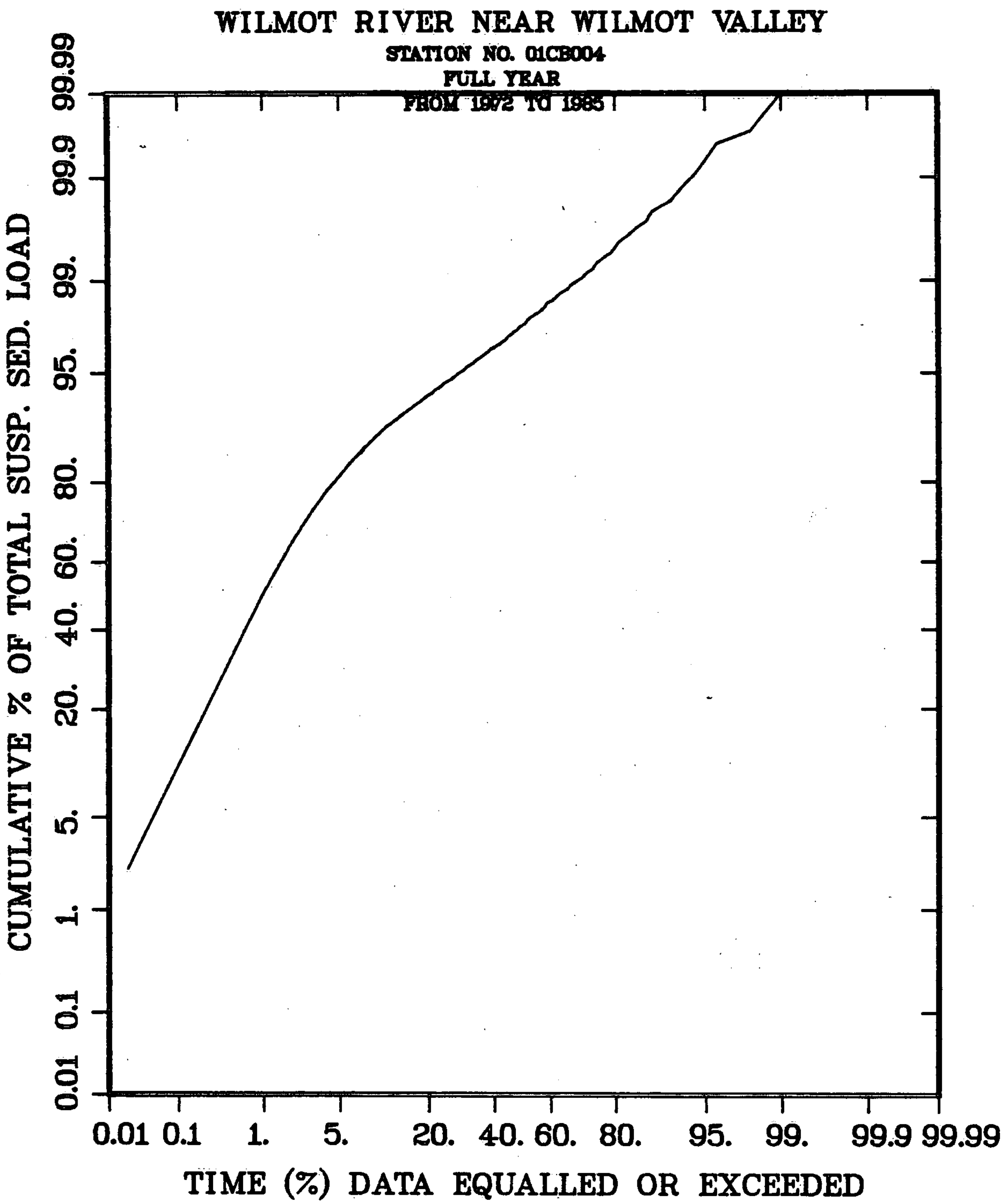


FIGURE 16 CUMULATIVE PERCENTAGE OF THE TOTAL SUSPENDED SEDIMENT LOAD VERSUS THE PERCENTAGE OF TIME DATA IS EQUALLED OR EXCEEDED.

