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UNITED STATES AGENCY FOR INTERNATIONAL DEVELOPMENT
IRRIGATION SYSTEMS MANAGEMENT PROJECT

STUDY TO ESTABLISH HYDRAULIC DESIGN CRITERIA FOR PAKISTAN IRRIGATION SYSTEM

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CONTENTS

	Page
1. Introduction	1
1.1 General	1
1.2 Method of investigation	2
1.3 Summary and conclusions	4
2. Problem description and study approach	8
2.1 "History" Summary of canal design in Pakistan	8
2.2 Problem description	12
2.3 Methodology	14
3. Available data	18
3.1 Data collection program	18
3.2 Data processing	18
3.3 Data screening	19
3.4 Discussion of data sets	20
3.5 Processing equilibrium data sets	21
4. Depth-velocity relation	26
4.1 Introduction	26
4.2 Depth-velocity relations	26
4.3 Available data sets	41
4.4 Results for different velocity relations	42
4.5 Additional analysis	42
4.6 Conclusions and recommendations	43
5. Width predictor	45
5.1 Introduction	45
5.2 Width predictors formulae	45
5.3 Available data sets	50
5.4 Results for different width predictors	51
5.5 Additional analyses	52
5.6 Conclusions and recommendations	54

CONTENTS

		Page
6.	Sediment transport relation	56
6.1	Introduction	56
6.2	Sediment transport relations	56
6.3	Available data sets	65
6.4	Results for different transport formulae	66
6.5	Conclusions and recommendations	66

TABLES

3.1 Data sets processed up to December, 1985.

3.2 General hydraulic data, EQ-measurements.

3.3 Grainsize distributions and sediment concentration.

3.4 Measured, predicted concentration and measured, predicted velocity.

3.5 Measured, predicted width and ratios predicted/measured width.

3.6 Ratios predicted/measured concentration and velocities.

3.7 Discrepancy ratios sediment transport predictors.

3.8 Roughness coefficients, confidence limits and slopes.

3.9 Measured and predicted widths.

4.1 Velocity predictors, ratios and standard deviations.

6.1 Percentage of observations with ratio of calculated over measured concentration between 0.667 and 1.5, between 0.5 and 2.0 and between 0.33 and 3.0

FIGURES

2.1 General design procedures

4.1 Depalpur canal system, measured versus predicted velocity, Lacey.

4.2 Depalpur canal system, measured versus predicted velocity, Engelund and Hansen.

4.3 Depalpur canal system, measured versus predicted velocity, Ackers and White.

4.4 Depalpur canal system, measured versus predicted velocity, Karim and Kennedy.

4.5 Depalpur canal system, measured versus predicted velocity, van Ryn.

4.6 Depalpur canal system, measured versus predicted velocity, Hydraulic Design Criteria.

4.7 Upper Gugera Branch, measured versus predicted velocity, Lacey.

4.8 Upper Gugera Branch, measured versus predicted velocity, Engelund and Hansen.

4.9 Upper Gugera Branch, measured versus predicted velocity, Ackers and White.

4.10 Upper Gugera Branch, measured versus predicted velocity, Karim and Kennedy.

4.11 Upper Gugera Branch, measured versus predicted velocity, van Ryn.

4.12 Upper Gugera Branch, measured versus predicted velocity, Hydraulic Design Criteria.

4.13 Upper Gugera disties, measured versus predicted velocity, Lacey.

4.14 Upper Gugera disties, measured versus predicted velocity, Engelund and Hansen.

4.15 Upper Gugera disties, measured versus predicted velocity, Ackers and White.

4.16 Upper Gugera disties, measured versus predicted velocity, Karim and Kennedy.

4.17 Upper Gugera disties, measured versus predicted velocity, van Ryn.

4.18 Upper Gugera disties, measured versus predicted velocity, Hydraulic Design Criteria.

4.19 Lower Gugera Branch, measured versus predicted velocity, Lacey.

4.20 Lower Gugera Branch, measured versus predicted velocity, Engelund and Hansen.

4.21 Lower Gugera Branch, measured versus predicted velocity, Ackers and White.

4.22 Lower Gugera Branch, measured versus predicted velocity, Karim and Kennedy.

4.23 Lower Gugera Branch, measured versus predicted velocity, van Ryn.

4.24 Lower Gugera Branch, measured versus predicted velocity, Hydraulic Design Criteria.

4.25 Mailsi canal system, measured versus predicted velocity, Lacey.

4.26 Mailsi canal system, measured versus predicted velocity, Engelund and Hansen.

4.27 Mailsi canal system, measured versus predicted velocity, Ackers and White.

4.28 Mailsi canal system, measured versus predicted velocity, Karim and Kennedy.

4.29 Mailsi canal system, measured versus predicted velocity, van Ryn.

4.30 Mailsi canal system, measured versus predicted velocity, Hydraulic Design Criteria.

4.31 Sind canal system, measured versus predicted velocity, Lacey.

4.32 Sind canal system, measured versus predicted velocity, Engelund and Hansen.

4.33 Sind canal system, measured versus predicted velocity, Ackers and White.

4.34 Sind canal system, measured versus predicted velocity, Karim and Kennedy.

4.35 Sind canal system, measured versus predicted velocity, van Ryn.

4.36 Sind canal system, measured versus predicted velocity, Hydraulic Design Criteria.

4.37 Canal systems Punjab & Sind, measured versus predicted velocity, Lacey.

4.38 Canal systems Punjab & Sind, measured versus predicted velocity, Engelund and Hansen.

4.39 Canal systems Punjab & Sind, measured versus predicted velocity, Ackers and White.

4.40 Canal systems Punjab & Sind, measured versus predicted velocity, Karim and Kennedy.

4.41 Canal systems Punjab & Sind, measured versus predicted velocity, van Ryn.

4.42 Canal systems Punjab & Sind, measured versus predicted velocity, Hydraulic Design Criteria.

4.43 Canal systems Punjab & Sind, measured versus predicted velocity, Hydraulic Design Critria, ripple roughness included.

4.44 Measured velocity versus ripple roughness.

4.45 Bedform classification.

4.46 Bedform classification, ACOP data.

5.1 Depalpur canal system, measured versus predicted top width, Lacey.

5.2 Depalpur canal system, measured versus predicted top width, Chang.

5.3 Depalpur canal system, measured versus predicted bed width, Velikanov.

5.4 Depalpur canal system, measured versus predicted bed top width, Yalin.

5.5 Depalpur canal system, measured versus predicted bed width, Hydraulic Design Criteria.

5.5 Depalpur canal system, measured versus predicted bed width, Hydraulic Design Criteria.

5.6 Upper Gugera Branch, measured versus predicted top width, Lacey.

5.7 Upper Gugera Branch, measured versus predicted top width, Chang.

5.8 Upper Gugera Branch, measured versus predicted bed width, Velikanov.

5.9 Upper Gugera Branch, measured versus predicted top width, Yalin.

5.10 Upper Gugera Branch, measured versus predicted bed width, Hydraulic Design Criteria.

5.11 Upper Gugera disties, measured versus predicted top width, Lacey.

5.12 Upper Gugera disties, measured versus predicted top width, Chang.

5.13 Upper Gugera disties, measured versus predicted bed width, Velikanov.

5.14 Upper Gugera disties, measured versus predicted top width, Yalin

5.15 Upper Gugera disties, measured versus predicted bed width, Hydraulic Design Criteria.

5.16 Mailsi canal system, measured versus predicted top width, Lacey.

5.17 Mailsi canal system, measured versus predicted top width, Chang.

5.18 Mailsi canal system, measured versus predicted top width, Yalin.

5.19 Mailsi canal system, measured versus predicted bed width, Velikanov.

5.20 Mailsi canal system, measured versus predicted bed width, Hydraulic Design Criteria.

5.21 Sind canal systems, measured versus predicted top width, Lacey.

5.22 Sind canal systems, measured versus predicted top width, Chang.

5.23 Sind canal systems, measured versus predicted bed width, Velikanov.

5.24 Sind canal systems, measured versus predicted top width, Yalin.

5.25 Sind canal systems, measured versus predicted bed width, Hydraulic Design Criteria.

5.26 Canal systems Punjab & Sind, measured versus predicted top width, Lacey.

5.27 Canal systems Punjab & Sind, measured versus predicted top width, Chang.

5.28 Canal systems Punjab & Sind, measured versus predicted bed width, Velikanov.

5.29 Canal systems Punjab & Sind, measured versus predicted top width, Yalin.

5.30 Canal systems Punjab & Sind, measured versus predicted bed width, Hydraulic Design Criteria.

5.31 HDC - Ks factor versus measured top width.

5.32 Normalized HDC - Ks factor versus d_{50}

5.33 Normalized HDC - Ks factor versus d_{90}

5.34 Normalized HDC - Ks factor versus depth.

5.35 Normalized HDC - Ks factor versus slope.

5.36 Normalized HDC - Ks factor versus Chezy's coefficient.

5.37 Concentration HDC versus ratio of bed width HDC over measured bed width, Depalpur Canal System.

5.38 Concentration HDC versus ratio of bed width HDC over measured bed width, Upper Gugera Branch.

5.39 Concentration HDC versus ratio of bed width HDC over measured bed width, Upper Gugera disties.

5.40 Concentration HDC versus ratio of bed width HDC over measured bed width, Sind Canal systems.

5.41 Concentration HDC versus ratio of bed width HDC over measured bed width, Punjab and Sind Canal systems.

6.1 Depalpur canal system, measured versus predicted concentration, Ackers and White.

6.2 Depalpur canal system, measured versus predicted concentration, Engelund and Hansen.

6.3 Depalpur canal system, measured versus predicted concentration, Karim and Kennedy.

6.4 Depalpur canal system, measured versus predicted concentration, van Ryn.

6.5 Depalpur canal system, measured versus predicted concentration, Yang.

6.6 Upper Gugera branch, measured versus predicted concentration, Ackers and White.

6.7 Upper Gugera branch, measured versus predicted concentration, Engelund and Hansen.

6.8 Upper Gugera branch, measured versus predicted concentration, Karim and Kennedy.

6.9 Upper Gugera branch, measured versus predicted concentration, van Ryn.

6.10 Upper Gugera branch, measured versus predicted concentration, Yang.

6.11 Upper Gugera disties, measured versus predicted concentration, Ackers and White.

6.12 Upper Gugera disties, measured versus predicted concentration, Engelund and Hansen.

6.13 Upper Gugera disties, measured versus predicted concentration, Karim and Kennedy.

6.14 Upper Gugera disties, measured versus predicted concentration, van Ryn.

6.15 Upper Gugera disties, measured versus predicted concentration, Yang.

6.16 Sind canal systems, measured versus predicted concentration, Ackers and White.

6.17 Sind canal systems, measured versus predicted concentration, Engelund and Hansen.

6.18 Sind canal systems, measured versus predicted concentration, Karim and Kennedy.

6.19 Sind canal systems, measured versus predicted concentration, van Ryn.

6.20 Sind canal systems, measured versus predicted concetnrration, Yang.

6.21 Canal systems Sind and Punjab, measured versus predicted concentration, Ackers and White.

6.22 Canal systems Sind and Punjab, measured versus predicted concentration, Engelund and Hansen.

6.23 Canal systems Sind and Punjab, measured versus predicted concentration, Karim and Kennedy.

6.24 Canal systems Sind and Punjab, measured versus predicted concentration, van Ryn.

6.25 Canal systems Sind and Punjab, measured versus predicted concentration, Yang.

6.26 Canal systems Sind and Punjab, measured versus predicted concentration, Hydraulic Design Criteria.

6.27 Upper Gugera branch, measured versus predicted concentration, Hydraulic Design Criteria.

6.28 Upper Gugera disties, measured versus predicted concentration, Hydraulic Design Criteria.

6.29 Sind canal systems, measured versus predicted concentration, Hydraulic Design Criteria.

6.30 Canal systems Sind and Punjab, measured versus predicted concentration, Hydraulic Design Criteria.

1. INTRODUCTION

1.1 General

The Government of Islamic Republic of Pakistan and the World Bank after having decided to concentrate efforts on upgrading the Pakistan Irrigation System and on cooperation and transfer of knowledge in the field of the management and operational capabilities of the Provincial Irrigation Departments, formulated the Irrigation System Management Project. As part of the Irrigation System Management Project co-financed by the United States Agency of International Development, PRC/Checchi Consultants are working under the USAID/PRC Contract No: 391-0467-CC-00-7011-00, dated 03-17-1984.

Under this contract amongst others, Research Activities have been formulated in relation to the sedimentation and erosion problems in parts of the extensive Pakistan Irrigation System.

A relatively small part of the system is causing problems. Due to continuous sedimentation and deferred maintenance this part of the canal system is performing unsatisfactory, gives insufficient water to the tail ends and requires regular measures to prevent bank breaches. Measures that are generally taken are strengthening and raising of the banks, rehabilitation or sometimes even redesign of (a part of) a canal system.

At present extensive works have been planned on a large number of canals.

Prior to the execution of these works a redesign should be made that minimizes future maintenance and that reduces the risk for future dramatic developments like high siltation rates or canal bank breaches. (For a number of canals the redesign of these systems will be made by the PRC/Checchi Engineering Team).
The redesign has to be based on Hydraulic Design Criteria that are applicable to the Pakistani irrigation systems.

In order to establish the Hydraulic Design Criteria for Pakistan, an extensive measuring compaign was executed by ACOP (Alluvial Channel Observation Project) and a large number of data sets were handed over to PRC/Checchi Engineering Team for further analyses. The present report presents the results of the analyses of the ACOP data sets and gives recommendations for the Hydraulic Design Criteria to be used in redesign of Pakistani irrigation systems. The study was executed by B. Bakker* and H. Vermaas*, members of PRC/Checchi Engineering Team.

In this report Chapter 2 gives a detailed problem description and the method of investigation. The available data sets, the screening that was required to obtain an acceptable data base are discussed in Chapter 3. Chapter 4 deals with the depth-velocity predictors and shows that very accurate predictions can be obtained. (This chapter is basically a continuation of a previous report dealing with this subject - Bakker and Vermaas) [1]
Chapter 5 gives the results for different width predictors while Chapter 6 describes the accuracy of the application of transport formulae in Pakistani irrigation canals.
The conclusions and recommendations of this study will be included in the Hydraulic Design Criteria - final version.

1.2 Method of Investigation

The irrigation system provides water to the farmers for irrigation of the land with the crops. The water while flowing through the system transports sediments. The flow has got a limited transport capacity for the coarse bed material. With reduced flow velocities the transport capacity for the finer sediments is also limited. A canal system or canal section therefore can only be in the equilibrium

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* Project engineers, Delft Hydraulics Laboratory, The Netherlands, temporarily on deputation in PRC/Checchi Engineering Team.

situation, when the amount of sediment entering the system or section equals the transport capacity. If this is not fulfilled, erosion or sedimentation will occur. In fact one observes in parts of the canal systems a continuous sedimentation (especially in the tail ends) and occasionally degradation of canal bed indicating that the equilibrium situation does not yet exist.

A stable canal section can be characterized as follows:

The hydraulic conditions, i.e. discharge regime, roughness, width, depth, velocity and slope in the canal section establish a transport capacity equal to the sediment input.

The major part of the Pakistan irrigation canals has been designed according to the emperical relations of Lacey [2]. With information on discharge and on grainsize of the bed-material Lacey's relations give values for the hydraulic conditions of a stable canal, i.e. width, depth, velocity and slope. No attention is paid to the sediment input and therefore problems can be expected in situations with too low or too high a sediment supply.

Since 1929 many investigators have concentrated on stable channel design. Investigations of phenomenae have been executed; data have been gathered and methods have been developed applicable in canal design.
Concerning the sediment transport numerous formulae have been presented relating the sediment transport capacity to the existing hydraulic conditions.
At the same time a number of very valuable methods have been presented relating width, depth and velocity in the canal to the sediment grainsize, discharge and slope. As all expressions and formulae are interrelated, the equilibrium situation of the canal is completely determined by the sediment supply, discharge and grainsizes.

With the availability of a large number of data sets that was collected for this purpose by ACOP (Alluvial Channel Observation Project), it is possible to test different methods for prediction of depth-velocity, width and sediment transport.

Based on previous investigations Bakker and Vermaas, [1], and recent experience in the studies by Delft Hydraulics Laboratory selections were made for most promising depth-velocity relations, width predictors and transport formulae.
The results for depth-velocity predictor showed that the ripple roughness had to be included. With that it becomes very accurate and requires therefore no further analysis. The width predictor however is not very accurate, partly due to the data that were used and possibly partly due to the absence of a relationship between the width and a specific hydraulic or sediment parameters. This has been part of additional analysis.
The evaluation of several transport formula involved the testing of the available data sets. A further refinement of the formulae was not attempted due to unexplained inconsistencies in the data sets.