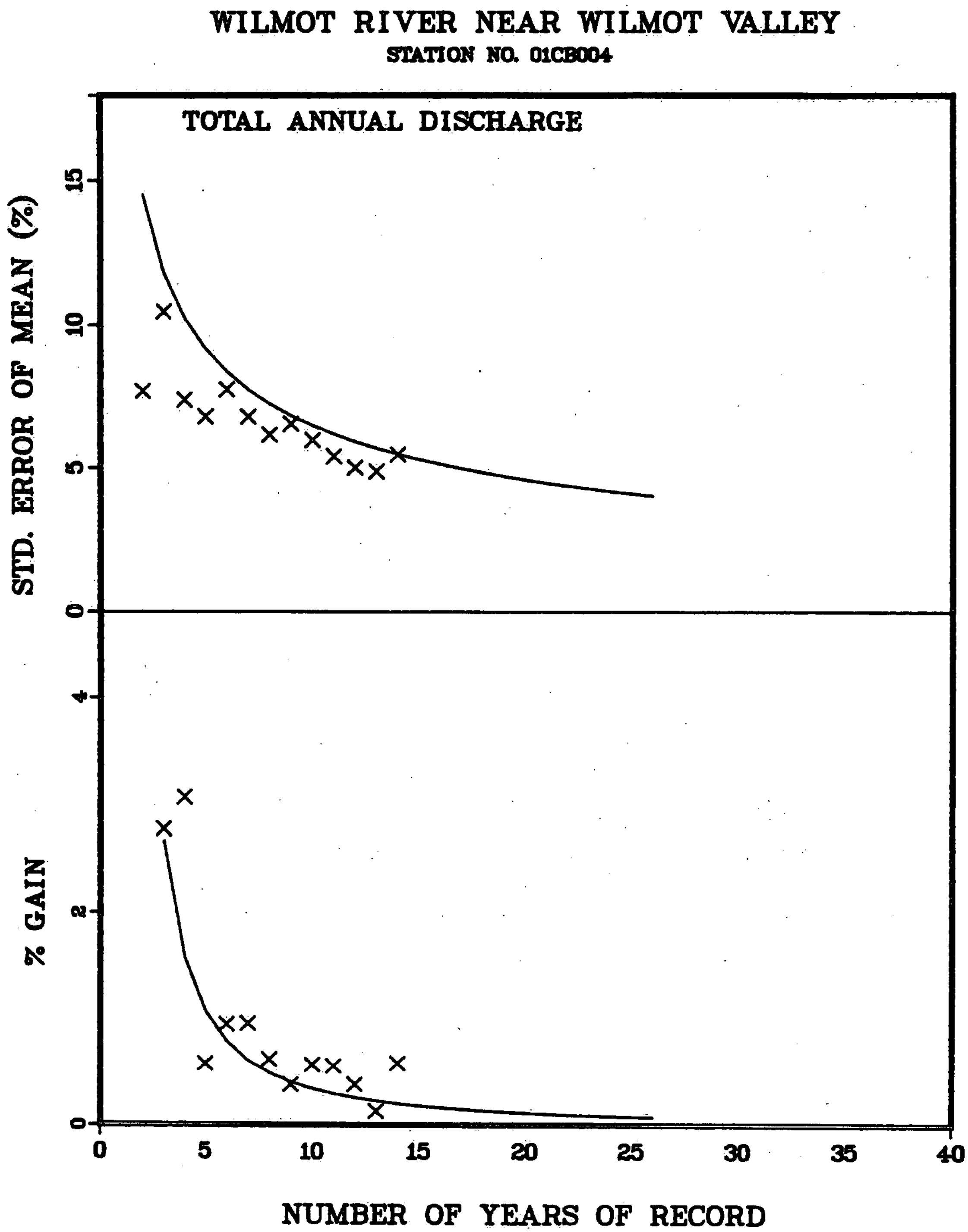


FIGURE 17 RELATION BETWEEN THE STANDARD ERROR OF THE MEAN ANNUAL TOTAL DISCHARGE AND RECORD LENGTH. THE PERCENTAGE GAIN IN THE STANDARD ERROR OF THE MEAN FOR EACH ADDITIONAL YEAR OF RECORD IS SHOWN IN THE BOTTOM HALF OF THE FIGURE.

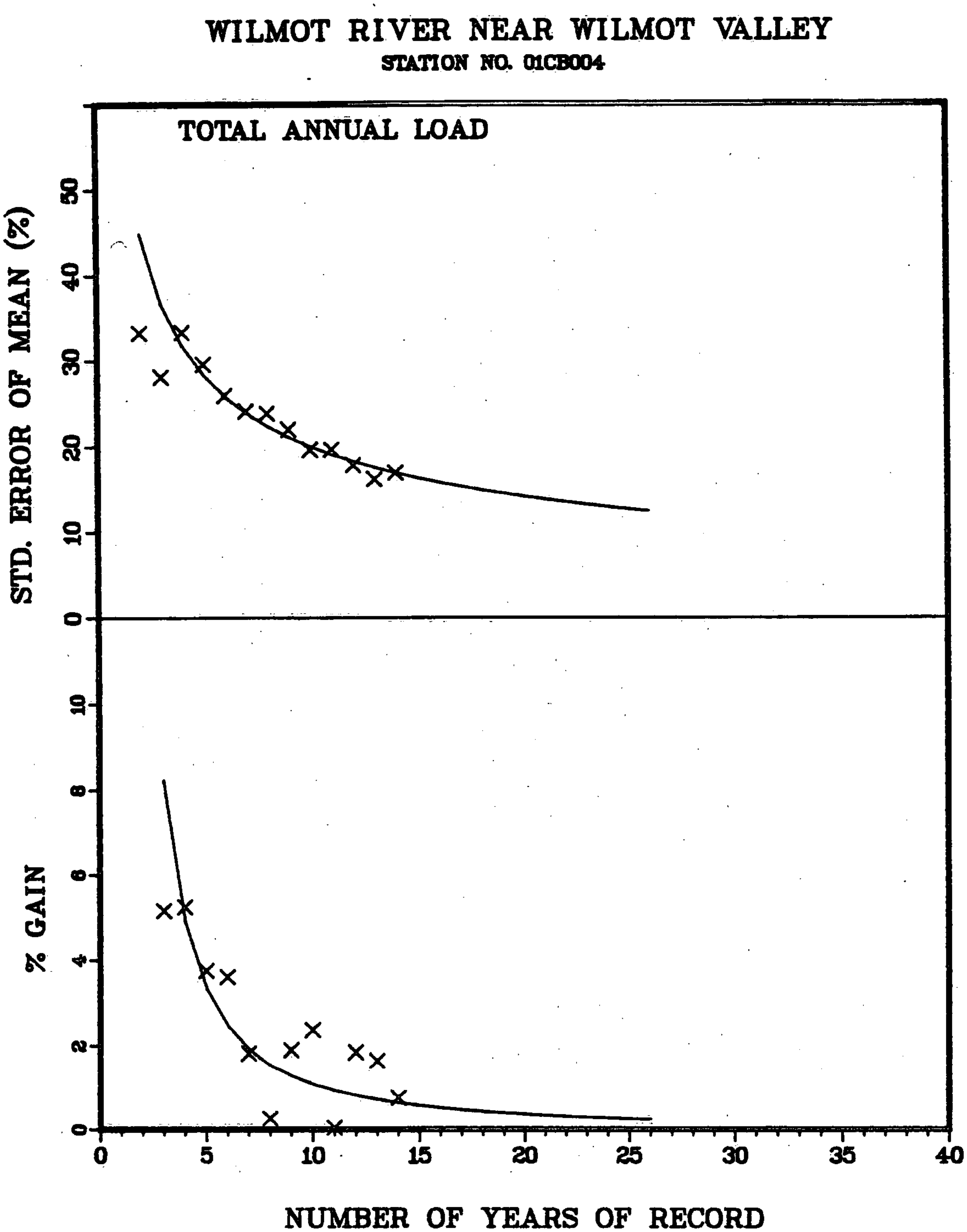


FIGURE 18 RELATION BETWEEN THE STANDARD ERROR OF THE MEAN ANNUAL TOTAL SUSPENDED SEDIMENT LOAD AND RECORD LENGTH. THE PERCENTAGE GAIN IN THE STANDARD ERROR OF THE MEAN FOR EACH ADDITIONAL YEAR OF RECORD IS SHOWN IN THE BOTTOM HALF OF THE FIGURE.

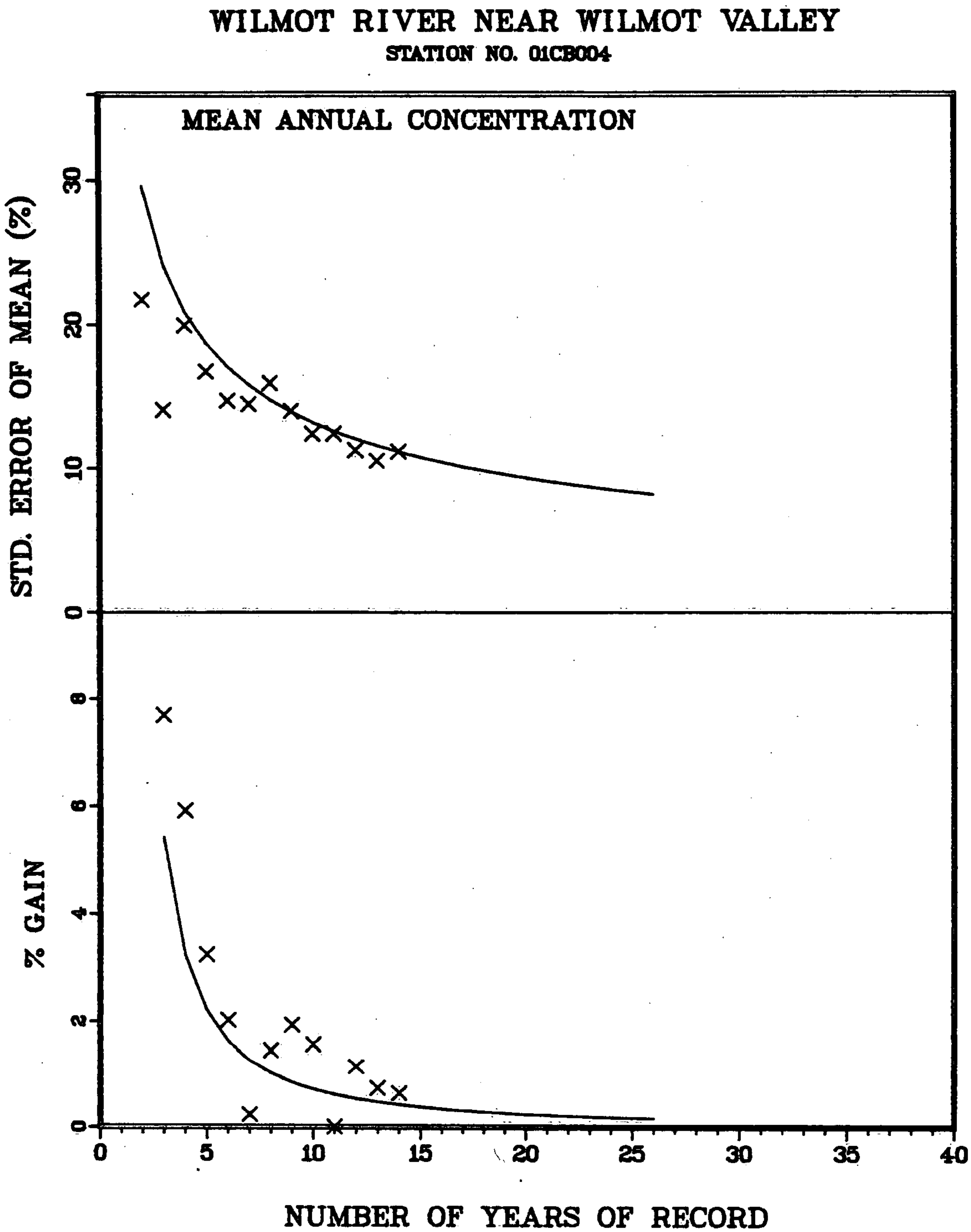


FIGURE 19 RELATION BETWEEN THE STANDARD ERROR OF THE MEAN ANNUAL SUSPENDED SEDIMENT CONCENTRATION AND RECORD LENGTH. THE PERCENTAGE GAIN IN THE STANDARD ERROR OF THE MEAN FOR EACH ADDITIONAL YEAR OF RECORD IS SHOWN IN THE BOTTOM HALF OF THE FIGURE.

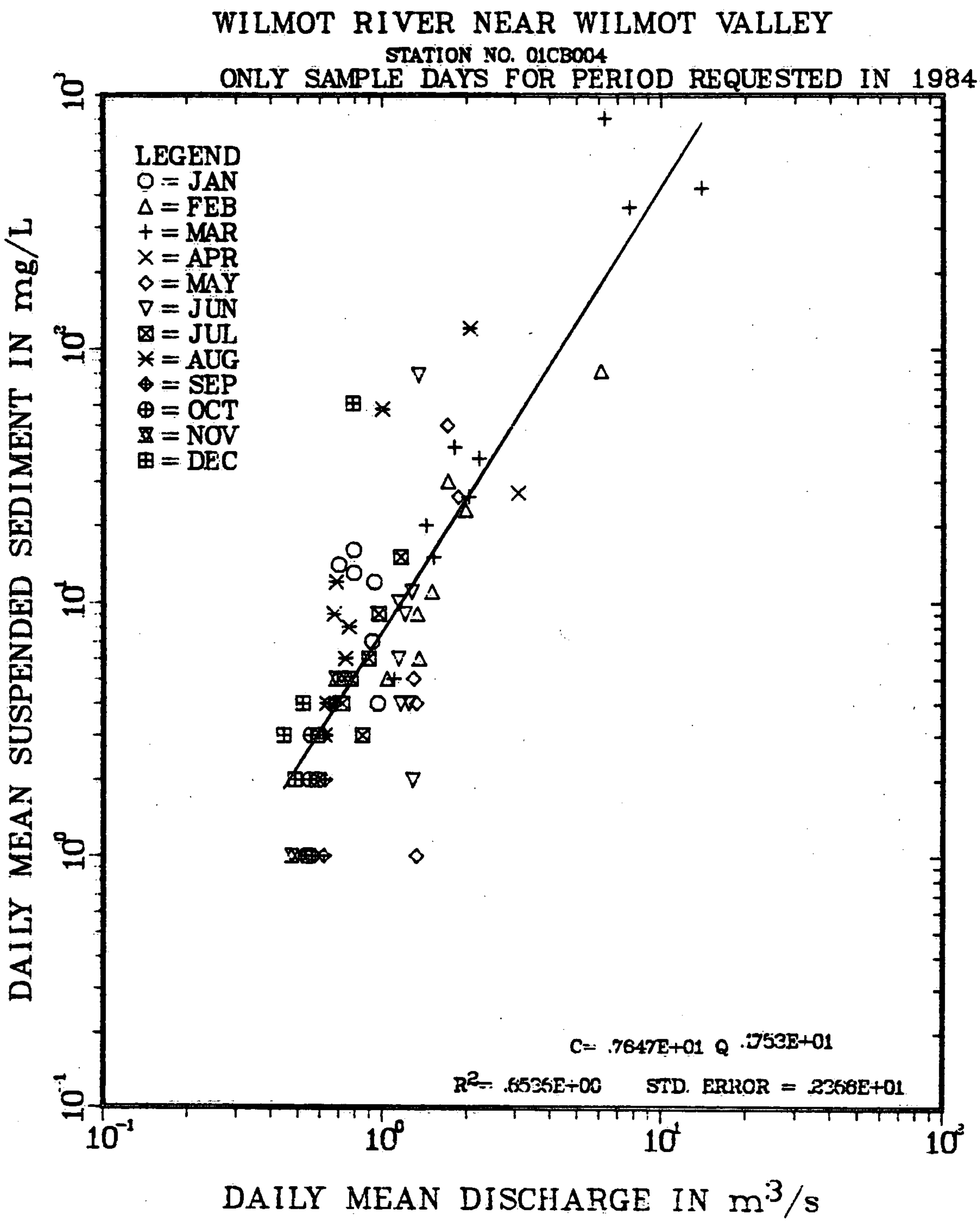


FIGURE 20 RATING RELATIONSHIP FOR DAILY MEAN DISCHARGE VERSUS DAILY MEAN SUSPENDED SEDIMENT.