Based on the results from the investigations the Hydraulic Design Criteria were formulated. These criteria should be used during redesign of Pakistani irrigation systems.

1.3 Summary and Conclusions

Design Method

Analysis of the design method that has been applied in Pakistan showed that the sediment input into the canal is lacking in the method. As sediment input is one of the determining factors in the canal behaviour, the method is not acceptable.

- A method has been proposed, called the design cycle, dividing the design into three computation steps:
  - width computation
  - depth-velocity computation
  - sediment transport capacity computation

  Selection of the correct slope will achieve a sediment transport capacity equal to the sediment input.

Depth Velocity Relations

- A number of velocity predictors has been investigated. They gave all reasonable results.

- The best results were obtained by applying the HDC formula (the in 1985 developed and further improved HDC relation by Bakker and Vermaas. This relations is based on van Ryn's formulae). In general the ratio of predicted over measured velocity is close to one and the standard deviation of the ratio is small. This indicates that most of the results (for the ratio) are close to one. The inclusion of the ripple roughness is a necessary expansion for an accurate depth-velocity predictor in the Pakistan canals.

- The results obtained with HDC are very satisfactory. Further refinements are not required.

Width Predictor

- All formulae that formed part of the investigations show similar relations. The results obtained with these formulae are therefore almost identical.

- Although on the whole the width predictors show good results, individual observations may sometimes give a ratio for predicted over measured width as low as 0.5 and as high as 1.8. For practical applications these ratios are somewhat too extreme.

- Further analyses of the available data sets do not reveal any relationship between the canal width and respectively depth, slope, sediment concentration, D_{50} and D_{90}.

- The inaccuracy of the formulae is probably caused by the fact that: 1. the measurement was not executed during width forming discharge, 2. bank soil characteristics are not taken into account in detail, 3. human and animal interference have an important influence on width.

- HDC formula (comparable to Lacey and Blench) offers the best method for the redesign of irrigation systems. The width coefficient can then be chosen in accordance to the observed value.

Transport Relations

- The renown and widely accepted formulae for sediment transport were applied on the Pakistani canals. Comparison between calculated and measured concentrations show disappointing results.

- The available data sets show apparent inconsistencies. Under the same hydraulic and sediment conditions in some locations a wide range of concentrations has been observed. This 'inconsistency' is probably the main cause for the poor results (large scatter) with the transport relation.

- Before further analyses and refinement of formulae is undertaken it is recommended that the inconsistencies in the data sets first be resolved.

Conclusions

It is concluded that a new design method should be applied during the redesign of irrigation systems. The new method, laid down in the Hydraulic Design Criteria, consists of the following parts:

- Width computation.

  As HDC formula gives good results and offers flexibility during redesign it is recommended to use this formula.

- Depth velocity computation.

  The HDC method gives the best results when applied on Pakistani canals and is therefore recommended for use in the redesign procedure.

- Sediment transport relation.

  Based on the results of this study there is no preference for a particular sediment transport formula. Although the results were disappointing it is expected that most formula can be applied successfully in the Pakistani canals.
  As the Engelund-Hansen transport relation is relatively simple and easy to apply, this formula is recommended for use during redesign of irrigation canals.

2. Problem Description and Study Approach

2.1 "History" Summary of Canal Design in Pakistan*

History of canals in Pakistan shows that four canals, Western Jamna, Upper Bari Doab, Sirkind and Lower Swat were constructed in the years of 1825, 1856, 1872 and 1880 and that their designs were based on the Chezy relationships.

For a period other researchers sought ways for determining more appropriate values for the Chezy C. None of the relationships, although used extensively, proved to be satisfactory for designing canals heavily laden with sediment.

Near the end of the 19th Century Kennedy, Executive Engineer of Punjab Irrigation published his theory of silt transport based on his observations at 30 selected locations on the Upper Bari Doab Canal near Lahore where he considered the channel to be in regime. From the data collected over a period of several years he was the first to formulate the basic law that shallower canal sections are capable of transporting greater silt loads, a conclusion that is still recognised as an emperical, but well established design basis. The basic assumptions were that: (a) the vertical components of eddies supported silt particals; (b) the silt transporting power of a channel was dependent solely upon its velocity which controls the eddies; (c) the silt transporting power was also related to the depth which limited the effects; (d) the eddies and the silt transporting power was not influenced by the bed width. Kennedy used the information to develop his noted equation which gives the critical velocity (no silting - no scouring) correlated with depth but not with width of the

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* The material contained in this write up was obtained mainly from "Role of Regime Concept in the Design of Alluvial Channels, in the Indus Basin, [DFCR Bulletin, Vol.9 No.], June 1979".

channel. In 1904 he gave "rough" rules for bed-widths to depth ratios for designing silt stable channels.

In the early part of the 20th Century the Lower Chenab, Lower Jhelum, Upper Chenab, Lower Bari Doab, and Upper Jhelum were designed and built using the Kennedy theory and his rough rules.

A further development in the design of stable channels occured when Lindley proposed equations taking into account the bed-width to depth ratios. The Sutlej Valley, Sukkur and Rohri canals came into being about the same time (1932). The designs of the Sutlej Valley and Sukkur canals were based on the Kennedy-Lindley concepts. The design of the Rohri was based on a combination of emperical relationships including those of Kennedy, Manning and others.

In 1933 the Irrigation Research Institute in Lahore started data observations on the Lower Jhelum, Lower Chenab, Upper Chenab and Upper Bari Doab. Analyses of the data in 1936 gave emperical equations. Later on analysis on a rational basis included forces on the sediment particles. Other attempts were made to develop relationships between the hydraulic parameters and channel geometry for designing non-silting, non-scouring channel in alluvial material.

These surely had some influence on work done by Lacey to develop his Regime Concept during the period 1926 to 1939 in which he introduced a silt factor, related to the mean bed material diameter. The set of equations could be used to calculate the velocity, areas of cross-section, slope, width and depth of channel for a particular discharge and silt grade.

Lacey did not present any new unpublished information but rearranged the available data to reduce the number of independent parameters to a minimum.

Lacey's method was accepted officially by the Central Board of Irrigation in 1934 as standard design criteria for regime canals. Some of the major canals based on Lacey's formulae were the Haveli (1939), Thal (1946), BRBD Link (1951), B.S. Link (1954), M.R. Link (1956), Kotri (1955), Taunsa (1958) and Guddu (1962). Many of the older canals were remodelled using his method.

In the early 1960's review was made of literature and data from various parts of the world on the design of regime channels after development of the Lacey equations of that time. Lane's "Tractive Force Method" and Einstein's "Bed Load Functions" were considered outstanding contributions to the design of regime canals. Those theories, although of sound theoretical basis, had not provided reliable and practical design criteria for the Pakistan canals.

Although several interesting and significant attempts were made to produce practical design criteria on the basis of Einstein's approach none had gained recognition as a practical design basis. Lacey's approach, although unsatisfactory from the purely theoritical point of view, provided reliable design criteria of wide recognition as a practical solution for problems relating the design of canals in the Indo-Pakistan area.

As a result of the review the Lacey method was adopted for the Phase I link canals. At the same time it was decided to collect more data on the performance and operation of representative existing canals for further evaluation of the design procedures.

The Canals and Headworks Observation Program (CHOP) was started in 1961 to collect sediment samples and flow data in appropriate areas for application to design of Phase II Link Canals. On the basis of the data collected by CHOP it was decided that the scope of the observation program should be expanded to other canals of similar nature in Pakistan.

This decision led to the establishment of the "Alluvial Channels Observation Project" (ACOP) in 1974 in an attempt to verify the basic alluvial mechanics phenomena. Although this monitoring program has been gradually expanded there has been no concerted effort to prove or revise the Lacey equations for the designing of canals in alluvial materials. Deteriorating conditions (siltation and scour) observed in many of Pakistan's canal systems in recent years supports a belief that more research is required to establish the validity or revise the Lacey method. Such a program could not be undertaken without the extensive and detailed monitoring of water and sediment flow as executed by ACOP.

2.2 Problem Description

The Pakistani irrigation canals with a total length of over 1 million kilometer, transport water to an irrigated area of approximately 160.000 km^2, that provides food for over 80 million people.

The very size of the systems makes it almost impossible to comprehend and impossible to be familiar with all the problems in the systems.

The major problem in the systems is a continuous sedimentation. Especially in the tail ends the shallowing of canals causes problems, as the amount of water that reaches the farmers, is no longer sufficient.
To overcome this shortage of water usually the water level in the canals will be raised.
This again causes problems for the banks. Strengthening and raising of the banks is required to prevent breaches.

In all, due to the continuous sedimentation regular maintenance works are required.

Part of the system has not been maintained properly as one could not afford the expenditure, nor had the required equipment, management and capabilities for this largest system in the world.
This resulted into a deteriorated and not properly functioning irrigation system. Some farmers are feeling the consequences now. In the end the consequences will be felt by Pakistan as a whole as the crops will be of lower quality and the harvests will be reduced.

One may ask if it is possible to minimize the costs for the required maintenance works, i.e. reducing the sedimentation in the canals or concentrating it at certain locations.

Parts of the canal systems are not suffering from sedimentation. On the contrary, one can observe a continuous degradation of the canal bed. The flow is eroding the bed and as such lowers the water levels. The fixed intakes of the farmers along the canal are no longer operating properly. And once again the farmers have to bear the burden by reduced crops and thus reduced income.

In both canal types, i.e. eroding and silting up type, one cannot speak of a equilibrium situation. The 'in-regime' situation has not been achieved.
The canals are not behaving according to the design rules. The amount of sediment entering the canal does not match the transport capacity of the canal.

At present extensive works have been planned on the canals. Dealing both with the banks and the prism of the canals: Maintenance and rehabilitation works. The works are mainly to improve the functioning of the canals. For some canals the design is adapted at the same time to meet the increased water demand of the farmers.
The rehabilitation works and the redesign of some canals to meet the increased water demands, have been based on the same design rules that have been applied since several decades. So the same problems as one can observe at present are to be expected in future in these rehabilitated or redesigned canals.

The question now arises what procedure should be followed and which methods and formulae should be used during redesign of the Pakistani irrigation canals in order to get a good prediction for the future behaviour of the canals.

2.3 Methodology

The task of the study is to advise and recommend on the most favourable method for stable canal design under the Pakistani conditions. This task is complicated and simple at the same time. It is simple because many methods applicable in stable canal design have been presented in the last few decades. So one can concentrate on available methods, for the time being, and try to identify the best method for the conditions in Pakistan. It is difficult because the number of different methods is almost countless and very often the methods are very complicated. It is clear that the number of methods to be verified in this study has to be limited. Fortunately, recently some studies have been executed by the Delft Hydraulics Laboratory in which the performance of the different methods has been compared (using the World Flume Data Bank). [3,4]
Moreover, in January 1985, the PRC/Checchi Engineering team completed a study and submitted a report presenting results of the preliminary investigations on alternative depth-velocity relations. [1]

An irrigation canal operating throughout the year transports water and sediment. Both are in general a function of time. When the yearly sediment input is equal to the yearly sediment transport capacity the bottom level will not change.
The canal is in regime !

When the sediment input however is not equal to the transport capacity the bottom level will change. Sedimentation or erosion occurs in the canal (section).
This will give a change in: cross-sections, velocities, water depths and (possibly) widths of the canal.
This adaptation continues until the sediment transport capacity equals the sediment input into the canal.
Then the canal is in regime.

In general one assumes that for one combination of discharge, sediment input and grainsize only one specific 'in-regime' - condition is possible. The independent variables of a canal system are therefore:

$S_{inp.}(t)$	=	Sediment input (as function of time)
$Q(t)$	=	Discharge (as function of time)
D	=	Grainsize, grainsize-distribution of transported material and bed material.

And the 'in-regime' situation can be characterized by the dependent variables and relations, as follows:

$$\int_{year} S_c(t)dt = \int_{year} S_{inp}(t)dt \qquad (2.1)$$

B	=	Width of canal (-section)
h	=	Depth of canal (-section)
v	=	Velocity in the canal (-section)
i	=	Slope in the canal (-section)
$S_c(t)$	=	Sediment transport in the canal (-section)

For the width of an 'in-regime' canal some suggestions have been made relating the width to the independent variables. When the independent variables and the width and slope of the canal are available, there are a number of methods that give the value of the velocity and the depth in the canal. The methods range from very simple to very complicated depth-velocity relations. Provided the other variables are available there are a number of formulae available that compute the sediment transport in the canal. These transport formulae are dealth with in numerous handbooks on sediment transport. [5,6]

With these equations for sediment transport, width, depth and velocity, and with the input of the values for the independent variables it is possible to calculate the characteristics of the 'in-regime' canal. To fulfill equation (2.1) one has to choose (or compute) the correct slope. This is achieved through an iterative process in the design procedure (see fig. 2.1).

In his design method Lacey used formulae to calculate the slope, width, depth and velocity for a, so called, 'regime canal'. The effect of the sediment input on the final equilibrium situation is not included in Lacey's method.

However as has been described above, the sediment input is a very important factor in the canal behaviour and can not be neglected in canal design.

The suggested design procedure is not as straightforward as Lacey's method, but guarantees a better motivation and a better understanding and, above all, a better performance of the designed canal.

A requirement however, is that reliable formulae for calculation of width, depth, velocity and sediment transport can be used for the Pakistani canals.

The underlying study tries to identify the formulae and relations for width, depth, velocity and sediment transport that perform best in Pakistani canals.
For this purpose ACOP (Alluvial Channel Observation Project) collected a large number of data sets that could be used to test the applicability of different theories.

The depth-velocity predictor was investigated earlier, Bakker and Vermaas. [1] Based on that study a number of most promising depth-velocity predictors (steps) are selected for further analysis.

Comparison of predicted value with measured value will indicate which method is best. Extra research will indicate whether improvement can be made on existing formulae.

A number of highly empirical width predictors is selected for testing. Although one may have doubts about the validity/accuracy of the data sets with respect to testing on width predictors, some further analyses can be made to reveal a relationship between the width and any hydraulic or sediment parameter other than discharge.

The research for the identification of the best sediment transport formula is problematic. Although the database of ACOP data is extensive, the total data set with reliable sediment data is very limited. Moreover, there seems to be inconsistencies in the data sets that will adversely influence the results with sediment transport relations.

Based on the results of all investigations, Hydraulic Design Criteria will be formulated to be used while redesigning irrigation systems.

3. Available Data

3.1 Data collection program

Under the terms of the agreement between the Federal Coordination Cell (F.C.C.) and Alluvial Channels Observation Project (ACOP), [7] ACOP started early 1984 collection of baseline data and measuring of hydraulic and sediment data in the four provinces. The collection and measuring of data under the terms of the agreement will continue upto the end of 1986.

An important part of the data collection program are the equilibrium measurements, EQ-data sets. EQ-measurements are defined as discharge/sediment measurements in a selected study reach under steady flow conditions at or near full supply discharge. The study reach is selected such that it is free of up or downstream influences. In addition to discharge measurements slope measurements are carried out in the study reach and the canal segment bounding the study reach between two control structures. Sediment measurements consist of sampling of both suspended and bed material at the discharge measuring section of the study reach.

A detailed description of the set up of an EQ-measurement is given in [8].

3.2 Data processing

Data of EQ-measurements is coded by ACOP according to formats provided by PRC/C to ACOP. The coded data is then punched, listed and checked by ACOP. The next step is that the data is processed by a specially, for this purpose, developed software package, the EQ-program. The results of the EQ-program are printed and stored on diskette. The EQ-program also generates reduced data files which form the input data sets for further interpretation and analyses. A detailed description of the software package including the listing of the programs is given in [9,10].

3.3 Data Screening

Several criteria have been applied to determine if the EQ-data set could be used for further analysis and verification of velocity, width and sediment transport predictors. As the screened data sets were to be used to verify relations developed for steady and uniform flow conditions the criteria are mainly related to equilibrium conditions during the measurement.
Applied criteria are:

- Check on the location of the measurement in relation to the location of the structures bounding the study reach.

- Comparison of the study reach slope with the structure to structure slope. In case of significant differences it was concluded that either the measurement was incorrect or non-uniform flow conditions existed. Statistical confidence limits of the structure to structure slope measurements were also used to check the consistency of the slope measurements.

- Check on cross section and bedwidth.
  The irrigation canals have typically steep side slopes. Any cross sectional measurement with side slopes flatter than two horizontal to one vertical was deemed incorrect or unrepresentative.

- Check of stage discharge relationship.
  Stage discharge relationship was checked if more data sets measured at one location but on a different date were available.

- Check of consistency of slope, discharge and cross section if more data sets measured at one location on different dates were available.