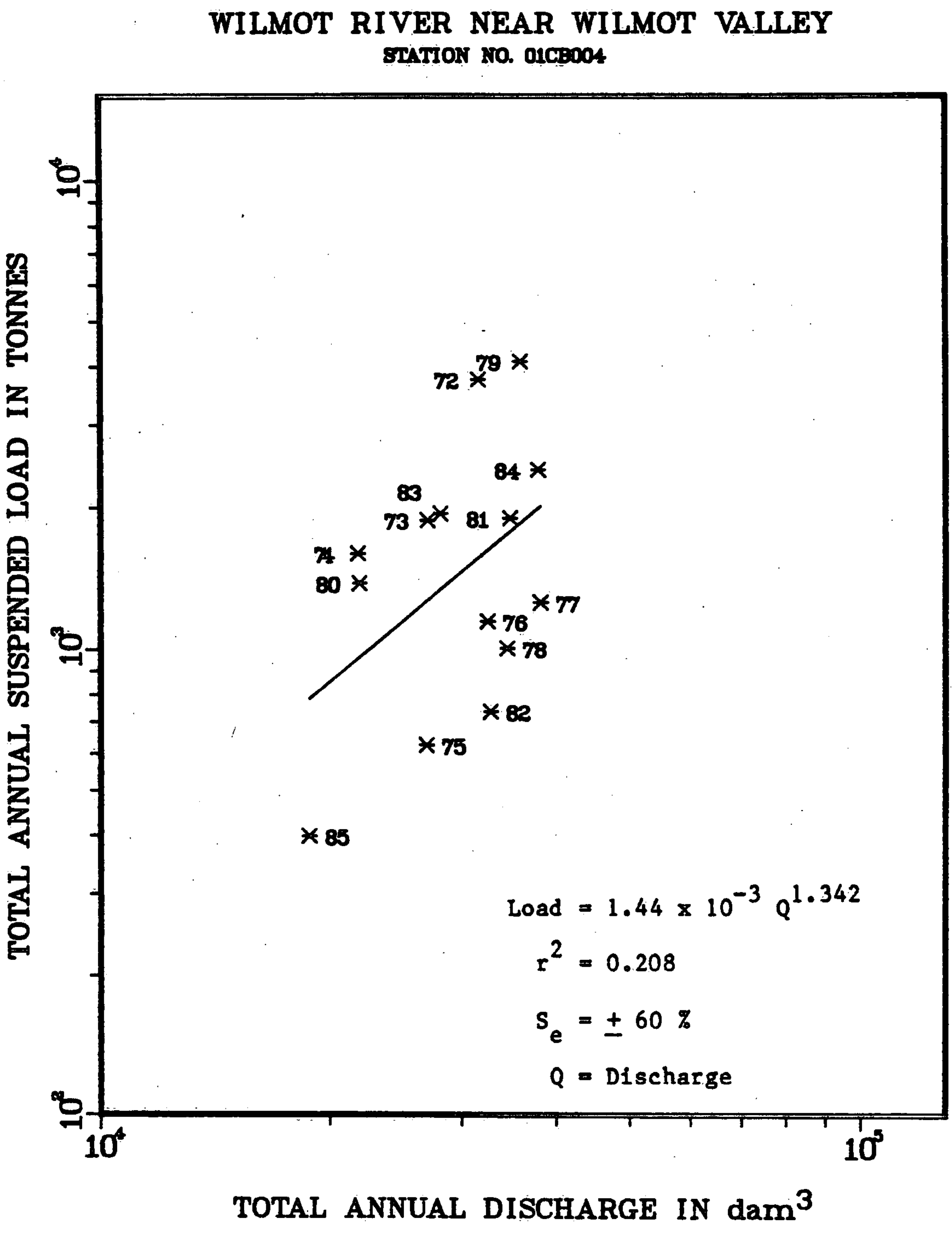


FIGURE 21 RATING RELATIONSHIP FOR TOTAL ANNUAL DISCHARGE VERSUS TOTAL ANNUAL SUSPENDED LOAD.

WILMOT RIVER NEAR WILMOT VALLEY

STATION NO. 01CB004

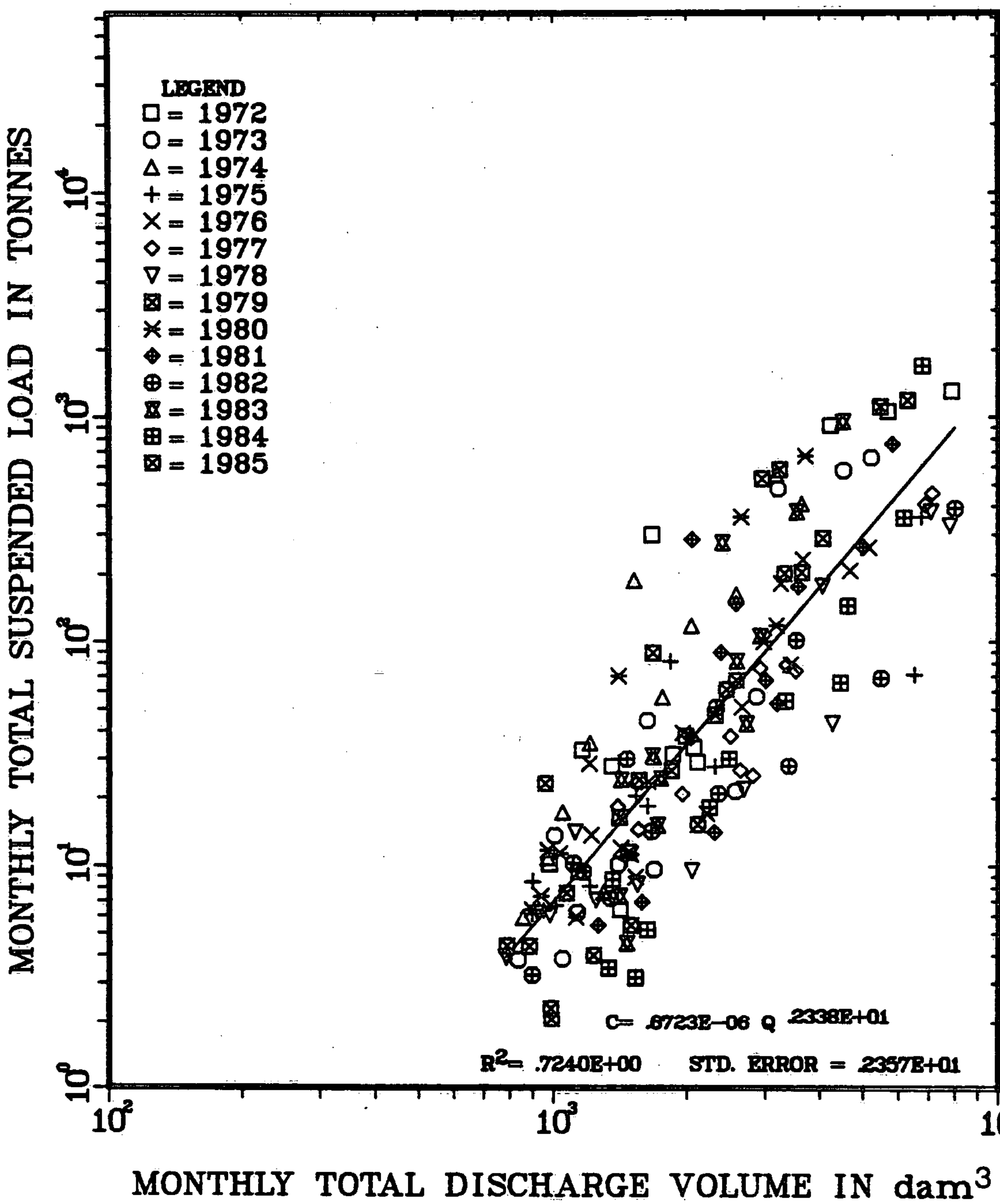


FIGURE 22 RATING RELATIONSHIP FOR MONTHLY TOTAL DISCHARGE VERSUS MONTHLY TOTAL SUSPENDED LOAD.