3.4 Discussion of data sets.

In table 3.1 an inventory of data sets processed upto December 1985 has been given. Table 3.1 shows that a total of 671 EQ-data sets were screened and processed by the end of 1985. This number is also the number of measurements provided by ACOP to PRC/C per December 01, 1985. Measurements received after December 01, 1985 are not included in the data sets, these measurements will be processed seperately.
The data sets are mainly collected in the Punjab systems: Depalpur, Mailsi, Gugera and Mianali systems. Data collected in Sind and NWFP was treated collectively as data from Sind and NWFP systems. No data from Baluchistan systems was provided by ACOP. For a number of 533 data sets the processing could be totally completed. The difference between total sets processed and total sets completed is due to either error or incomplete data sets. In incomplete data sets essential field data is missing. These data sets have been sent back to ACOP for completion. In cases where the software does not come to a normal end or the software provides an understandable error message the data set is classified as an error data set. Trying to solve these errors we learned that in at least 95% the problems can be traced back to uncorrectable input data as negative slopes or a complete disagreement between water surface and bed slope. In questionable data sets all necessary data is available, however it is possible to indicate what might be wrong in the data. These data sets are sent back to ACOP including the reason for classifying the particular data set as questionable for verification with field data. Problematic data sets are data sets which are processed without problems and which pass the screening procedure mentioned under para 3.3 However, in these data sets the Manning roughness coefficient is computed completely out of line from expectations. In alluvial unlined canals in Pakistan the expected Manning roughness coefficient is in the order of 0.023. Data sets which show a Manning coefficient below 0.017 or above 0.029 are classified as problematic.

The remaining data sets are classified either as hydraulic or sediment data sets. Sediment data sets contain hydraulic as well as sediment data, hydraulic data sets do not need sediment data. The sediment data sets are part of the hydraulic data sets.
Hydraulic data sets are used for verification of the depth velocity relations.
Sediment data sets are used for verification of sediment transport relations.
Hydraulic and problematic data sets are used for verification of the width predictor.
From table 3.1 it is seen that the following numbers of data sets have been used for verification of the different relations.

Depth velocity relations	292 data sets
Sediment transport relations	169 data sets
Width relations	368 data sets

3.5 Processing Equilibrium Data Sets

The results of the 292 equilibrium data sets as they were used during the verification of the HDC roughness relations are given as tables 3.2 - 3.9.

Table 3.2 shows general hydraulic information regarding each measurement. This information is either recorded, measured or calculated based on field data.

No.	-	Serial number of measurement, added by computer.
Experiment	-	Abbreviation of canal, disty or minor name.
Reach	-	Location of measurement in RD.
Date	-	Date of measurement.
Discharge	-	Computed based on measured velocities and cross section.

Depth	-	Computed average depth based on depth measurements.
Velocity	-	Computed average velocity based on velocity measurements.
Top width	-	Measured.
Average width	-	Computed, based on measurement of cross section.
Bed width	-	Computed, based on measurement of cross section.
Hydraulic radius	-	Computed, based on measurement of cross section.
Slope - st.rch.	-	Slope in "study reach", computed based on regression analysis of water levels.
Slope - str. str.	-	Slope in canal segment, computed based on regression analysis of water levels at structures (structure to structure).
Temperature	-	Measured water temperature.
Side slope left, right.	-	Computed based on measured cross section.

Table 3.3 shows general information on sediment grainsizes and concentrations of the bed and suspended load samples taken as part of the EQ-measurement. Part of the information is computed based on grainsize analysis data provided by ACOP.

No	-	Serial number of measurement, added by computer.
D_{35}, D_{50}, D_{90}	-	Grainsize dimensions bed material, based on 1 to 5 bed material samples.
Sigma	-	Geometric standard deviation bed material.
Suspended load concentration	-	Concentrations < 2, 2-62, > 62 microns based on 1 to 20 suspended load samples and computed according to Modified Einsteins Procedure.[9]In the part > 62 microns the computed bed load according to Modified Einsteins Procedure is included.
Total	-	Total concentration suspended load.

> 62 microns	-	Concentration of suspended load particles > 62 microns.
Grainsize distribution suspended load > 62 microns.	-	Based on grainsize analyses, the part < 62 microns has been discarded. D_{10}, D_{35}, D_{50}, D_{90}.
Sigma	-	Geometric standard deviation suspended load > 62 microns.
Computed bed load	-	Computed bed load concentration according to Modified Einstein Procedure.

Table 3.4 gives the comparison between measured concentration, velocity and predicted concentration, velocity according to different theories.

No	-	Serial number of measurement, added by computer.
> 62 microns	-	Measured concentration > 62 microns, computed bed load is included.
EH	-	Predicted concentration according to Engelund-Hansen. [11]
YG	-	Predicted concentration according to Yang. [12]
AW	-	Predicted concentration according to Ackers-White. [13]
KK	-	Predicted concentration according to Karim-Kennedy. [14]
VR	-	Predicted concentration according to van Ryn. [15]
HDC	-	Predicted concentration according to Hydraulic Design Criteria.
Measured	-	Measured velocity.
Lacey	-	Predicted velocity according to Lacey. [2]
EH	-	Predicted velocity according to Engelund. [16]
AW	-	Predicted velocity according to White et al. [17]
KK	-	Predicted velocity according to Karim-Kennedy [14]
VR	-	Predicted velocity according to van Ryn. [15]
HDC	-	Predicted velocity according to Hydraulic Design Criteria.

Table 3.5 shows information related to measured and predicted width, including the ratios predicted/measured with.

No.	-	Serial number measurement, added by computer.
Top width	-	Measured.
Bed width	-	Computed, based on cross section measurements.
Top width Lacey	-	Predicted top width according to Lacey.
Top width HDC	-	Predicted top width according to Hydraulic Design Criteria.
Bed width HDC	-	Predicted bed width according to Hydraulic Design Criteria.
KS	-	Factor in width predictor HDC.
Ratio predicted/ measured.	-	Top width Lacey Top width HDC Bed width HDC

Table 3.6 gives the ratio is for predicted/measured concentration and velocities.

No.	-	Serial number measurement, added by computer.
EH	-	Engelund-Hansen.
YG	-	Yang
AW	-	Ackers-White
KK	-	Karim-Kennedy
VR	-	van Ryn
HDC	-	Hydraulic Design Criteria
Lacey	-	Lacey

The discrepancy ratios are related to the prediction of sediment concentration and given in table 3.7.

Table 3.8 show calculated roughness coefficients, 95% confidence limits for study reach and structure to structure slope, and measured study reach slope in comparison with Laceys slope.

No.	-	Serial number measurement, added by computer.
Chezy	-	Chezy's roughness coefficient, C
Mannings n	-	Mannings roughness coefficient, n
Study Reach	-	95% confidence limits study reach slope
Structure to Structure	-	95% confidence limits structure to structure slope.
NE	-	Indication for the number of water levels measured in the study reach.
NH	-	Indication for the number of water levels measured in the canal segment at structures.
Measured slope	-	Measured slope in the study reach.
Lacey slope	-	Slope according to Lacey to be used in case of design of redesign.

Table 3.9 gives measured and predicted widths according to Lacey, Yalin, Chang and Velikanov.

No.	-	Serial number measurement, added by computer.
Top width	-	Measured.
Bed width	-	Computed, based on cross section measurements.
Top width Lacey	-	Predicted top width according to Lacey. [18]
Top width Yalin	-	Predicted top width according to Yalin. [19]
Top width Chang	-	Predicted top width according to Chang. [20]
Top width Velikanov	-	Predicted top width according to Velikanov. [21]

The results given in all figures, chapters 4, 5 and 6, related to velocity, width and sediment prediction are computer generated and based on similar tables.

4. Depth-velocity relation

4.1 Introduction

Depth-velocity relations have been developed by many investigators all over the world. In Pakistan Kennedy (1895), Lindley (1919) and Lacey (1929) did pioneering work in introducing depth-velocity relations into design of alluvial channels. Recent studies in USA and Europe led to improvement of existing or introduction of new relations which are more accurate. In comparison with width and sediment transport relations recently developed depth-velocity relations give very good results.

Based on the results of the previous study on this subject by the PRC-Engineering team, Bakker and Vermaas [1], six depth-velocity relations were selected for further investigation (para 4.2). Application of these relations on the available data sets (para 4.3) shows that the results are very encouraging (para 4.4). It is concluded that three relations should be discarded as the accuracy is relatively low, two relations give fairly good results and the in 1985 by the PRC-Engineering team proposed relation in the preliminary HDC - gives best results. However, a bias as can be seen in Fig. 4.42 is still present.

Further analysis showed that the bias can be removed by taking into account the ripple roughness. Formulating the ripple roughness as a function of the velocity in the canal and including this in the depth-velocity relation, very accurate results can be obtained. Fig. 4.43.

4.2 Depth-velocity relations

Lacey (1929)

In 1929 Lacey [2] published his relations for design of alluvial channels. The given relations are related to the prediction of width, slope and depth-velocity. Based on these relations it is possible to

derive four different relations for the velocity, Bakker and Vermaas, [1]. To avoid complications by the application of a measured slope and to have a direct relation with the discharge the following relation was selected:

$$V = 0.794\, Q^{1/6}\, f^{1/3} \tag{4.1}$$

Where Q = discharge (ft^3/s)

and $f = 1.59\ \sqrt{D_{50}}$ (4.2)

D_{50} = Particle diameter (mm)

Engelund (1966)

Based on flume data only, Engelund [16] presented in 1966 a relation between normalized grain-roughness shear stress, Θ', and normalized total shear stress, Θ.

The relations between Θ' and Θ which were originally presented in a graph can be used as a velocity predictor. In order to test this depth velocity predictor the following approach was followed in this study. The index m relates to measured values.

1. Estimate hydraulic radius of the bed, h_j
   (h_j start value = h measured)
2. Compute normalized total shear stress,

$$\Theta = \frac{h_j\ i}{\Delta d_{50}} \tag{4.3}$$

3. Compute normalized grain-roughness shear stress,

$$\Theta' = 0.4\ \Theta^2 + 0.06 \qquad \text{for } \Theta' \leq 0.55 \tag{4.4}$$

$$\Theta' = \Theta \qquad \text{for } 0.55 < \Theta' \leq 1 \tag{4.5}$$

$$\Theta' = \{0.3+0.7\ \Theta^{-1.8}\}^{-0.56} \qquad \text{for } \Theta' > 1 \tag{4.6}$$

4. Compute hydraulic radius related to grains, R_b'

$$R_b' = \frac{d_{50}\Theta}{i} \tag{4.7}$$

5. Compute average flow velocity, V_j

$$V_j = \sqrt{g \; R_b' \; i} \; \left(6 + 2.5 \ln \left(\frac{R_b'}{2d_{65}}\right)\right) \qquad (4.8)$$

6. Compute width, b

$$b = Q/(v_m * h_m)$$

7. Compute new hydraulic radius of the bed, h_{j+1}

$$h_{j+1} = Q/(b*v_j)$$

8. Compare new and old hydraulic radius of the bed, if

$$| h_{j+1} - h_j | > \frac{h_{j+1}}{200} \quad \text{then}$$

$$h_{j+2} = \frac{h_{j+1} + h_j}{2}$$

$$h_j = h_{j+2}$$

and repeat computation from 2

Where:	h_j	= hydraulic radius of the bed	(m)
	Q	= measured discharge	(m^3/s)
	i	= slope	(-)
	Δ	= 1.65, specific density	(-)
	d_{50}	= particle diameter	(m)
	d_{65}	= particle diameter	(m)
	Θ	= normalized total shear stress	(-)
	Θ'	= normalized grain-roughness shear stress	(-)
	R_b'	= hydraulic radius related to grains	(m)
	g	= acceleration of gravity	(m/s^2)
	b	= width	(m)
	V_j	= predicted velocity by Engelund	(m/s)
	V_m	= measured velocity	(m/s)
	h_m	= measured water depth	(m)

White (1979)

The method presented by White et. al. [17] in 1979 is based on extensive flume data (1432) and field data (263) in the lower flow regime. The method is used as a velocity predictor as follows:

1. Compute kinematic viscosity coefficient depending on temperature T (°C).

$$\nu = (1.14 - 0.031 * (T-15) + 0.00068 * (T-15)^2)*10^{-6} \quad (4.9)$$

2. Estimate flow depth, h_j

(h_j start value = $h_{measured}$)

3. Compute bed shear velocity, u_*

$$u_* = \sqrt{g\ h_j\ i} \quad (4.10)$$

4. Compute particle parameter based on grainsize distribution of surface material, D_*

$$D_* = D_{65} \left(\frac{g\Delta}{\nu^2}\right)^{1/3} \quad (4.11)$$

5. Compute parameters, n and A

$$\left.\begin{aligned} n &= 0.0 \\ A &= 0.17 \end{aligned}\right\} \quad \text{for } D_* \geq 60 \quad (4.12)$$

$$\left.\begin{aligned} n &= 1.0 - 0.56 \log D_* \\ A &= \frac{0.23}{\sqrt{D_*}} + 0.14 \end{aligned}\right\} \quad \text{for } 1 \leq D_* < 60 \quad \begin{aligned} &(4.13) \\ &(4.14) \end{aligned}$$

6. Compute mobility parameter, F_{fg}

$$F_{fg} = \frac{U_*}{\sqrt{g\Delta D_{65}}} \quad (4.15)$$

7. Compute mobility parameter, F_{gr}

$$F_{gr} = A + (F_{fg} - A) * \left(1.0 - 0.7\left(1.0 - \frac{1}{e^{(\log D_*)^{1.7}}}\right)\right) \quad (4.16)$$

8. Compute average flow velocity, V_j

$$V_j = \left(\frac{F_{gr} * \sqrt{gD_{65}}}{U_*^{\,n}}\right)^{\frac{1}{1-n}} * \sqrt{32} * \log(10h_j/D_{65}) \qquad (4.17)$$

9. Compute width, b

$$b = Q/(V_m * h_m)$$

10. Compute new flow depth, h_{j+1}

$$h_{j+1} = Q/(b*V_j)$$

11. Compare new and old flow depth, if

$$|h_{j+1} - h_j| > \frac{h_{j+1}}{200}, \quad \text{then}$$

$$h_{j+2} = \frac{h_{j+1} + h_j}{2}$$

$$h_j = h_{j+2}$$

and repeat computation from 3.

Where:	ν	=	Kinematic viscosity	(m^2/s)
	T	=	Temperature	(°C)
	h_j	=	Flow depth	(m)
	U_*	=	Bed shear velocity	(m/s)
	g	=	Acceleration of gravity	(m/s^2)
	i	=	Slope	(-)
	Δ	=	1.65, specific density	(-)
	D_*	=	Particle parameter	(-)
	D_{65}	=	Particle diameter	(m)
	n	=	Particle parameter	(-)
	A	=	Particle parameter	(-)
	F_{fg}	=	Mobility parameter	(-)
	F_{gr}	=	Mobility parameter	(-)
	v_j	=	Predicted velocity by White	(m/s)
	b	=	Width	(m)
	v_m	=	Measured velocity	(m/s)
	h_m	=	Measured waterdepth	(m)

Karim (1981)

The method presented by Karim and Kennedy [14] is based on multiple regression analyses of numerous flume and field data. The method is used as a velocity predictor as follows:

1. Compute width, b

$$b = \frac{Q}{v_m * h_m} \tag{4.18}$$

2. Compute kinematic viscosity coefficient depending on temperature T (C).

$$\nu = (1.14 - 0.031 * (T-15) + 0.00068 * (T-15)^2)*10^{-6} \tag{4.19}$$

3. Compute particle parameter, D_*

$$D_* = D_{50} \left(\frac{\Delta g}{\nu^2}\right)^{1/3} \tag{4.20}$$

4. Compute critical mobility parameters, Θ_{cr} depending on value of D_*

$$\Theta_{cr} = 0.24\ D_*^{-1} \quad \text{for } D_* \leq 4 \tag{4.21}$$

$$\Theta_{cr} = 0.14\ D_*^{-0.64} \quad \text{for } 4 < D_* \leq 10 \tag{4.22}$$

$$\Theta_{cr} = 0.04\ D_*^{-0.1} \quad \text{for } 10 < D_* \leq 20 \tag{4.23}$$

$$\Theta_{cr} = 0.013\ D_*^{0.29} \quad \text{for } 20 < D_* \leq 150 \tag{4.24}$$

$$\Theta_{cr} = 0.055 \quad \text{for } D_* > 150 \tag{4.25}$$

5. Compute critical bed shear velocity, $U_{*,cr}$

$$U_{*,cr} = \sqrt{\Theta_{cr} g\ d_{50} \Delta} \tag{4.26}$$

6. Compute particle fall velocity, W_s, depending on value of D_*

$$W_S = \frac{\Delta g\ d_{50}^2}{18\nu} \quad \text{for } D_* \leq 3 \tag{4.27}$$

$$W_s = \frac{10\nu}{d_{50}} \left(\left(1 + \frac{0.01\ \Delta g\ d_{50}^3}{2} \right)^{0.5} - 1 \right) \quad \text{for } 3 < D_* \leq 25 \tag{4.28}$$

$$W_s = 1.1 \sqrt{\Delta g d_{50}} \qquad \text{for } D_* > 25 \tag{4.29}$$

7. Estimate flow depth, h_j

h_j (start value = 1.5 * $h_{measured}$)

8. Compute flow velocity, v_j

$$V_j = \frac{Q}{bh_j}$$

9. Compute shear velocity, U_*

$$U_* = \sqrt{g\ h_j\ i} \tag{4.30}$$

10. Compute various parameters according to Karim approach

$$V1 = \log\left(\frac{V_j}{\sqrt{g\Delta d_{50}}}\right) \tag{4.31}$$

$$V2 = \log\left(\frac{h_j}{d_{50}}\right) \tag{4.32}$$

$$V3 = \log\ (1000*i) \tag{4.33}$$

$$V4 = \log\left(\frac{U_*}{W_s}\right) \tag{4.34}$$

$$V5 = \log\left(\frac{W_s\ d_{50}}{\nu}\right) \tag{4.35}$$

$$V6 = \log\left(\frac{U_* - U_{*,cr}}{\sqrt{\Delta g\ d_{50}}}\right) \tag{4.36}$$

$$x = -2.28 + V1 * 2.97 + V2 * V6 * 0.30 + V1 * V6 * 1.06 \tag{4.37}$$

11. Compute total transport, QT

$$QT = 10^x * \sqrt{\Delta g\ d_{50}^3} \tag{4.38}$$

12. Compute additional parameters

$$V8 = \log \frac{QT}{\sqrt{\Delta g\ d_{50}^{3}}} \tag{4.39}$$

$$Y = 0.905 + V8 * 0.167 + V4 * V5 * V8*0.083 + V4 * V5 * 0.217 - V2 * V3 * V4 * 0.041 \tag{4.40}$$

13. Compute predicted velocity by Karim, V_{j+1}

$$V_{j+1} \doteq 10^{Y} * \sqrt{g\ \Delta d_{50}} \tag{4.41}$$

14. Compare new and old flow velocity, if

$$|V_j - V_{j+1}| > \frac{Q}{100\ b\ h_m}, \quad \text{then}$$

$$h_{j+1} = \frac{Q}{b\ v_{j+1}}$$

$$h_{j+2} = \frac{h_j + h_{j+1}}{2}$$

$$h_j = h_{j+2}$$

and repeat computation from 8

where:

Q	=	Discharge	(m^3/s)
b	=	Width	(m)
v_m	=	Measured velocity	(m/s)
h_m	=	Measured water depth	(m)
T	=	Temperature	(°C)
ν	=	Kinematic viscosity	(m^2/s)
d_{50}	=	Particle diameter	(m)

Δ	=	1.65 specific density	(-)
g	=	Acceleration of gravity	(m/s^2)
D_*	=	Particle parameter	(-)
Θ_{cr}	=	Critical mobility parameter	(-)
$U_{*,cr}$	=	Critical bed shear velocity	(m/s)
W_s	=	Particle fall velocity	(m/s)
h_j	=	Flow depth	(m)
V_j	=	Flow velocity	(m/s)
i	=	Slope	(-)
U_*	=	Shear velocity	(m/s)
V1--V6 x,Y,V8	}	Various parameters	(-)
QT	=	Total transport	(M^2/s)
V_{j+1}	=	Velocity predicted by Karim	(m/s)

van Ryn (1985)

The method presented by van Ryn [15] is based on the prediction of bed form dimensions, and hence the effective bed roughness. The metnod can be used for prediction of flow depth as well as for prediction of sediment transport. Here the part related to the prediction of flow depth and the use of this method as a velocity predictor is described.

1. Compute width, b (4.42)

$$b = \frac{Q}{v_m * h_m}$$

2. Compute kinematic viscosity coefficient depending on temperature T (°C)

$$\nu = (1.14 - 0.031 * (T-15) + 0.0068 * (T-15)^2)*10^{-6} \quad (4.43)$$

3. Compute particle parameter, D_*

$$D_* = d_{50} \left(\frac{\Delta g}{\nu^2}\right)^{1/3} \tag{4.44}$$

4. Compute critical mobility parameter, Θ_{cr}, depending on value of D_*

$$\Theta_{cr} = 0.24\ D_*^{-1} \qquad \text{for } D_* \leq 4 \tag{4.45}$$

$$\Theta_{cr} = 0.14\ D_*^{-0.64} \qquad \text{for } 4 < D_* \leq 10 \tag{4.46}$$

$$\Theta_{cr} = 0.04\ D_*^{-0.1} \qquad \text{for } 10 < D_* \leq 20 \tag{4.47}$$

$$\Theta_{cr} = 0.013\ D_*^{0.29} \qquad \text{for } 20 < D_* \leq 150 \tag{4.48}$$

$$\Theta_{cr} = 0.055 \qquad \text{for } D_* > 150 \tag{4.49}$$

5. Estimate flow depth, h_j

h_j (start value = 1.5 * $h_{measured}$)

6. Compute flow velocity, V_j

$$V_j = \frac{Q}{b\ h_j} \tag{4.50}$$

7. Compute hydraulic radius of the bed, R_b

$$R_b = \frac{b\ h_j}{b + 2\ h_j}$$

8. $$C_g = 18 \log \left(\frac{12\ h_j}{3\ d_{90}}\right) \tag{4.51}$$

9. Compute effective bed shear velocity related to grains, $U_{*,g}$

$$U_{*,g} = \frac{\sqrt{g} * V_j}{C_g} \tag{4.52}$$

10. Compute particle mobility parameter, Θ'

$$\Theta' = \frac{U_{*,g}^2}{g \Delta d_{50}} \tag{4.53}$$

11. Compute transport stage parameter, T_s

$$T_s = \frac{\Theta' - \Theta cr}{\Theta_{cr}} \tag{4.54}$$

12. Compute predicted bed form height, Δd

$$\Delta d = [0.11*(\frac{d_{50}}{h_j})^{.3} * (1-e^{-0.5T_s}) * (25-T_s)] \tag{4.55}$$

13. Compute predicted bed form length, λd

$$\lambda d = \Delta d/[0.015 * (\frac{d_{50}}{h_j})^{.3} * (1-e^{-0.5T_s}) * (25-T_s)] \tag{4.56}$$

14. Compute effective roughness of movable bed surface, k_s

$$k_s = 3\ d_{90} + 1.1*\Delta d* \left(1-e^{-25\frac{\Delta d}{\lambda d}}\right) \tag{4.57}$$

15. Compute Chezy-coefficient related to the bed, C_b

$$C_b = 18 \log (\frac{12R_b}{k_s}) \tag{4.58}$$

16. Compute predicted flow velocity by Van Ryn, V_{j+1}

$$V_{j+1} = C_b * \sqrt{R_b * i} \tag{4.59}$$

17. Compute new flow depth, h_{j+1}

$$h_{j+1} = \frac{Q}{b*V_{j+1}}$$

18. Compare new and old follow depth, if

$$|h_{j+1} - h_j| > \frac{h_{measured}}{100}, \text{ then}$$

$$h_{j+2} = \frac{h_{j+1} + h_j}{2}$$

$$h_j = h_{j+2}$$

and repeat computation from 6.

where:

b	=	Width	(m)
Q	=	Discharge	(m^3/s)
V_m	=	Measured velocity	(m/s)
h_m	=	Measured water depth	(m)
T	=	Temperature	(°C)
ν	=	Kinematic viscosity	(m^2/s)
D_*	=	Particle parameter	(-)
Δ	=	1.65, specific density	(-)
g	=	Acceleration of gravity	(m/s^2)
d_{50}	=	Particle diameter	(m)
Θ_{cr}	=	Critical mobility parameter	(-)
h_j	=	Flow depth	(m)
V_j	=	Flow velocity	(m)
d_{90}	=	Particle diameter	(m)
C_g	=	Chezy coefficient related to grains	($m^{1/2}/s$)
$U_{*,g}$	=	Effective bed shear velocity related to grains.	(m /s)
Θ	=	Particle mobility parameter	(-)
T_s	=	Transport stage parameter	(-)
Δd	=	Bed form height	(m)
λd	=	Bed form length	(m)
k_s	=	Effective bed roughness	(m)
C_b	=	Chezy coefficient related to the bed	($m^{1/2}/s$)
V_{j+1}	=	Predicted flow velocity by van Ryn.	(m/s)

HDC (1986)

The depth-velocity relation in HDC is based on the afore mentioned van Ryn approach. However the PRC/C Engineering team is of the opinion that the water discharge over the sand-bed portion of the wetted portion of the canal boundary is paramount in determining

the behaviour of the alluvial canal. The water molds the sediment on the bed into bars and smaller sandwaves which are the principal resistance to flow.

Moreover during the research it was experienced that for smaller velocities the bedform roughness by ripples was under estimated by the van Ryn approach. The appropriate ripple roughness has been incorporated in the HDC accordingly. (see per. 4.5).

To comply with Pakistani conditions the method is completely in British Units.

The application of the HDC depth-velocity relation is as follows:

1. Compute kinematic viscosity coefficient depending on temperature T (°C).

$$\nu = (1.23-0.033\ (T-15) + 0.00073\ (T-15)^2) * 10^{-5} \qquad (4.60)$$

2. Compute particle parameter , D_*

$$D_* = \left(\frac{(ss-1)\ g}{\nu^2}\right)^{1/3} \qquad (4.61)$$

3. Compute critical Shields parameter, Θ_{cr}, depending on value of D_*

$$\Theta_{cr} = 0.24\ D_*^{-1} \qquad \text{for } D_* \leq 4 \qquad (4.62)$$

$$\Theta_{cr} = 0.14\ D_*^{-0.64} \qquad \text{for } 4 < D_* \leq 10 \qquad (4.63)$$

$$\Theta_{cr} = 0.04\ D_*^{-0.1} \qquad \text{for } 10 < D_* \leq 20 \qquad (4.64)$$

$$\Theta_{cr} = 0.013\ D_*^{0.29} \qquad \text{for } 20 < D_* \leq 150 \qquad (4.65)$$

$$\Theta_{cr} = 0.055 \qquad \text{for } D_* > 150 \qquad (4.66)$$

4. Compute average side slope, Z

$$Z = (\text{side slope left bank} + \text{side slope right bank})/2$$

5. Compute discharge over the bottom width

$$Q_b = Q/\ [(\frac{Z^3}{2(Z^2+1)^{0.5}})^{0.5}\ \frac{h}{B_b} + 1] \qquad (4.67)$$

6. Estimate flow depth, h_j

$$h_j = \frac{Q^{1/3}}{1.1} \tag{4.68}$$

7. Compute average width, B_a

$$B_a = B_b + h_j * Z \tag{4.69}$$

8. Compute velocity, V_j

$$V_j = \frac{Q_b}{B_b * h_j} \tag{4.70}$$

9. Compute Darcy's Friction Factor due to sandgrain roughness, f'

$$f' = 8\left(5.75 \log \left(\frac{12h_j}{3d_{90}}\right)\right)^{-2} \tag{4.71}$$

10. Compute Shields parameter for flow over the sand grains, Θ'

$$\Theta' = \frac{f' v_j^2}{8g\, d_{50}(ss-1)} \tag{4.72}$$

11. Compute dimensionless shear parameter, T_s

$$T_s = \frac{\Theta'}{\Theta_c} - 1 \tag{4.73}$$

12. Compute average height of the sandwaves on the bed, Δ

$$\Delta = 0.11\, h_j \left(\frac{d_{50}}{h_j}\right)^{0.3} [(-\exp(-0.5T_s)]\ (25-T_s) \tag{4.74}$$

13. Compute average length of the sandwaves on the bed, λ

$$\lambda = 7.3\, h_j \tag{4.75}$$

14. Compute roughness parameter for sand dunes on the bed, κ_{dune}

$$\kappa_{dunes} = 1.1\ \Delta\ [1-\exp\ (-25\ \frac{\Delta}{\lambda})] \tag{4.76}$$

15. Compute roughness parameter for sand ripples on the bed, $\kappa_{ripples}$

$$\kappa_{ripples} = 0.3 \quad \text{for } V_j \leq 1.3 \text{ (ft/s)} \tag{4.77}$$

$$\kappa_{ripples} = ((2.5-V_j)/1.2)*0.3 \quad \text{for } 1.3 < V_j < 2.5 \text{ (ft/s)} \tag{4.78}$$

$$\kappa_{ripples} = 0 \quad \text{for } V_j \geq 2.5 \text{ (ft/s)} \tag{4.79}$$

16. Compute Darcy's friction factor due to form roughness, f

$$f = 8\left(5.75 \log \left(\frac{12\ h_j}{3d_{90} + \kappa}\right)\right)^{-2} \tag{4.80}$$

Where $\kappa = \kappa_{dunes} + \kappa_{ripples}$

17. Compute new velocity, V_{j+1}

$$V_{j+1} = \frac{8g\ h_j\ i}{f} \tag{4.81}$$

18. Compute new flow depth, h_{j+1}

$$h_{j+1} = \frac{Q_b}{B_b * V_{j+1}} \tag{4.82}$$

19. Compare new and old flow depth, if

$$|h_{j+1} - h_j| > \frac{h_j}{500}, \quad \text{then}$$

$$h_{j+2} = \frac{h_{j+1} + h_j}{2}$$

$$h_j = h_{j+2}$$

and repeat computation from 7.

Where:

ν	=	Kinematic viscosity	(ft^2/s)
T	=	Temperature	(°C)
D_*	=	Particle parameter	(-)
d_{50}	=	Particle diameter	(ft)
ss	=	Specific gravity	(-)

g	=	Acceleration due to gravity	(ft/s^2)
Θ_{cr}	=	Critical Shields parameter	(-)
Q	=	Discharge	(ft^3/s)
Q_b	=	Discharge over the bottom of the canal.	(ft^3/s)
Z	=	Average side slope of the banks	(-)
B_b	=	Width of the bottom of the canal	(ft)
h_j	=	Flow depth	(ft)
B_a	=	Average width of the canal	(ft)
V_j	=	Flow velocity	(ft/s)
f'	=	Darcy's friction factor due to sand grain roughness	(-)
d_{90}	=	Particle diameter	(ft)
Θ'	=	Shields parameter for flow over the sand grains	(-)
T_s	=	Shear parameter	(-)
Δ	=	Height of the sandwaves on the bed	(ft)
λ	=	Length of the sandwaves on the bed	(ft)
κ	=	Roughness parameter for bed forms	(ft)
κ_{dunes}	=	Roughness parameter for sand dunes	(ft)
$\kappa_{ripples}$	=	Roughness parameter for ripples	(ft)
f	=	Darcy's friction factor due to form roughness	(-)

4.3 Available data sets

The available data sets were collected by ACOP under the agreement between ACOP and FCC. The formulae discussed in para 4.2 can be tested by using the data sets. However, it is required that the data sets are taken under uniform flow conditions according to the definition of an EQ-measurement.

All data sets were screened according to the method given in par 3.3. The remaining data sets were used to test the depth-velocity relations.

4.4 Results for different depth-velocity relations

With the available data sets it was investigated which relation gave the best result as compared with the measured velocity.

The following relations were investigated:

1. Lacey
2. Engelund-Hansen
3. Ackers and White
4. Karim-Kennedy
5. van Ryn
6. HDC - Hydraulic Design Criteria

All relations have been applied to the following data sets:

115 data sets Depalpur Canal system	(Fig. 4.1-4.6)
19 data sets Upper Gugera branch	(Fig. 4.7-4.12)
38 data sets Upper Gugera distributaries	(Fig. 4.13-4.18)
12 data sets Lower Gugera system	(Fig. 4.19-4.24)
32 data sets Mailsi canal system	(Fig. 4.25-4.30)
48 data sets Sind canal system	(Fig. 4.31-4.36)
All canal systems	(Fig. 4.37-4.42)

The overall results of the application of the formulae on the hydraulic data sets are also given in Table 4.1.

From all the results presented in Fig. 4.1-4.43 and table 3.6 page 7 it is concluded that the results of Lacey and Karim-Kennedy are comparable , both methods lead to an under prediction of the velocity of approx. 10%. The method of Ackers-White leads to an overprediction of the velocity of approx. 15%. The results of the methods of Engelund-Hansen and van Ryn are comparable in over-predicting the velocity by 7%. The newly presented method HDC which is basically an improved van Ryn method shows superior results.

4.5 The Additional Analysis

Initially the HDC method did not include the ripple roughness. The results, that were then obtained show a distinct bias (see Fig 4.42).