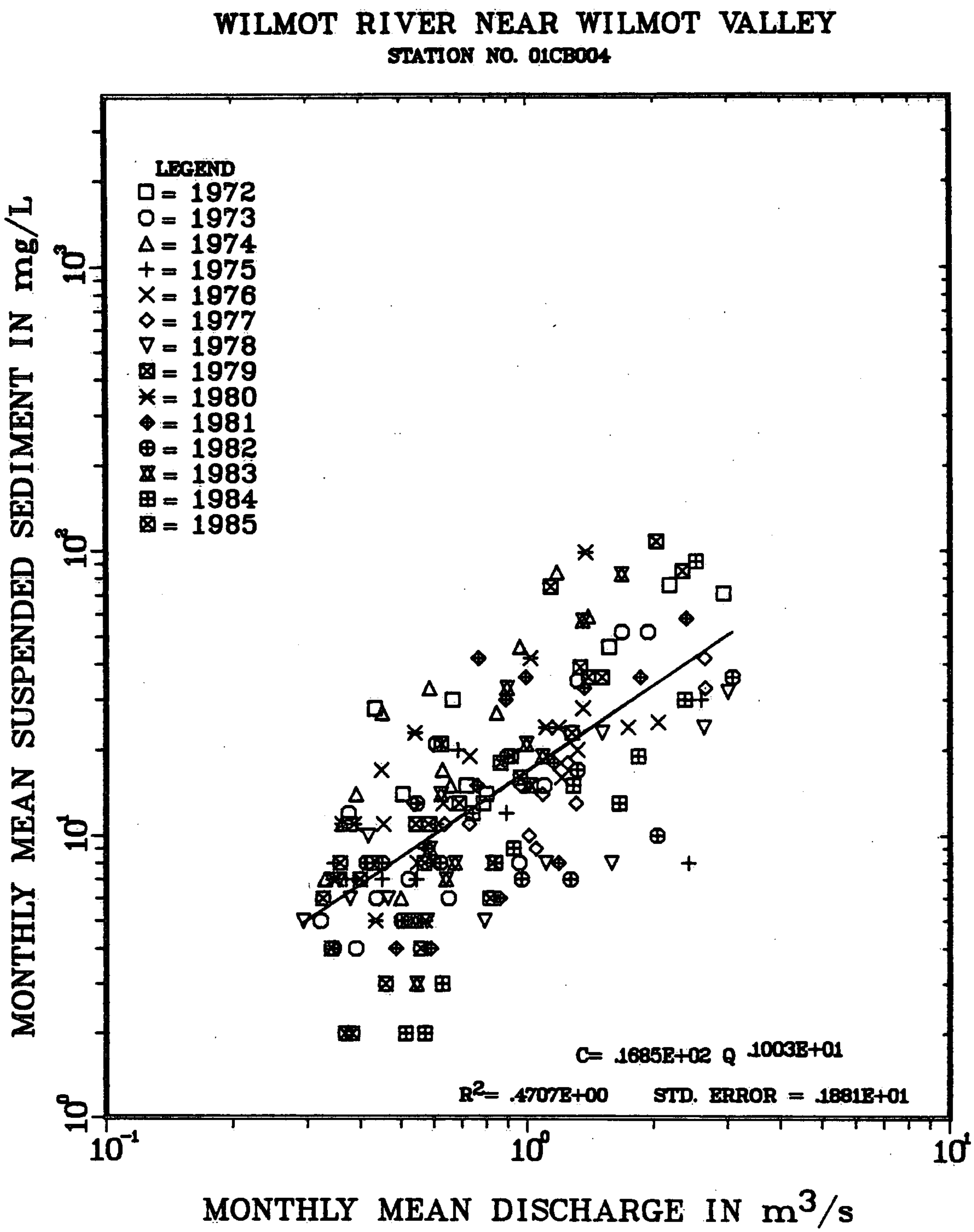


FIGURE 23 RATING RELATIONSHIP FOR MONTHLY MEAN DISCHARGE VERSUS MONTHLY MEAN SUSPENDED SEDIMENT.