The low velocities are generally overpredicted, while the higher velocities are correctly predicted. Fig 4.44 shows the measured roughness κ minus the calculated roughness κ (grain roughness plus dune roughness)as a function of velocity V. The roughness for low velocities is clearly under estimated.

In figure 4.45 the bedform classification in terms of D_* and transport stage parameter T, according to van Ryn [15] is given.

For the ACOP-data sets the transport stage parameter plotted versus the particle parameter shows that most data sets represent the ripple bedform condition. (see Fig. 4.46).

Based on these results it is concluded that the ripple roughness should form a part of the predicted total roughness of a canal. The proposed formula for the ripple roughness are (see also Fig.4.44).

κ_{ripple} =	0.3	for $V \leq 1.3$	(ft/s)
κ_{ripple} =	((2.5-V)/1.2)*0.3	for $1.3 < V < 2.5$	(ft/s)
κ_{ripple} =	0	for $V \geq 2.5$	(ft/s)

The total roughness of the canals now becomes:

$$\kappa_t = 3D_{90} + \kappa_{ripples} + \kappa_{dunes}$$

The HDC results, ripple roughness included, are shown in Fig. 4.43.

4.6 Conclusions and Recommendations

In the study to identify the depth-velocity relation that gives the best results for the alluvial canals in the irrigation system in Pakistan six different relations have been tested, including a recently proposed method, HDC, by the PRC-Cheechi Engineering team. The conclusions of this study are:

1. The results of Lacey's emperical relation are comparable with results of more rational relations of Ackers-White and Karim-Kennedy.

2. The resullts of Engelund-Hansen and Van Ryn relating the velocity to respectively grain roughness and bed form roughness give better results.

3. HDC based on Van Ryn's approach relating the velocity to phenomenae occurring at or over the bed width and including ripple roughness gives superior results.

4. Application of a method based on hydraulic and morphologic parameters gives a better understanding of what is happening in an irrigation canal.

5. From Fig. 4.7-4.12 it is seen that all relations show poor results when applied on data of the Upper Gugera Branch. As Upper Gugera Branch suffers from scouring and does not flow in an alluvial bed these results can be expected.

Recommendations

1. Based on the results of the study the HDC depth-velocity relation is recommended to be applied during the redesign of alluvial channels in the irrigation system.

2. As the HDC gives excellent results over the entire velocity range, no studies are required to further improve this depth velocity predictor.

5. Width Predictor

5.1 Introduction

The relation between the 'equilibrium' width of an alluvial canal and its hydraulic and sediment (-ological) characteristics is not (yet) fully understood.

Whereas both roughness predictors and sediment transport relations recently have been based on a description of the physical processes in an alluvial canal, for the width it is not even clear which physical processes govern the equilibrium width of an alluvial canal.

The relations presented in literature are therefore mostly empirical. They relate the width to discharge, slope and grainsize and occasionally to the soil characteristics.

A completely different approach to the prediction of the 'equilibrium' width is given by extremal hypotheses for regime canals.
Although very interesting, the extremal hypotheses are still highly controversial and have yet to prove their applicability on prototype situations.

In this study a number of width predictors (par 5.2) has been tested using the ACOP data (par 5.3).
Although the results of these tests (par 5.4) and the results of further analysis (par 5.5) are not very spectacular, the results show that the proposed relation (par 5.6) can be applied successfully.

5.2 Width predictors formulae

Lacey (1929)

Alongwith his formulae for depth, velocity and slope prediction Lacey published in 1929 a relation for the width of an 'in-regime' canal.

Lacey relates in 1958 [18] the top width of a stable alluvial channel to the discharge through the canal as follows:

$$B_t = 2.67\ Q^{0.5} \qquad (5.1)$$

in which:

B_t = top width of the 'in-regime' canal (ft)
Q = discharge through the canal (ft^3/s)

Notes:

1. The factor 2.67 is not dimensionless.
2. Lacey's formula does not show any influence of the soil conditions on the equilibrium width of a canal. However, it seems reasonable to expect different widths for a canal with highly cohesive soils and a canal excavated in sandy soil.

H.H. Chang (1985)

In his paper, presenting a graphical method for the design of stable alluvial canal, [20] Chang gives the relation for the equilibrium width as follows:

$$B_t = 4.17\ \left(\frac{S}{\sqrt{d}} - \frac{0.00238}{Q^{0.51}}\right)^{0.05}\ Q^{0.5} \qquad (5.2)$$

in which:

S = canal slope (-)
d = median diameter of bed material (mm)

Notes:

1. Chang's formula shows the top width as a function of the slope, grainsize and discharge.

2. However, its basic form is comparable to Lacey's formula, relating the top width to the square root of the discharge.

3. The influence of the slope and the diameter (in 5.2) on the top width is very small as they are raised to the power 0.05 respectively 0.025.

4. Considering the above, it must be concluded that results with Chang's formula will probably be almost identical to the results with Lacey's formula.

Sanoyan (1985)

In his article on stable alluvial beds, [21] Sanoyan mentions the unpublished work of Velikanov for the morphological relationship between bed width, slope, grainsize and discharge.

The suggested relationship is:

$$B_b = C \left(\frac{Q}{\sqrt{d_{50} * S}} \right)^{0.5} \qquad (5.3)$$

in which:

B_b = bed width (ft)

C = constant ($ft^{-1.25}$ $s^{1/2}$)

D_{50} = grainsize (mm)

S = Slope

Notes:

1. Relation (5.3) includes the same parameters as (5.2). However, the influence of both diameter and slope is much stronger in the prediction of the width in (5.3) than in (5.2).

2. In constrast to the previous formulae this formulae predict the bed width and not the top width.

3. Like (5.1) and (5.2) formula, (5.3) also relates the width to the square root of the discharge.

Yalin and Lai (1985)

The derivation of the regime equations by Yalin and Lai [19] includes some description of the physical processes. Yalin and Lai argue that widening of the canal stops when the shear stress at the toe of the bank equals the critical shear stress for the bed particles.

As in their opinion the determining factor for the width is the ratio of discharge and shear stress, they suggest the following width predictor:

$$B_t = \alpha \left(\frac{Q}{U_{*cr}}\right)^{0.5} \qquad (5.4)$$

in which:

U_{*cr}	=	critical shear velocity for bed material	(ft/s)
α	=	constant for width prediction	(-)

Notes:

1. As in all previously mentioned width predictors the width in (5.4) is suggested to depend on the square root of the discharge.

2. Yalin and Lai suggest a new parameter in the width predictor i.e. U_{*cr} = critical shear velocity for bed material. For the computation of the value of U_{*cr} the modified Shields function should be used.

Blench (1957)

Blench [21] in his article gives a very interesting description of regime formulae. He states that 'Lacey's formula for width prediction (for small bed-load charge) can be generalized to':

$$B_a = (F_b \, Q/F_s)^{0.5} \qquad (5.5)$$

in which:

B_a	=	average width	(ft)
F_b	=	bed factor (=0.8 to 1.2)	(ft/s^2)
F_s	=	side factor (=0.1 to 0.3)	(ft^2/s^2)

Notes:

1. Although Blench indicates the limits for the values of F_b and F_s, it is still required to make ones own choice while designing a canal.

2. Once again the suggested relationship between discharge and width is unchanged as compared to the previously discussed methods.

3. With limiting values for F_b and F_s formula (5.5) can be re-written as:

$$B_a = \alpha \sqrt{Q} \qquad (5.5a)$$

with α = 1.6 to 3.5

Extremal Hypotheses

Besides the above mentioned, largely imperical width predictors there are a number of theories, that all argue that the combination of discharge, grain-sizes and sediment transport rate establish a particular equilibrium width in the canal. In doing so, the canal would fulfill certain conditions. The different conditions or concepts that have been presented in literature are the concepts of:

- minimum stream power
- minimum unit stream power
- minimum energy dissipation rate
- maximum friction factor
- maximum sediment transport rate

These concepts are still highly controversial and the applicability in prototype situations still has to be proved.

An in depth discussion of the controversies of the concepts is presented in Davis et al and Griffiths [22,23].

5.3 Available Data Sets

The data sets that are available to test the different width predictions, were collected by ACOP (see also chapter 3).
A large number of data sets were available.

The formulae as discussed in para 5.2 can be tested by using these data sets. However, it is required that the data sets were collected during the 'width-forming' discharge.

Unfortunately in many systems the actual 'full supply discharges' are no longer the design discharges. In many canals the design discharge is exceeded by 10-20%. The only information on the actual full supply discharge is the data sets collected by ACOP.

During the data processing it was seen that there are many locations where ACOP collected more than one data set. The discharge in the data sets for one location varies, sometimes considerably. The conclusion from this is that ACOP did not always collect the data set at full supply discharge.

In order to test the width predictors all available data sets were screened with respect to the presence of full supply discharge. In other words if there was more than one data set in a location, all data sets were skipped except the one with the highest discharge.
If there was only one data set in a location it was necessarily assumed that the data set was collected during full supply discharge.

The width predictors were tested by using the remaining, reduced number of data sets.

5.4 Results for different width predictors

Using the available data sets it was investigated which formula gives the best width prediction as compared with the measured width.

The investigated formulae are:

1. Lacey : $B_t = 2.67\ Q^{0.5}$ (5.1)

2. Chang : $B_t = 4.17\ \left(\frac{S}{\sqrt{d_{50}}} - \frac{0.00238}{Q^{0.51}}\right)^{0.05}\ Q^{0.5}$ (5.2)

3. Velikanov : $B_b = C\left(\frac{Q}{\sqrt{d_{50}*S}}\right)^{0.5}$ (5.3)

4. Yalin : $B_t = \alpha\ (Q/U*_{cr})^{0.5}$ (5.4)

5. HDC : $B_b = K_s\ Q_b^{0.5}$ (5.5)

in which:

HDC	=	Hydraulic Design Criteria
K_s	=	width coefficient
Q_b	=	discharge over the bed (ft^3/s)
Q	=	discharge (ft^3/s)
d_{50}	=	grainsize (mm)
S	=	slope (-)

The values for C, α and K_s used in the investigations are respectively 0.16, 1.11 and K_s = 2.2 and 2.6 for respectivley Sind and Punjab systems.

All formulae have been applied on the following data sets:

- Depalpur canal system	(fig. 5.1 - 5.5)
- Upper Gugera Branch	(fig. 5.6 - 5.10)
- Upper Gugera Distributaries	(fig. 5.11 - 5.15)
- Mailsi Canal System	(fig. 5.16 - 5.20)
- Sind Canal System	(fig. 5.21 - 5.25)
- All canal systems	(fig. 5.26 - 5.30)

From all results as presented in fig. 5.1 - 5.30 it must be concluded that Lacey, Chang, Yalin and HDC give almost the same results. Velikanov is slightly less accurate.

All methods show a very satisfactory overall agreement between the predicted width and the measured width (see fig. 5.26 - 5.30). However, although the average ratio of predicted width over measured width is close to one for all methods and the trend is very close to the line of perfect agreement, individual data sets show sometimes large discrepancies between predicted and measured width.

It was therefore decided to do some further analyses in order to refine and improve the width predictor.

5.5 Additional Analyses

The scatter in the results for all formulae is caused by:

1. Incorrect data.
2. Local disturbances.
3. Incorrect formula.

After the thorough screening of the data sets it is no longer possible to identify inaccurate data sets. However, it will be clear that some of data sets used in the investigations still contain errors or inaccuracies.

Above all it is not clear whether the discharge in the data set is the width forming discharge. Because of this reason, the results will always contain scatter.

A formula that gives a perfect prediction for the width of an 'untouched' alluvial channel, may perform poorly if (local) disturbances are present in the location of observation. Local disturbances may be: increased level of turbulence downstream of bridge or structure, water buffalo's using the canal for drinking and bathing and human interference like killa bushings. These disturbances will increase the scatter in the results when applying width predictors.

Probably the most important cause of scatter is the absence of some (important) factors in the formulae. A factor that has most probably a major influence on the equilibrium width is the composition of bank and bed material in the canal (with respect to cohesion). Unfortunately there is no information available on this factor in the canal and can therefore not be included in the formulae. In this study it was investigated whether the results of HDC could be improved by including some functional relationship between the width and specific parameters.

Fig. 5.31 shows the variation of K_s as calculated from the data sets, versus measured top width. It can be concluded that, irrespective what the top width or size of the canal is, K_s varies between approximately 1.6 and 3.5 (like Blench suggests in his formula). The average value is 2.6 for Punjab and 2.2 for Sind canals. The next set of figures, fig. 5.32 - 5.41, show the normalized value K_s, i.e. K_s divided by the average value of K_s = 2.65 versus grainsizes D_{50} and D_{90}, versus depth, versus slope, versus Chezy coefficient, and versus sediment concentration. From these figures it is not possible to find any relationship between K_s and any of the other parameters.
It is possible that the relationships are not evident because of the

scatter from other sources. However, at this stage of the study it must be concluded that any relationship between width and any parameter other than the discharge seems to be absent. Refinement of the suggested HDC - width formula is therefore not possible.

Note:
In the above mentioned study it is not investigated whether any of the extremal hypotheses is applicable to the Pakistani irrigation canals. The consideration for this was that such a sophisticated and highly complicated method as an extremal hypothesis would involve, would probably never be accepted by the PID's. Moreover to check the applicability of these methods, an extensive data base of ACOP data sets with accurate sediment concentration information is required. This is not available (see also chapter 6).

5.6 Conclusions and Recommendations

In the study to find the width predictor that is best applicable in the Pakistani irrigation canals a number of formulae has been tested. The conclusions from this study are:

1. All formulae show the same relationship between discharge and width, i.e. $B=\alpha Q^{0.5}$

2. All formulae give very satisfactory results when applied on the Pakistani canals.

3. Through (single) regression analysis it was not possible to identify any functional relationship between the width and grainsizes, slope, depth, roughness or sediment transport.

4. It is expected that an important part of the scatter in the results (inaccurate prediction) is created by the fact that the discharge during the measurement was not the width forming discharge.

5. Scatter will furthermore have been created by local disturbances in the canal, for which the width predictor is no longer valid.

Recommendations

1. Based on the results of the study it is advised to use the HDC - width predictor in the redesign of canal systems.

2. The K_s value should then be chosen in accordance to the observations in the existing canal system.

3. It might be worthwhile to examine possible improvements on HDC - width predictor by means of multiple regression analysis.

4. Until it is clear from literature that a canal actually behaves according to a particular extremal hypothesis, one should not design canals based on any of these hypothesis.

6. Sediment Transport Relation

6.1 Introduction

The most essential part in the design of alluvial canals is the design with respect to the sediment transport phenomenae.
To be more precise: during the redesign of a canal system the sediment transport capacity of the redesigned sections should be compared with incoming amount of sediment and it should then be decided whether erosion and sedimentation are within acceptable limits or whether modification (for example sandtraps) are required.
The sediment transport capacity can be estimated by applying a sediment transport formula.
In literature many formulae can be found. Unfortunately all these formulae give different answers, in fact a very wide range of answers.
This study is aimed at identifying the most promising sediment transport formula for the Pakistani irrigation canals.

Based on the experience by PRC-Engineering team with this subject, a limited number of transport relations were selected for testing para 6.2. Applying the formulae on the available data sets para 6.3, the results are disappointing, para 6.4. It was concluded that several formulae seem to be promising but with low accuracy.

However, the results are such that there is no preference for one formula over another.

6.2 Sediment transport relations

Sediment transport formulae relate, in general, the sediment transport rate to the local hydraulic and sediment (-ological) conditions. In all transport relations observations have been used to calibrate one or more coefficients. Some transport relations are completely empirical.

The sediment transport formulae that are most promising, according to the PRC-Engineering, for application in Pakistani irrigation canals, have been selected for further analysis. The formulae, indicated by the name of their authors are:

- Ackers and White
- Engelund and Hansen
- Karim and Kennedy
- van Ryn
- Yang

These formulae and the steps to calculate the sediment transport are summarized below:

Ackers and White

The Ackers and White transport formula [13] is developed for the total load and is based on large number of data from both the field and from flume experiments.

1. Calculate $D_* = D_{35} (g\Delta/\nu^2)^{1/3}$ (6.1)

   Calculate n from: $n = 1$ for $D_* \leq 1$ (6.2)

   $n = 0$ for $D_* \geq 60$ (6.3)

   $n = 1-0.56 \log D_*$ for $1 < D_* < 60$ (6.4)

   Calculate $U_* = \sqrt{ghi}$ (6.5)

2. Calculate $A = 0.23/\sqrt{D_*} + 0.14$ (6.6)

   or $A = 0.17$ for $D_* \geq 60$ (6.7)

   Calculate $m = 9.66/D_* + 1.34$ (6.8)

   or $m = 1.5$ for $D_* \geq 60$ (6.9)

Calculate C_{gr} = $\exp^{2.86 \ln D_* - 0.434 (\ln D_*)^2 - 8.13}$ (6.10)

or C_{gr} = 0.025 for $D_* \geq 60$ (6.11)

3. Calculate $\bar{u}$ = Q/Wh, directly from the field data of discharge, width and water depth.

Calculate F_{gr} = $\frac{U_*^n}{\sqrt{g\Delta D_{35}}} \left(\frac{\bar{U}}{\sqrt{32} \log (10 R_b/D_{35})}\right)^{1-n}$ (6.12)

4. Calculate the total sediment transport:

$$G_{vt} = C_{gr} WD_{35} \left(\frac{\bar{U}}{U_*}\right)^n \left(\frac{F_{gr}}{A} - 1\right)^m \quad (6.13)$$

Where:

D_*	=	particle parameter	(-)
D_{35}	=	grainsize dimension	(m)
g	=	acceleration of gravity	(m/s^2)
ν	=	kinematic viscosity	(m^2/s)
Δ	=	specific density, 1.65	(-)
n, A, m, C_{gr}	=	parameters in Ackers-White relation.	(-)
h	=	flow depth	(m)
i	=	slope	(-)
U_*	=	bed shear velocity	(m/s)
W	=	bed width	(m)
R_b	=	hydraulic radius of the bed	(m)
$\bar{u}$	=	average flow velocity	(m/s)
G_{vt}	=	total sediment transport	(m^3/s)

A more comprehensive description of the method is given in [10,17].

Engelund and Hansen

The Engelund and Hansen formula [11] is a total load transport predictor, which was developed on the basis of data from mainly flume experiments. The particle diameters used in these experiments ranged from 190 to 930 microns. Particle diameters of the bed material load in Pakistan irrigation canals ranges normally from 75 to 350 microns. The formula is of a relative simple form, which can be considered as an operational advantage. The expression in its original form in the metric system reads as follows:

$$g_{vt} = 0.05 \sqrt{g\Delta D^3_{50}} \left(\frac{hS_b}{\Delta D_{50}}\right)^{5/2} \left(\frac{C^2}{g}\right) \qquad (6.14)$$

in which:

g_{vt}	=	volumetric sediment transport per unit width	(m^2/s)
g	=	gravity acceleration	(m/s^2)
Δ	=	relative sediment density = $(\rho s - \rho w)/\rho w$	(-)
D_{50}	=	representative particle size	(m)
h	=	water depth	(m)
S_b	=	bed slope	(-)
C	=	Chezy roughness coefficient	$(m^{1/2}/s)$
ρs	=	density of sediment	(kg/m^3)
ρ_w	=	density of water	(kg/m^3)

The total sediment transport over the full cross-section is:

$$G_{vt} = W * g_{vt} \qquad (6.15)$$

in which W represents the bed width.

Karim-Kennedy

Karim-Kennedy developed a method for the combined prediction of both roughness and sediment transport. However, as the relation is now used to check the sediment transport part, the sediment transport prediction was discoupled from the roughness prediction. This could be done as the measured prototype values of discharge Q, water depth h, average velocity $\bar{u}$, and bed slope S_b are known. The calculation is executed through the following steps:

1. Calculate $U_* = \sqrt{ghS_b}$ (6.16)

   and $\bar{u} = Q/Wh$ (6.17)

2. Calculate $D_* = D_{50}\ (\Delta g/\nu^2)^{1/3}$ (6.18)

   Calculate Θ_{cr} relations 4.21 - 4.25

   Calculate $U_{*cr} = \sqrt{g\Delta D_{50}\Theta_{cr}}$ (6.19)

3. Calculate $X_1 = \log\ (\bar{U}/\sqrt{g\Delta D_{50}})$ (6.20)

   $X_2 = \log\ (h/D_{50})$ (6.21)

   $X_{11} = \log\ [(U_*-U_{*cr})\ /\ \sqrt{g\Delta D_{50}}]$ (6.22)

4. Calculate $S_t = -2.2786 + 2.9719X_1 + 0.2989X_2X_{11} + 1.06X_1X_{11}$ (6.23)

   $g_{vt} = \sqrt{g\Delta D^3{}_{50}}\ .\ 10^{S_t}$ (6.24)

   and $G_{vt} = Wg_{vt}$ (6.25)

for symbols and dimensions see chapter 4.

van Ryn

The van Ryn method [15] is build up from two separate parts, one for the prediction of bed load transport and one for suspended sediment transport. The expression for the bed load transport is based on the equations of motion for saltating particles. By means of data from flume experiments the expression is calibrated, making use of a relation between the so-called bed concentration and the maximum bed concentration. Extensive verification tests have been carried out for a large number of flume and field data, showing a high accuracy of prediction in a wide range of application.

The suspended sediment transport prediction is based on the reference concentration near the bed, and on the diffusion equation for the suspended sediment:

$$\varepsilon_s \frac{\partial c}{\partial z} + c w_s = 0 \qquad (6.26)$$

in which:

c	=	sediment concentration
ε_s	=	sediment diffusion coefficient
z	=	vertical coordinate
w_s	=	particle fall velocity

By using specific relations for the w_s and ε_s parameters, the equilibrium concentration vertical can be found, starting from the reference concentration as derived from the bed load transport prediction.

By means of integrating over the depth, from the reference concentration till the water level, the product of concentration times velocity the total suspended load transport can be determined.

Verification of the computed total load, as the sum of bed load and suspended load sediment transport, showed good results for a large number of field and flume data.

Stepwise the calculations follow the next procedure:

a. Bed Load

1. Calculate D_* = $D_{50}\ (g\Delta/\nu^2)^{1/3}$ (6.27)

   Calculate Θ_{cr} from relations 4.21 - 4.25

   Calculate U_{*cr} = $\sqrt{g\Delta D_{50}\Theta_{cr}}$ (6.28)

2. Calculate C'_b = $18 \log (12h/3D_{90})$ (6.29)

   Calculate U'_{*b} = $\bar{U}\ \sqrt{g/C'_b}$ (6.30)

   Calculate T_p = $\dfrac{(U'_*)^2_b - (U_{*cr})^2}{(U_{*cr})^2}$ (6.31)

3. Calculate g_{vtb} = $0.053\ \sqrt{g\Delta D^3_{50}} \cdot \dfrac{T_p^{2.1}}{D_*^{0.3}}$ (6.32)

being the bed load sediment transport per unit width, for h and $\bar{U}$ actual values from prototype measurement have been taken.

b. Suspended Load

4. Calculate K_s from:

$$C = 18 \log (12h/K_s) \quad (6.33)$$

or

$$K_s = 12.10^{-C/18} \quad (6.34)$$

with

$$C = Q/Wh^{3/2} \; S_b^{1/2} \quad (6.35)$$

Check minimum value $K_s \geq 0.01$ h

maximum value $K_s \leq 0.05$ h

5. Calculate reference concentration:

$$C_a = 0.015 \; D_{50} T_p^{3/2} / K_s D_*^{0.3} \quad (6.36)$$

6. Calculate particle size suspended sediment:

$$D_s = [1+0.011(\sigma_s-1)(T_p-25)] \; D_{50} \quad (6.37)$$

with

$$\sigma_s = 1/2 \; (D_{84}/D_{50}+D_{50}/D_{16}) \quad (6.38)$$

7. Calculate fall velocity of suspended sediment, W_s

for D < 100 microns:

$$W_s = \frac{1}{18} g \frac{\Delta D^2}{\nu} \text{ (Stokes)} \quad (6.39)$$

for $100 \leq D < 300$ microns:

$$W_s = \sqrt{2/3\Delta g \; d^3 + 36\nu^2} - 6\nu)/d \quad \text{(Rubey)} \quad (6.40)$$

for $300 \leq D < 1000$ microns:

$$W_s = \frac{10\nu}{D} [(1+0.01\frac{\Delta g D^3}{\nu^2})-1] \quad \text{(Zanke)} \quad (6.41)$$

$D > 1000$ microns

$$W_s = 1.1 \sqrt{\Delta g D} \tag{6.42}$$

8. Calculate $U_* = \sqrt{ghS_b}$ (6.43)

and $\beta = 1+2(W_s/U_*)^2$ (6.44)

9. Calculate $\Phi = 2.5\ (W_s/U_*)^{0.8}\ (c_a/c_o)^{0.4}$ (6.45)

with $c_o = 0.65$ (6.46)

10. Calculate suspension parameters:

$$Z = W_s/0.4\ \beta\ U_* \tag{6.47}$$

and $Z' = Z + \Phi$ (6.48)

11. Calculate $F' = K_s/h$ (6.49)

and $$F = \frac{(F')^{Z'} - (F')^{1.2}}{(1-F')^{Z'}\ (1.2-Z')} \tag{6.50}$$

12. Calculate the suspended load transport per unit width.

$$g_{vts} = F\bar{U}h\ c_a \tag{6.51}$$

c. Total Load

13. Calculate the total sediment transport:

$$G_{vt} = W\cdot(g_{vtb} + g_{vts}) \tag{6.52}$$

A complete description of the method, including supporting data is given by van Ryn [15].

Yang

Yang [11] gives the following relation for the computation of bed load.

$$\log C_{ts} = 5.435-0286 \log \frac{wd}{\nu} - 0.447 \log \frac{U_*}{w} + (1.799-0.409 \log \frac{wd}{\nu} - 0.314 \log \frac{U_*}{w}) \log \left(\frac{VS}{w} - \frac{V_{cr}S}{w}\right) \tag{6.53}$$

$$U_* = \sqrt{gDs} \tag{6.54}$$

$$\frac{V_{cr}}{w} = \frac{2.5}{\log \frac{U_* d}{\nu} - 0.06} + 0.66 \quad \text{for} \quad \frac{U_* d}{\nu} < 70 \tag{6.55}$$

$$\frac{V_{cr}}{w} = 2.05 \quad \text{for} \quad \frac{U_* d}{\nu} \geq 70 \tag{6.56}$$

Where:

Log	=	Logaritm to the base 10
C_{ts}	=	bed load concentration in p.p.m.
W	=	terminal fall velocity
d	=	D_{50}
ν	=	Kinematic viscosity
U_*	=	shear velocity
V	=	velocity
S	=	slope
V_s	=	unit stream power
$V_{cr}S$	=	critical unit stream power required at incipient motion.

6.3 Available data sets

As discussed in chapter 3 the number of data sets, available for the testing of transport formulae is relatively limited, but still enough to get a clear picture of the validity of transport formulae in Pakistani irrigation canals.

The transport formulae describe the transport of bed material. Transport may take place as bed load as well as in suspended load. In the Pakistani canals one observes that part of the suspended material does not consist of bed material. This part is called wash load. In general one defines washload as that part of the suspended load with grainsize smaller than 62 microns.

The remaining part, grainsizes larger than 62 microns, can according to all

present theories and formulae only be transported in limited amounts. This amount depends on the 'local' hydraulic conditions. This implicates that in a location in a canal, given the hydraulic and sediment (-ological) conditions, a certain amount of sediment coarser than 62 microns will be transported.

Reviewing the available data sets, it is clear that either the above mentioned theory or the observations are not correct. In locations where several measurements have been executed under practically the same hydraulic conditions, completely different concentrations of particles coarser than 62 microns have been observed.

Considering this, it is obvious that the sediment transport formulae will not be able to reproduce these type of observations. An enormous scatter may be expected for these observation points.

6.4 Results for different transport formulae

The transport formulae as discussed in para 6.2 have been applied on the available data sets.

The results are presented in table 6.1 and in figures 6.1 - 6.25.

Compared to the others the results for Yang are poorest. The other formulae give comparable results.

The results shown in table 6.1 for HDC are based on a slightly modified version of Ackers-White approach, in this relation the water depth over the bed is used which is in line with the depth-velocity relation.

It is clear that percentages are low for all formulae. As was discussed in 6.3, this was anticipated. At this stage it does not seem wise to try to improve the any of the formulae. It is advisable to concentrate on the data sets first and try to explain the apparent inconsistences in the concentrations in relation to the hydraulic conditions.

6.5 Conclusions and Recommendations

The study of the applicability of renown transport formulae on Pakistani irrigation canals leads to the following conclusions;

1. The available data sets seem to be inconsistant. Under the same hydraulic and sediment (-ological) conditions a wide range of concentrations has been measured. This is in contradiction to current theories for sediment transport.

2. The results for the application of the selected transprot formulae are disappointing. The scoring percentages are somewhat low, although comparable to results generally obtained with transport formulae.

3. Except for Yang, all transport formulae give comparable results, Yang has a lower accuracy.

4. Based on the results of this study there is no preference for Ackers - White, Engelund - Hansen, Karim-Kennedy, or van Ryn. For including most physical background in the formulae van Ryn is appropriate.

Recommendations

1. For the Hydraulic Design Criteria the transport relation of Engelund-Hansen should be selected as this relation gives the best results and is relatively simple in its formulation.

2. The apparent inconsistencies in measured concentrations require further explanation. It is recommended to set up a detailed investigation to study these inconsistencies. A detailed measuring campaign by ACOP under supervision by an experienced 'sediment transport engineer' will be required.

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NAME OF SYSTEM	HYDRAULIC DATA SETS	SEDIMENT DATA SETS	PROBLEM-ATIC SETS	QUESTION-ABLE SETS	TOTAL SETS COMPLETED	ERROR DATA SETS	INCOMPLETE DATA SETS	TOTAL SETS PROCESSED
SIND CANAL SYSTEMS	48	43	26	21	95	9	15	119
DEPALPUR CANAL SYSTEM	115	57	17	68	200	28	0	228
MAILSI CANAL SYSTEM	52	2	5	17	74	6	0	80
UPPER GUGERA SYSTEM (BRANCH)	19	19	25	14	58	3	4	65
UPPER GUGERA SYSTEM (DISTIES)	38	32	2	28	68	7	30	105
LOWER GUGERA BRANCH SYSTEM	12	12	1	4	17	4	1	22
MIANALI BRANCH SYSTEM	8	4	0	3	11	1	8	20
NWFP CANAL SYSTEMS	0	0	0	10	10	2	20	32
TOTAL	292	169	76	165	533	60	78	671

TABLE 3.1 DATA SETS PROCESSED UP TO DECEMBER, 1985.