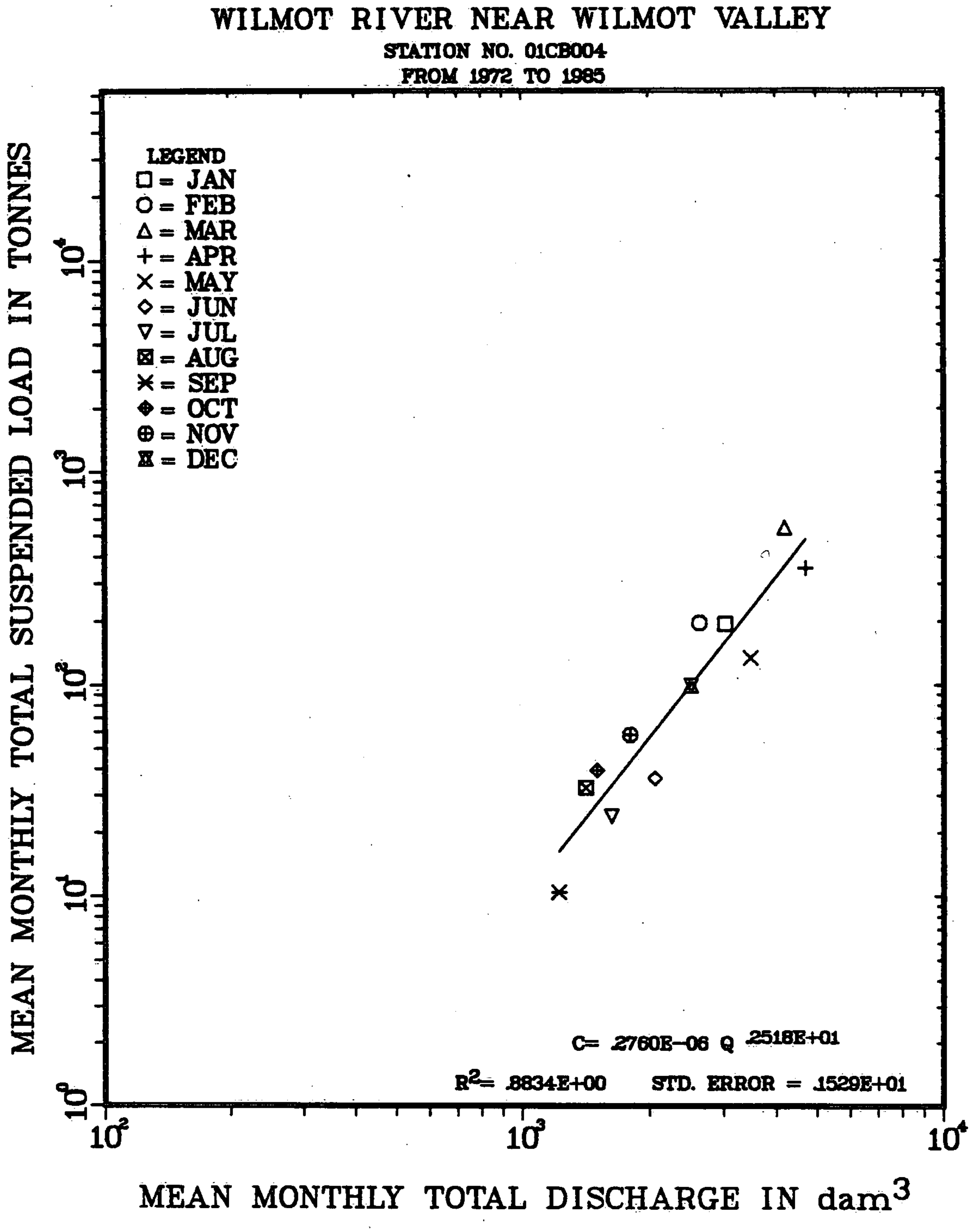


FIGURE 24 RATING RELATIONSHIP FOR MEAN MONTHLY TOTAL DISCHARGE VERSUS MEAN MONTHLY TOTAL SUSPENDED LOAD.

APPENDIX C
(Photographs)

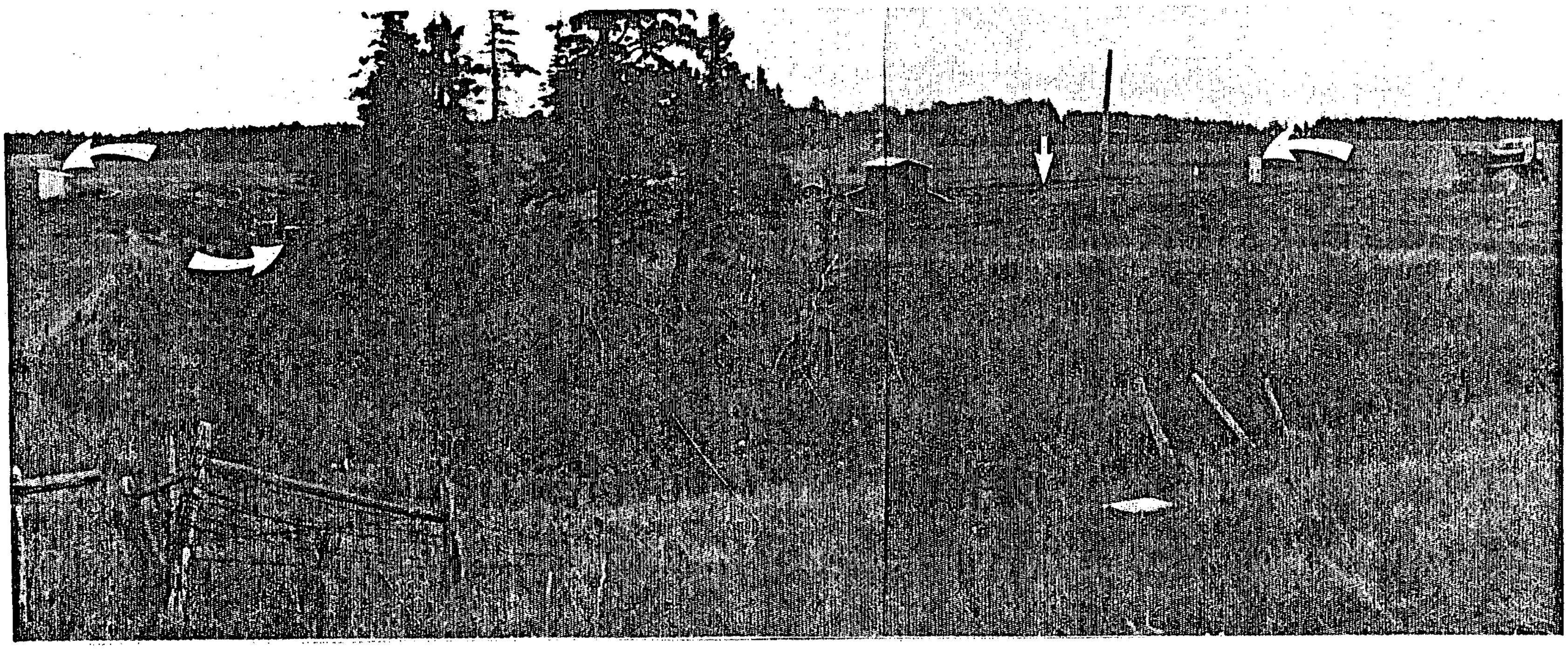


Plate 1. This is one of the soil erosion test sites noted on the fall field trip. Note the soil erosion test plots (straight arrow), the meteorologic station (right arrow) and the hydrometric station and Parshall flume (left arrows). This site is located 1.5 km southeast of Norboro.

Plate 2. A large potato harvest operation at Paynter. Note the type of equipment required and the large relatively flat fields lacking protective windrows, representive of the Wilmot basin.

Plate 3. Note the soil compaction on this harvested potato field at Baldwin, also note the down slope direction of the harvested crop rows.

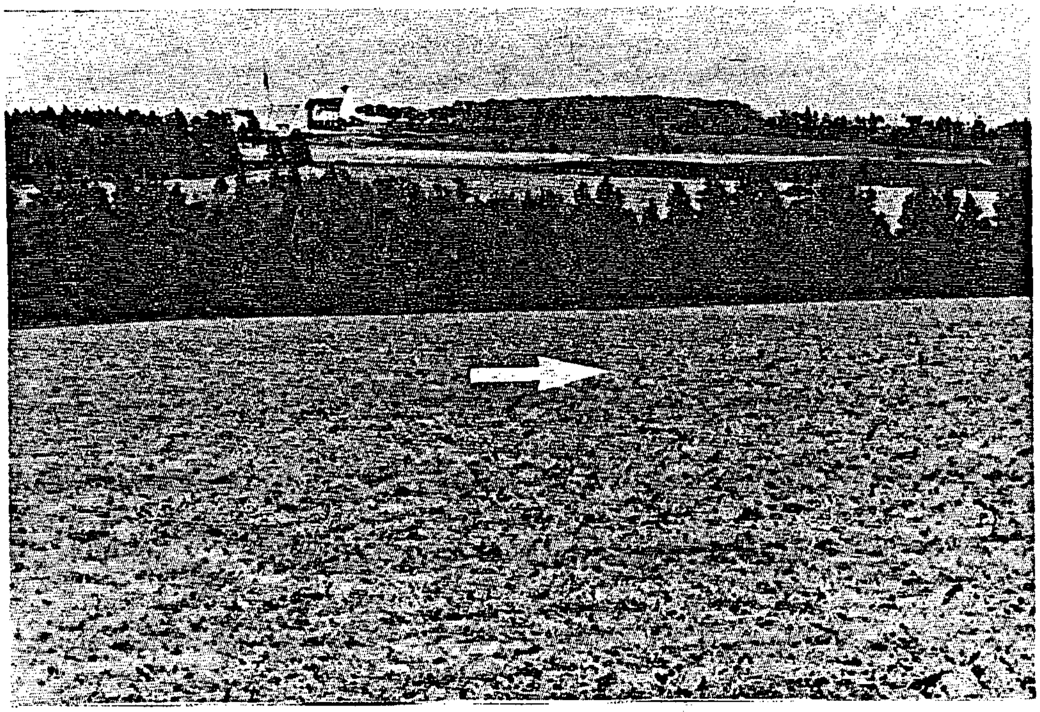


Plate 4. One means of conserving soil is to employ contour and cross slope cultivation practices as shown by the arrow. This field is located near Summerfield.

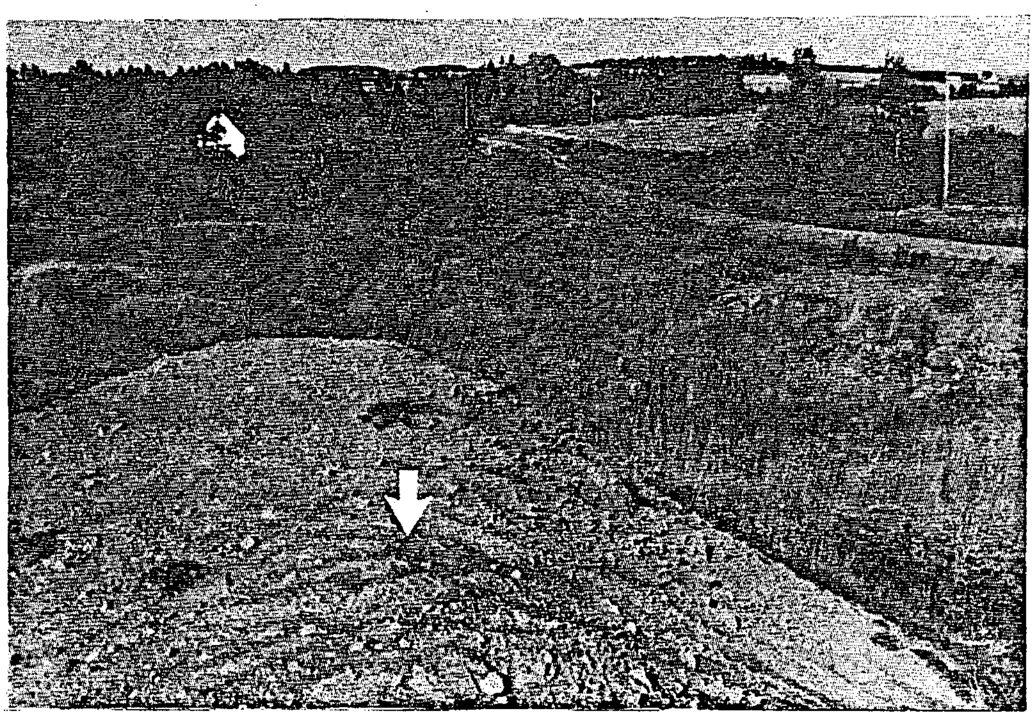


Plate 5. The use of recreational vehicles as can be seen by the tracks (arrow) in this old extraction site adjacent to the Wilmot River near Norboro retards the establishment of protective vegetative cover.

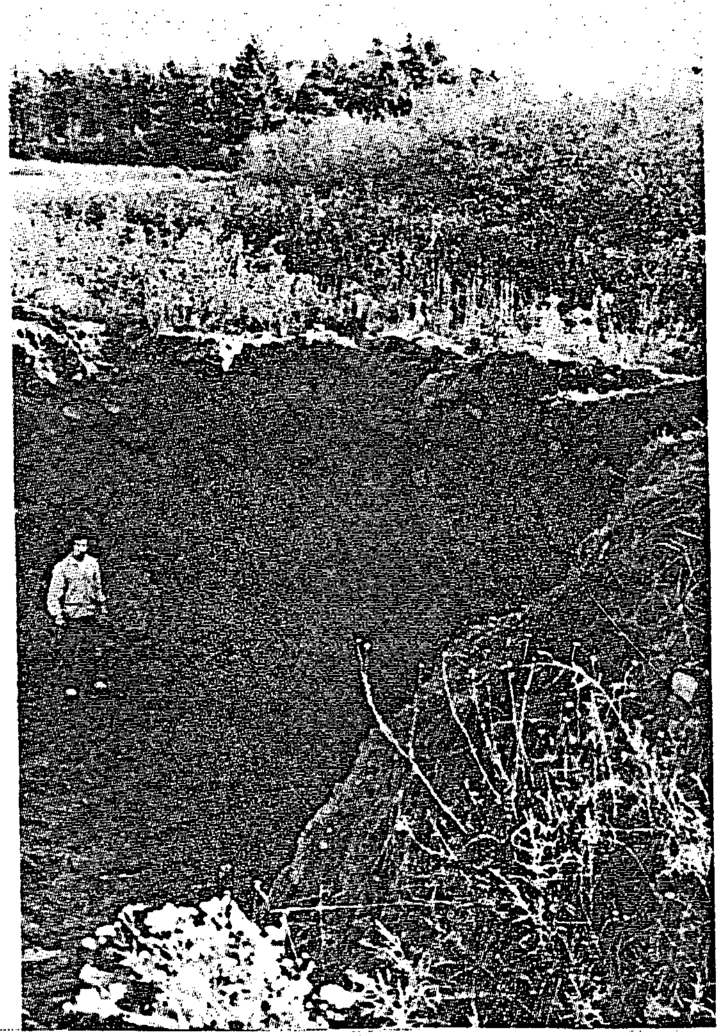


Plate 6. An active pit one kilometre east of Baldwin threatens to undermine a tributary of the Wilmot River located in the alder shrubs in the upper right of the photograph.

Plate 7. Direct access to a long portion of the Wilmot River bank is causing bank slumping as was evident one kilometre southwest of Summerfield.

Plate 8. The vegetated fringe (just north of the gauge site) shown in this photograph protects the Wilmot River from any erosion from the ploughed field.

Plate 9. This field between Summerfield and Springfield is not protected from runoff by a grassed fringe. Note the gully (arrows) running through the centre of this photograph.