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (10**-3) St.rch	Slope (10**-3) Str.str	Teape-rature (C)	Side slope left	Side slope right
1	UG-BRANCH	187+000	12-12-1983	4084.39	8.89	3.22	153.00	142.54	132.08	7.94	.127	.167	14.25	1.07	1.28
2	UG-BRANCH	188+000	16-05-1984	4640.50	10.10	3.02	174.00	152.37	130.75	8.57	.139	.120	24.67	1.04	3.24
3	UG-BRANCH	188+000	11-12-1983	4140.98	8.68	3.01	171.67	158.65	145.63	7.78	.146	.118	14.67	1.52	1.48
4	UG-BRANCH	205+000	12-12-1983	4393.01	8.46	3.03	183.00	171.60	160.21	7.69	.153	.129	14.50	1.38	1.32
5	UG-BRANCH	205+000	26-07-1984	4667.24	9.20	2.93	184.00	173.12	162.23	8.34	.109	.108	25.50	1.43	.94
6	UG-BRANCH	213+000	26-07-1984	4746.28	9.02	2.99	182.00	175.74	169.49	8.28	.161	.187	26.00	.73	.66
7	UG-BRANCH	224+000	13-12-1983	4278.96	10.20	3.00	151.00	139.87	128.75	8.97	.130	.167	15.00	1.18	1.00
8	UG-BRANCH	224+000	26-05-1984	4874.57	10.64	3.21	151.00	142.84	134.68	9.40	.130	.135	23.75	.91	.63
9	UG-BRANCH	224+000	28-07-1984	4519.88	10.01	3.16	150.00	142.97	135.93	8.92	.109	.136	25.50	.83	.57
10	UG-BRANCH	242+000	13-12-1983	4218.72	8.93	3.11	166.00	151.87	137.75	7.92	.122	.129	15.00	1.40	1.76
11	UG-BRANCH	242+000	26-05-1984	4699.81	9.78	3.06	166.00	157.07	148.15	8.79	.145	.135	26.75	.88	.94
12	UG-BRANCH	242+000	28-07-1984	4383.12	9.31	2.95	166.00	159.77	153.54	8.46	.155	.136	25.00	.75	.59
13	UG-BRANCH	256+000	17-05-1984	4250.36	8.84	3.04	165.33	158.02	150.71	8.04	.119	.138	23.13	.83	.82
14	UG-BRANCH	256+000	11-06-1984	4479.62	9.17	3.05	168.33	160.49	152.65	8.32	.116	.147	24.50	.82	.89
15	UG-BRANCH	260+000	26-05-1984	4681.33	9.68	3.23	158.00	149.58	141.15	8.67	.138	.148	25.50	.74	1.00
16	UG-BRANCH	260+000	28-07-1984	4313.47	8.73	3.27	157.00	151.33	145.65	7.93	.146	.139	25.50	.80	.50
17	UG-BRANCH	281+000	13-12-1983	3704.36	9.12	2.61	163.00	155.70	148.41	8.26	.116	.119	15.00	.82	.78
18	UG-BRANCH	281+000	26-05-1984	4399.82	9.53	2.97	163.00	155.63	148.25	8.60	.196	.148	25.25	.71	.83
19	UG-BRANCH	281+000	28-07-1984	4273.41	9.52	2.87	162.00	156.65	151.29	8.61	.152	.139	25.50	.50	.63
20	GD-DISTRY	0+650	11-07-1984	48.66	1.90	1.18	23.50	21.62	19.73	1.64	.203	.197	24.75	1.00	.99
21	GD-DISTRY	34+380	11-07-1984	23.02	2.10	1.31	9.00	8.36	7.73	1.45	.325	.326	29.00	.31	.29
22	GD-DISTY	0+650	13-05-1984	49.61	1.98	1.21	23.00	20.83	18.66	1.68	.181	.177	23.00	.95	1.25
23	GD-DISTY	34+380	13-05-1984	27.00	1.98	1.38	11.50	9.87	8.24	1.46	.315	.254	24.50	.71	.94
24	GN-DISTY	0+325	09-04-1984	72.87	2.33	1.23	26.00	25.35	24.70	2.00	.124	.124	19.50	.29	.26
25	GN-DISTY	0+325	12-07-1984	103.60	2.85	1.52	25.00	23.80	22.60	2.36	.132	.151	24.00	.45	.38
26	GN-DISTY	0+325	14-11-1984	94.76	2.58	1.49	25.80	24.69	23.59	2.18	.083	.086	19.00	.42	.43
27	GN-DISTY	36+000	14-11-1984	72.48	2.30	1.41	23.40	22.39	21.38	1.95	.225	.224	19.00	.40	.48
28	GN-DISTY	55+696	08-03-1984	67.82	2.59	1.51	19.50	17.39	15.29	2.00	.243	.251	15.00	.20	1.43
29	GN-DISTY	55+696	12-07-1984	74.79	2.69	1.49	21.00	18.61	16.22	2.09	.221	.228	24.00	.20	1.58
30	GN-DISTY	55+696	22-03-1984	58.06	2.27	1.49	18.00	17.12	16.24	1.84	.232	.236	21.50	.22	.56
31	GN-DISTY	81+000	16-11-1984	40.25	2.17	1.30	15.00	14.24	13.47	1.71	.270	.245	18.00	.36	.34
32	GN-DISTY	120+200	12-07-1984	12.55	1.64	.85	9.60	9.01	8.42	1.24	.204	.228	25.00	.38	.33
33	JN-DISTY	0+300	14-11-1983	45.38	2.16	1.21	19.83	17.39	14.95	1.75	.227	.223	18.00	1.14	1.12
34	JN-DISTY	0+300	22-10-1984	44.84	1.98	1.21	19.50	18.65	17.80	1.67	.195	.229	22.00	.63	.23
35	JN-DISTY	34+000	27-03-1984	23.16	1.41	1.44	12.50	11.41	10.32	1.16	.246	.265	24.00	.83	.71
36	JN-DISTY	34+000	29-07-1984	32.14	1.87	1.34	14.00	12.86	11.73	1.49	.233	.236	26.30	.71	.50
37	LR-DISTY	0+400	01-03-1984	33.39	2.31	1.31	13.00	11.03	9.05	1.67	.214	.222	12.50	1.25	.45
38	LR-DISTY	0+400	08-04- 984	35.42	2.34	1.29	13.50	11.74	9.98	1.73	.227	.227	19.00	.50	1.00
39	LR-DISTY	0+400	23-02-1984	29.33	1.94	1.27	13.00	11.91	10.82	1.51	.166	.244	10.00	.63	.50
40	LR-DISTY	1+100	14-12-1983	23.71	1.94	1.06	13.17	11.51	9.85	1.49	.219	.240	15.00	.90	.81
41	LR-DISTY	28+460	14-12-1983	20.58	1.76	1.14	12.00	10.24	8.47	1.34	.182	.210	15.00	1.00	1.00
42	LR-DISTY	28+460	07-05-1984	26.73	2.20	1.22	13.50	9.96	6.43	1.46	.184	.204	27.00	.71	2.50
43	LR-DISTY	28+460	24-10-1984	21.14	1.95	1.19	10.50	9.13	7.75	1.42	.193	.192	22.00	.50	.91
44	MW-DISTY	0+325	17-06-1984	207.71	2.69	1.56	50.50	49.30	48.09	2.45	.113	.107	25.00	.23	.67
45	MW-DISTY	86+900	24-11-1983	46.28	2.47	1.23	18.00	15.22	12.44	1.89	.170	.178	18.00	1.25	1.00

General hydraulic data, EQ-measurements

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (10**-3) St.rch	Slope (10**-3) Str.str	Tempe-rature (C)	Side slope left	Side slope right
46	MW-DISTY	117+619	18-06-1984	22.91	1.40	1.27	14.00	12.91	11.82	1.17	.157	.164	26.50	1.00	.56
47	SP-DISTY	0+500	09-05-1984	208.50	2.77	1.47	54.00	51.19	48.38	2.51	.107	.143	22.50	.67	1.36
48	SP-DISTY	0+500	15-12-1983	169.67	2.40	1.41	53.00	50.11	47.23	2.19	.175	.146	15.00	1.50	.91
49	SP-DISTY	25+150	15-12-1983	169.43	3.58	1.53	32.50	30.89	29.27	2.98	.111	.110	16.00	.38	.52
50	SP-DISTY	25+500	09-05-1984	191.70	3.88	1.69	33.00	29.25	25.49	3.13	.175	.157	25.00	1.05	.88
51	SP-DISTY	47+700	09-05-1984	131.27	3.61	1.49	27.50	24.37	21.24	2.85	.183	.171	25.00	1.18	.56
52	SP-DISTY	47+700	15-12-1983	114.55	3.34	1.31	27.60	26.13	24.67	2.70	.164	.163	15.00	.83	.05
53	SP-DISTY	48+325	10-05-1984	100.79	2.35	1.62	27.00	26.43	25.87	2.03	.221	.208	24.25	.26	.22
54	SP-DISTY	48+325	18-07-1984	109.52	2.52	1.68	27.00	25.88	24.75	2.15	.289	.273	26.00	.48	.42
55	SP-DISTY	74+750	16-12-1983	66.40	1.90	1.31	28.00	26.77	25.54	1.69	.247	.217	13.50	.77	.53
56	SP-DISTY	140+250	18-07-1984	21.21	1.85	1.43	10.00	8.01	6.03	1.29	.230	.228	30.00	.71	1.43
57	SR-MINOR	11+800	15-11-1984	2.53	.80	.75	5.00	4.20	3.41	.59	.473	.472	18.00	1.00	1.00
58	AG-DISTY	47+400	27-11-1984	24.88	1.85	1.23	11.50	10.87	10.24	1.42	.347	.347	17.50	.38	.29
59	KC-DISTY	0+250	28-11-1984	64.01	3.55	1.65	11.50	10.96	10.41	2.21	.135	.164	16.00	.14	.16
60	KC-DISTY	29+670	28-11-1984	41.67	1.30	1.20	28.00	26.58	25.16	1.19	.197	.199	18.00	1.18	1.00
61	LG-BRANCH	54+700	25-12-1984	1964.73	6.26	2.59	128.00	121.25	114.49	5.70	.173	.173	13.00	1.43	.73
62	LG-BRANCH	103+000	26-12-1984	1978.85	6.51	2.66	120.00	114.14	108.27	5.91	.145	.151	12.00	.89	.91
63	LG-BRANCH	119+100	26-12-1984	1756.29	6.66	2.74	101.00	96.36	91.71	5.92	.173	.170	12.00	1.07	.32
64	LG-BRANCH	167+000	27-12-1984	1598.46	5.56	2.53	120.00	113.51	107.01	5.08	.210	.208	11.50	1.02	1.32
65	LG-BRANCH	200+700	27-12-1984	1540.52	6.14	2.64	102.00	95.00	88.00	5.46	.188	.188	12.00	1.54	.74
66	LG-BRANCH	244+970	29-12-1984	1478.61	6.20	2.61	97.00	91.22	85.45	5.51	.202	.200	11.50	.61	1.25
67	LG-BRANCH	264+275	29-12-1984	1419.50	6.35	2.51	94.00	88.91	83.81	5.64	.199	.200	12.00	.78	.82
68	LG-BRANCH	293+500	31-12-1984	1122.98	5.70	2.70	76.00	72.95	69.90	5.02	.219	.217	11.50	.54	.54
69	LG-BRANCH	323+400	31-12-1984	827.89	4.64	2.62	72.00	67.99	63.98	4.14	.273	.271	11.50	.86	.87
70	AP-MINOR	46+527	12-11-1984	29.34	1.84	1.28	13.50	12.52	11.53	1.46	.300	.340	18.00	.36	.71
71	BH-DISTY	0+500	10-10-1984	254.81	3.64	1.59	46.80	44.17	41.53	3.18	.114	.115	24.25	.62	.83
72	BH-DISTY	17+550	09-08-1984	229.56	4.17	1.64	36.50	33.52	30.53	3.43	.106	.103	29.25	.74	.69
73	BH-DISTY	41+700	09-08-1984	183.52	3.79	1.62	31.00	29.90	28.79	3.09	.105	.105	31.50	.33	.25
74	BH-DISTY	41+700	10-10-1984	196.32	3.74	1.79	30.00	29.33	28.66	3.02	.124	.123	25.00	.36	.00
75	BH-DISTY	51+250	11-10-1984	89.93	3.28	1.66	19.80	16.52	13.23	2.41	.141	.184	25.00	1.00	1.00
76	BH-DISTY	94+300	11-10-1984	44.11	2.23	1.19	17.00	16.63	16.26	1.78	.215	.213	24.25	.33	.00
77	BJ-DISTY	16+500	04-10-1984	32.49	2.40	1.40	11.00	9.65	8.31	1.68	.286	.278	26.50	.67	.45
78	BT-DISTY	0+400	27-09-1984	178.01	3.75	1.92	26.20	24.69	23.19	2.96	.156	.158	26.00	.45	.35
79	BT-DISTY	56+900	27-09-1984	56.03	2.97	1.37	14.40	13.72	13.03	2.13	.200	.200	27.00	.25	.21
80	CK-DISTY	0+200	20-08-1984	256.53	3.05	1.93	48.00	43.66	39.31	2.66	.182	.180	24.00	1.60	1.25
81	CK-DISTY	33+800	24-09-1984	173.43	3.52	1.86	28.00	26.53	25.06	2.86	.140	.158	24.00	.43	.40
82	CK-DISTY	57+155	21-08-1984	117.89	2.44	1.69	31.00	28.67	26.34	2.11	.188	.185	27.00	1.11	.80
83	CK-DISTY	57+200	10-10-1984	81.97	2.19	1.30	30.50	28.77	27.04	1.93	.190	.186	22.00	.95	.63
84	CK-DISTY	108+480	21-08-1984	29.33	1.87	1.51	12.00	10.37	8.75	1.41	.224	.223	30.00	1.23	.50
85	CN-DISTY	0+900	23-08-1984	114.95	2.33	1.73	30.00	28.57	27.14	2.04	.227	.212	26.00	.36	.87
86	CN-DISTY	53+792	24-08-1984	63.84	1.87	1.35	27.00	25.17	23.34	1.64	.262	.250	28.00	.53	1.43
87	DP-CANAL	44+000	20-09-1984	2074.55	7.03	2.51	124.00	117.54	111.08	6.35	.093	.115	24.25	.98	.86
88	DP-CANAL	86+000	21-09-1984	970.77	6.05	2.07	82.00	77.47	72.94	5.32	.119	.109	24.00	.68	.82
89	DP-CANAL	152+000	04-10-1984	834.87	5.87	2.26	66.00	62.85	59.71	5.05	.124	.099	25.00	.61	.47
90	DP-CANAL	152+000	06-08-1984	826.86	5.92	2.23	67.00	62.56	58.11	5.08	.112	.094	26.00	.77	.73

General hydraulic data, EQ-measurements

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (10**-3) St.rch	Slope (10**-3) Str.str	Tempe-rature (C)	Side slope left	Side slope right
91	DP-CANAL	152+000	08-08-1984	833.72	5.83	2.24	67.00	63.96	60.92	5.04	.110	.095	26.00	.56	.49
92	DP-CANAL	152+000	10-10-1984	654.06	5.61	1.85	66.00	62.84	59.69	4.86	.095	.137	22.75	.63	.50
93	DP-CANAL	152+000	12-08-1984	830.55	5.86	2.25	67.00	63.13	59.26	5.04	.104	.092	27.00	.83	.49
94	DP-CANAL	152+000	19-08-1984	868.88	6.02	2.32	67.00	62.12	57.23	5.14	.115	.099	22.25	.79	.83
95	DP-CANAL	152+000	19-09-1984	818.52	5.71	2.36	66.00	62.84	59.68	4.94	.117	.100	25.75	.61	.50
96	DP-CANAL	152+000	21-09-1984	822.40	5.96	2.21	66.00	62.49	58.97	5.12	.116	.099	25.00	.53	.65
97	DP-CANAL	152+000	25-09-1984	878.72	5.95	2.34	67.00	63.17	59.34	5.11	.126	.098	23.25	.83	.45
98	FM-DISTY	0+500	09-10-1984	108.99	2.81	1.32	33.00	29.36	25.72	2.34	.165	.165	22.00	.59	2.00
99	FM-DISTY	17+100	10-10-1984	90.57	3.07	1.45	22.00	20.33	18.65	2.44	.155	.158	21.75	.50	.59
100	FM-DISTY	22+450	20-08-1984	130.84	3.47	1.55	26.00	24.26	22.51	2.78	.162	.160	26.00	.42	.59
101	FM-DISTY	35+100	10-10-1984	59.25	2.52	1.26	19.50	18.58	17.65	2.03	.173	.173	22.25	.45	.28
102	HV-DISTY	28+550	13-08-1984	116.59	3.03	1.66	24.50	23.18	21.87	2.47	.208	.239	30.50	.56	.31
103	JD-DISTY	0+100	24-09-1984	40.56	1.73	1.27	20.00	18.41	16.82	1.48	.159	.153	25.50	.83	1.00
104	JP-DISTY	0+250	05-10-1984	97.30	2.51	1.38	30.00	28.18	26.36	2.16	.197	.197	25.00	.45	1.00
105	JP-DISTY	22+250	27-08-1984	122.31	2.82	1.48	32.00	29.23	26.47	2.36	.206	.206	26.75	1.67	.29
106	KN-DISTY	0+700	23-09-1984	201.85	3.52	1.64	36.50	34.97	33.44	2.99	.129	.145	24.25	.43	.43
107	KN-DISTY	20+050	10-08-1984	166.54	3.62	1.46	33.00	31.52	30.03	3.01	.119	.119	27.00	.48	.34
108	KN-DISTY	20+050	23-09-1984	185.75	3.79	1.56	33.00	31.51	30.01	3.13	.158	.158	25.50	.48	.31
109	KN-DISTY	52+353	23-09-1984	94.86	2.86	1.39	26.50	23.94	21.38	2.35	.137	.138	27.25	1.11	.68
110	KN-DISTY	53+000	24-09-1984	84.45	2.96	1.33	23.00	21.52	20.04	2.39	.100	.100	23.33	.50	.50
111	LA-DISTY	0+500	17-08-1984	196.58	3.68	1.56	39.50	34.29	29.08	3.00	.093	.100	23.00	.83	2.00
112	LA-DISTY	0+500	28-09-1984	170.02	3.26	1.49	38.00	35.10	32.20	2.79	.085	.085	23.50	.67	1.11
113	LA-DISTY	47+000	29-09-1984	88.31	3.54	1.27	23.00	19.70	16.40	2.64	.114	.114	24.00	1.43	.43
114	LC-DISTY	169+523	26-08-1984	71.75	2.61	1.41	21.00	19.41	17.83	2.12	.172	.170	29.00	.50	.71
115	LCN-DISTY	141+700	03-10-1984	114.88	2.88	1.48	29.00	26.86	24.73	2.43	.157	.154	23.00	.71	.77
116	LCN-DISTY	169+523	04-10-1984	68.08	2.51	1.40	21.00	19.33	17.65	2.05	.179	.177	26.00	.50	.83
117	LD-CANAL	2+600	21-08-1984	1911.01	7.43	2.56	109.00	100.34	91.68	6.51	.157	.148	28.00	1.08	1.25
118	LD-CANAL	2+600	29-09-1984	1899.80	7.90	2.39	109.00	100.46	91.91	6.89	.131	.093	24.75	1.00	1.16
119	LS-BRANCH	7+830	13-10-1984	1397.86	8.66	2.30	76.00	70.31	64.62	7.13	.151	.149	22.00	.63	.69
120	LS-BRANCH	7+830	22-08-1984	1676.52	8.98	2.68	78.00	69.59	61.17	7.29	.129	.130	27.50	.95	.92
121	LS-BRANCH	45+800	13-10-1984	1371.94	8.32	2.18	81.00	75.64	70.28	6.98	.093	.092	23.00	.80	.49
122	LS-BRANCH	45+800	22-08-1984	1638.97	8.07	2.61	85.00	77.87	70.74	6.78	.088	.090	28.75	1.21	.56
123	LS-BRANCH	77+700	22-08-1984	1496.69	8.49	2.30	81.00	76.70	72.39	7.12	.072	.072	29.00	.49	.53
124	MK-DISTY	0+300	07-10-1984	64.51	2.48	1.43	20.00	18.24	16.49	2.00	.193	.192	24.00	1.00	.42
125	MK-DISTY	0+300	24-08-1984	81.25	2.95	1.52	20.50	18.15	15.80	2.26	.166	.170	27.50	1.25	.34
126	MK-DISTY	36+300	07-10-1984	28.59	1.86	1.27	13.00	12.06	11.12	1.46	.222	.219	27.00	.63	.38
127	ML-BRANCH	270+400	18-02-1985	1554.75	7.87	2.19	99.00	90.15	81.29	6.75	.143	.152	16.00	1.25	1.00
128	ML-BRANCH	270+400	22-04-1985	1527.27	8.61	1.95	99.00	90.76	82.51	7.34	.060	.092	23.50	1.20	.71
129	ML-BRANCH	302+877	07-08-1984	1231.20	5.01	2.28	112.00	107.78	103.57	4.63	.141	.176	24.00	.83	.85
130	ML-BRANCH	302+877	19-02-1985	910.50	4.60	1.86	112.00	106.35	100.71	4.24	.226	.178	13.00	1.03	1.43
131	ML-BRANCH	302+877	23-04-1985	1177.28	4.99	2.26	112.00	104.51	97.02	4.54	.169	.163	26.50	1.50	1.50
132	ML-BRANCH	306+166	07-08-1984	1176.08	5.91	2.08	103.00	95.76	88.52	5.24	.172	.193	26.50	1.94	.51
133	ML-BRANCH	306+166	24-04-1985	1092.46	5.33	2.07	104.00	99.03	94.05	4.85	.178	.195	22.25	1.03	.83
134	ML-BRANCH	358+600	24-04-1985	1046.48	4.28	2.15	119.00	113.95	108.89	3.99	.248	.194	24.25	1.28	1.08
135	ML-BRANCH	358+600	25-03-1985	986.29	4.13	2.10	118.00	113.47	108.94	3.86	.193	.186	18.50	.57	1.62