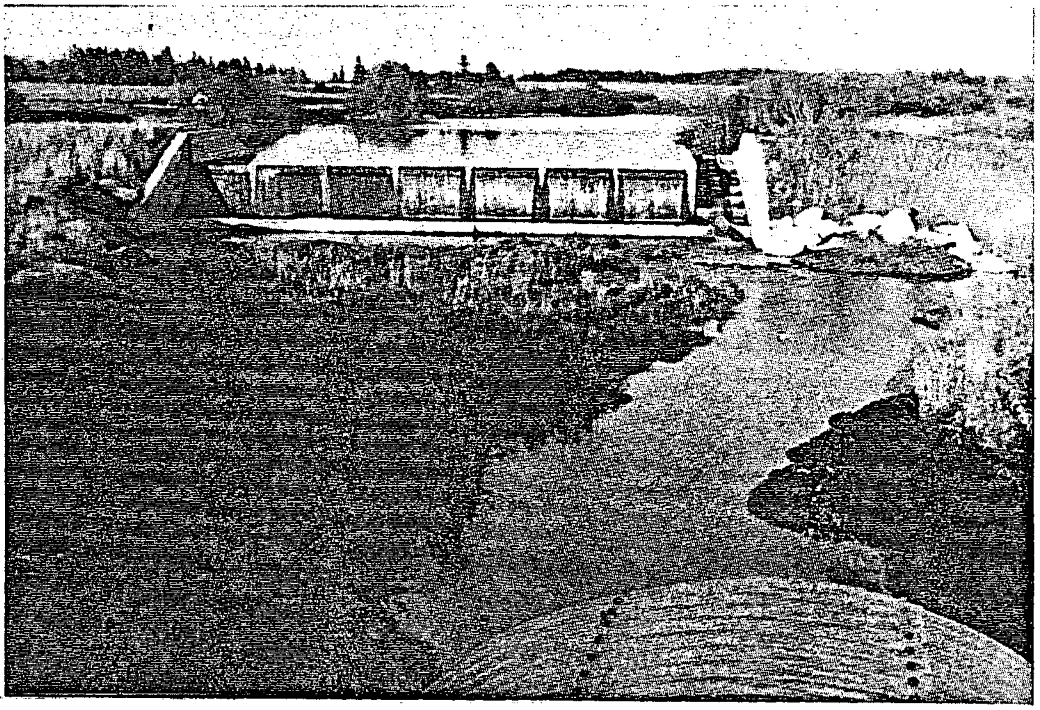


Plate 10. This man-made pond at Mill Valley tends to collect sediment from upstream locations. The fish ladder here and trout noted in other streams in the basin are indicators of adequate water quality.

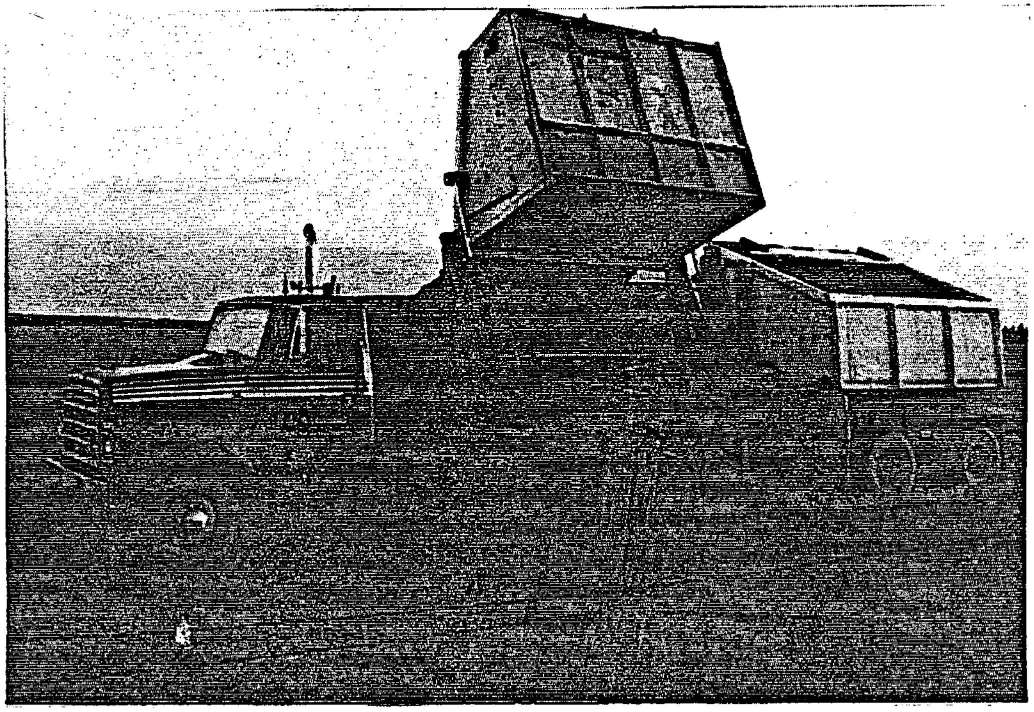


Plate 11. The lime in the hopper of this truck is applied to the fields at a rate of 4 to 5 tonnes/ha. This type of vehicle was noted loading three wheeled rigs throughtout the Wilmot basin. The loadings took place on field edges which reduce soil compaction.

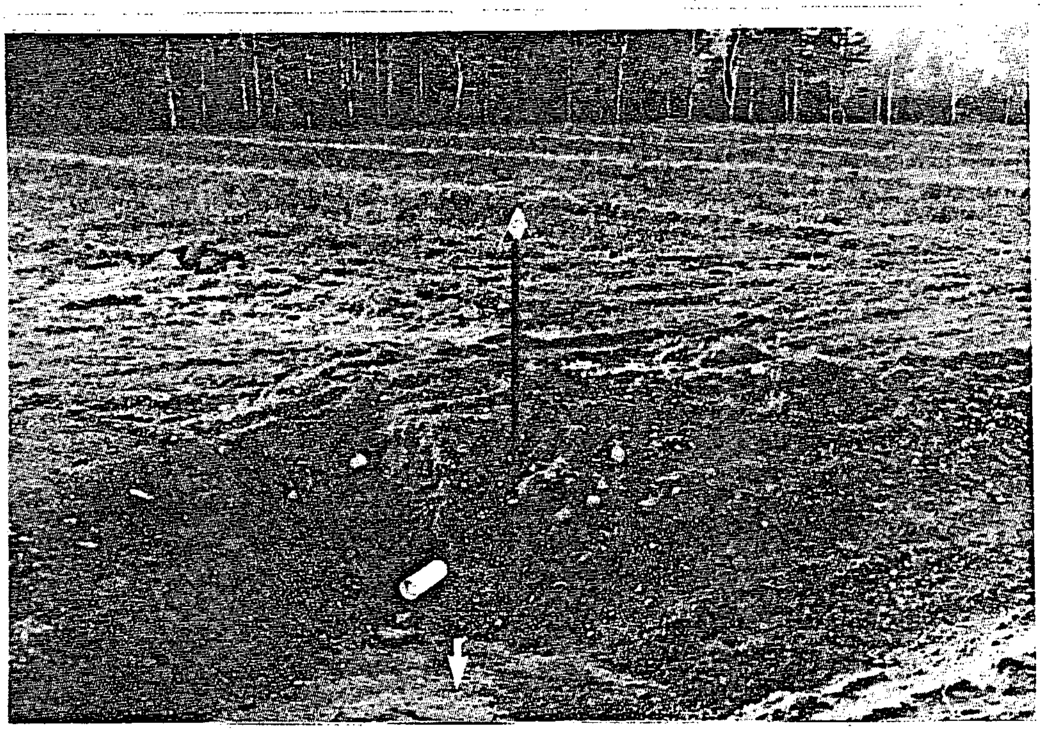


Plate 12. The raised ridges in the field in the background and the white pipe are indicators of tile-drainage. The arrow shows sediment deposits. This field is located 1 km north of Mill Valley.

Plate 13. Chemical cans (bottom arrow) were noted at the gauge site indicating that agricultural applications may have been mixed there. The upper, shorter arrow points to the sediment station. The longer arrow points to a leaning spruce tree indicating bank erosion in what is otherwise a well protected bank by the dense alder fringe vegetation.