General hydraulic data, EQ-measurements

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (1v**-3) St.rch	Str.str	Tempe-rature (C)	Side slope left	Side slope right
136	ML-BRANCH	370+000	26-03-1985	909.66	4.64	2.17	93.00	90.57	88.14	4.26	.196	.193	18.50	.57	.48
137	ML-BRANCH	370+015	09-08-1984	909.05	4.82	2.15	94.00	87.83	81.67	4.34	.203	.198	26.50	1.72	.83
138	ML-BRANCH	370+015	21-02-1985	834.66	4.70	2.03	91.00	87.39	83.79	4.28	.171	.171	13.00	1.08	.45
139	ML-BRANCH	370+015	25-04-1985	870.30	4.77	2.14	91.00	85.17	79.35	4.31	.203	.199	22.50	1.19	1.25
140	ML-BRANCH	435+190	09-08-1984	609.99	4.37	1.92	78.00	72.61	67.21	3.91	.177	.205	27.00	1.47	1.00
141	ML-BRANCH	435+190	21-02-1985	569.10	4.07	2.00	75.50	69.92	64.33	3.64	.190	.202	13.00	1.37	1.38
142	ML-BRANCH	435+190	26-03-1985	618.31	4.15	2.02	77.00	73.87	70.74	3.77	.165	.171	19.00	.97	.54
143	ML-BRANCH	435+190	26-04-1985	633.58	4.27	2.17	75.00	68.39	61.78	3.76	.197	.205	26.00	1.76	1.33
144	ML-BRANCH	458+600	27-04-1985	236.86	3.94	1.55	42.00	38.80	35.60	3.34	.157	.154	24.50	.86	.77
145	MS-DISTY	27+100	18-08-1984	29.95	1.72	1.28	16.00	13.61	11.22	1.36	.201	.217	29.00	2.00	.78
146	NO-DISTY	0+400	15-10-1984	224.89	3.07	1.80	41.50	40.60	39.71	2.70	.144	.145	22.50	.23	.36
147	NO-DISTY	0+400	25-08-1984	220.42	3.16	1.75	40.50	39.81	39.13	2.76	.141	.167	28.50	.22	.21
148	NO-DISTY	21+750	15-10-1984	202.03	3.14	1.82	37.00	35.39	33.78	2.72	.187	.168	23.00	.63	.40
149	NO-DISTY	21+750	25-08-1984	212.18	3.16	1.90	36.00	35.39	34.65	2.72	.187	.185	29.50	.20	.23
150	NO-DISTY	53+860	15-10-1984	109.01	2.78	1.73	23.50	22.73	21.95	2.28	.295	.296	23.00	.36	.20
151	NO-DISTY	53+860	25-08-1984	117.75	2.93	1.74	24.00	23.16	22.32	2.39	.278	.222	30.00	.26	.31
152	NO-DISTY	84+500	15-10-1984	25.63	1.54	1.09	16.90	15.26	13.62	1.29	.265	.262	24.50	1.25	.89
153	NO-DISTY	84+500	25-08-1984	32.60	1.42	1.51	16.00	15.26	14.53	1.22	.304	.303	28.00	.63	.42
154	NO-DISTY	92+145	25-08-1984	16.73	1.45	1.14	11.30	10.12	8.95	1.14	.233	.233	28.50	1.25	.38
155	NW-DISTY	0+500	07-10-1984	554.91	6.88	2.10	42.00	38.42	34.85	5.25	.196	.196	25.25	.51	.53
156	NW-DISTY	0+500	28-08-1984	615.40	7.23	2.21	42.00	38.49	34.98	5.45	.129	.189	27.00	.44	.53
157	NW-DISTY	14+000	07-10-1984	551.17	6.48	2.11	44.00	40.35	36.70	5.07	.160	.162	26.00	.56	.57
158	NW-DISTY	68+533	28-08-1984	312.03	4.03	1.96	42.00	39.51	37.01	3.42	.169	.165	28.00	.67	.57
159	NW-DISTY	92+800	29-08-1984	153.75	2.67	1.54	40.00	37.51	35.01	2.37	.175	.179	26.75	.87	1.00
160	NZ-DISTY	34+300	19-08-1984	22.57	2.33	1.13	10.00	8.59	7.18	1.58	.202	.202	26.00	.50	.71
161	NZ-DISTY	34+300	24-09-1984	20.60	2.03	1.22	10.00	8.35	6.71	1.42	.207	.206	27.00	.71	.91
162	PR-DISTY	0+500	01-10-1984	96.10	2.93	1.39	25.50	23.51	21.52	2.39	.170	.170	25.50	.36	1.00
163	PR-DISTY	0+500	26-08-1984	95.42	2.74	1.54	26.00	22.57	19.14	2.21	.154	.154	29.25	1.67	.83
164	PR-DISTY	36+270	26-08-1984	43.26	2.22	1.29	16.50	15.15	13.80	1.77	.157	.156	32.00	.71	.50
165	PR-DISTY	36+675	03-10-1984	53.21	2.41	1.44	17.20	15.29	13.38	1.88	.156	.174	25.00	1.00	.58
166	PR-DISTY	48+900	27-08-1984	20.11	1.71	1.08	12.00	10.90	9.80	1.34	.216	.164	30.00	.83	.45
167	RW-DISTY	60+400	14-02-1985	46.65	2.11	1.34	18.50	16.53	14.55	1.71	.283	.283	18.00	.63	1.25
168	RW-DISTY	60+400	28-08-1984	44.89	2.21	1.25	18.00	16.28	14.56	1.78	.190	.181	30.00	.56	1.00
169	SM-DISTY	0+650	11-08-1984	180.56	3.83	1.46	34.00	32.32	30.64	3.17	.138	.142	29.75	.63	.25
170	SM-DISTY	65+400	11-08-1984	47.06	2.15	1.57	15.00	13.91	12.83	1.69	.250	.253	32.50	.63	.38
171	TN-DISTY	1+450	02-04-1985	289.56	3.39	1.72	53.20	49.62	46.04	3.01	.151	.192	19.50	1.33	.78
172	TN-DISTY	1+450	17-04-1985	234.86	3.07	1.50	54.00	50.97	47.93	2.77	.152	.196	22.00	.98	1.00
173	TN-DISTY	1+450	22-10-1984	276.09	3.02	1.83	53.00	50.13	47.26	2.71	.188	.215	21.00	1.43	.48
174	TN-DISTY	16+463	02-04-1985	277.98	3.64	1.74	49.00	44.01	39.02	3.10	.226	.212	19.50	.74	2.00
175	TN-DISTY	16+463	17-04-1985	237.90	3.49	1.61	46.00	42.24	38.48	3.01	.222	.223	22.50	.73	1.43
176	TN-DISTY	16+463	22-10-1984	267.65	3.46	1.82	46.50	42.48	38.47	2.98	.259	.252	22.00	1.67	.65
177	TN-DISTY	16+500	10-08-1984	249.53	2.93	1.81	49.00	46.96	44.93	2.64	.211	.198	24.50	.89	.50
178	TN-DISTY	26+100	03-04-1985	76.12	1.74	1.60	29.00	27.40	25.81	1.56	.308	.265	21.00	.50	1.33
179	TN-DISTY	26+100	18-04-1985	72.30	1.70	1.53	28.50	27.72	26.95	1.53	.302	.292	21.00	.56	.36
180	TN-DISTY	26+100	23-10-1984	75.79	1.93	1.59	26.50	24.80	23.11	1.68	.282	.287	20.00	1.43	.33

General hydraulic data, EQ-measurements

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (10**-3) St.rch	Slope (10**-3) Str.str	Tempe-rature (C)	Side slope left	Side slope right
181	TN-DISTY	83+830	03-04-1985	43.37	1.95	1.36	19.00	16.42	13.84	1.57	.287	.262	21.00	1.82	.83
182	TN-DISTY	83+830	18-04-1985	39.19	1.90	1.25	19.00	16.47	13.94	1.53	.276	.280	25.50	.67	2.00
183	US-BRANCH	41+000	08-08-1984	371.05	4.59	1.96	45.50	41.33	37.16	3.82	.105	.110	29.00	.91	.91
184	US-BRANCH	41+000	26-09-1984	361.54	4.63	1.92	45.00	40.74	36.47	3.84	.116	.115	27.00	1.07	.77
185	BA-DISTY	55+000	29-09-1984	15.55	1.83	.99	9.50	8.55	7.59	1.33	.272	.254	28.00	.63	.42
186	BS-DISTY	0+350	16-08-1984	55.00	2.26	1.40	19.40	17.40	15.40	1.83	.227	.224	31.50	.77	1.00
187	BS-DISTY	0+500	19-11-1984	45.02	2.30	1.35	17.20	14.49	11.78	1.76	.226	.221	25.00	1.43	.92
188	BS-DISTY	9+000	19-11-1984	31.97	2.04	1.32	13.20	11.84	10.48	1.57	.248	.246	19.00	.67	.67
189	CD-BRANCH	2+000	26-11-1984	1520.54	7.19	2.27	98.00	93.04	88.08	6.34	.125	.125	17.00	.75	.63
190	CD-BRANCH	2+300	26-08-1984	1477.19	7.00	2.16	103.00	97.53	92.07	6.22	.133	.132	30.00	.75	.81
191	CD-BRANCH	17+000	26-11-1984	1297.16	5.54	2.12	120.00	110.30	100.60	4.97	.122	.118	16.50	1.50	2.00
192	CD-BRANCH	38+500	26-11-1984	1213.33	6.22	2.30	88.50	84.78	81.06	5.52	.148	.142	16.50	.48	.71
193	CD-BRANCH	47+950	26-11-1984	1184.98	6.00	2.15	98.00	91.90	85.80	5.36	.142	.142	16.50	1.00	1.03
194	CD-BRANCH	47+950	27-08-1984	1082.71	5.81	2.02	97.50	92.22	86.94	5.22	.109	.127	30.00	.86	.96
195	CD-BRANCH	73+425	26-11-1984	1142.51	5.72	2.19	97.50	90.98	84.47	5.10	.143	.143	17.00	.81	1.47
196	CW-DISTRY	93+250	31-07-1984	102.56	2.21	1.63	31.00	28.50	26.00	1.92	.196	.196	32.00	1.43	.83
197	CW-DISTY	1+000	30-07-1984	378.98	3.64	2.29	47.80	45.38	42.96	3.20	.190	.183	30.50	.71	.62
198	CW-DISTY	27+400	17-09-1984	378.36	3.81	2.16	48.00	45.97	43.95	3.33	.170	.170	31.00	.59	.48
199	CW-DISTY	28+400	24-09-1984	288.41	3.99	1.97	39.50	36.61	33.71	3.35	.172	.175	28.50	.71	.74
200	CW-DISTY	61+425	30-07-1984	229.23	3.46	1.94	36.00	34.04	32.08	2.94	.171	.171	32.00	.71	.42
201	CW-DISTY	61+430	24-09-1984	211.26	3.83	1.83	33.00	30.12	27.25	3.13	.179	.179	29.00	.81	.69
202	CW-DISTY	61+430	25-09-1984	215.19	3.66	1.96	33.00	29.93	26.86	3.01	.178	.176	28.50	.89	.78
203	CW-DISTY	62+900	31-07-1984	149.13	2.76	1.56	37.50	34.52	31.54	2.40	.201	.193	31.50	.91	1.25
204	HA-DISTY	0+350	22-11-1984	177.67	3.19	1.49	40.00	37.42	34.84	2.75	.126	.126	18.00	.37	1.25
205	HA-DISTY	23+100	22-11-1984	97.54	2.51	1.34	30.00	28.87	27.74	2.18	.221	.221	18.00	.56	.34
206	HA-DISTY	23+370	29-07-1984	104.25	2.66	1.40	29.20	28.01	26.82	2.28	.153	.167	30.50	.42	.48
207	HA-DISTY	69+700	22-11-1984	26.46	1.70	1.21	15.00	12.81	10.62	1.34	.247	.228	18.50	1.67	.91
208	JL-DISTY	21+300	22-07-1984	150.10	3.15	1.71	29.20	27.98	26.75	2.63	.191	.200	29.00	.33	.44
209	JL-DISTY	35+300	27-09-1984	102.08	3.38	1.89	17.80	16.02	14.25	2.47	.197	.227	27.50	.38	.67
210	JL-DSITY	0+500	18-07-1984	170.20	2.97	1.58	38.30	36.35	34.40	2.59	.160	.157	29.00	.31	1.00
211	JW-DISTY	14+000	12-10-1984	84.75	2.92	1.60	19.50	18.18	16.86	2.27	.175	.173	24.00	.67	.24
212	KR-BRANCH	56+500	13-10-1984	547.40	5.08	2.28	51.00	47.23	43.45	4.27	.169	.165	22.50	.70	.79
213	KR-BRANCH	56+500	14-09-1984	581.28	5.33	2.20	53.00	49.67	46.34	4.49	.165	.164	30.00	.48	.77
214	KR-BRANCH	56+500	17-08-1984	591.43	5.21	2.26	53.50	50.19	46.87	4.42	.169	.165	31.50	.58	.69
215	KR-BRANCH	56+500	17-09-1984	613.28	5.67	2.26	51.00	47.92	44.85	4.70	.168	.164	30.00	.49	.60
216	KR-BRANCH	75+425	17-09-1984	597.37	4.88	2.24	57.50	54.53	51.56	4.23	.171	.160	30.00	.68	.54
217	KR-BRANCH	75+650	17-08-1984	571.99	4.61	2.22	59.00	55.79	52.59	4.03	.171	.163	31.50	.71	.68
218	MH-DISTY	1+000	16-10-1984	441.27	4.57	1.88	54.50	51.35	48.20	3.96	.181	.174	22.50	.54	.83
219	MH-DISTY	1+000	27-11-1984	395.20	3.99	1.86	56.00	53.33	50.67	3.53	.177	.170	16.00	.78	.56
220	MH-DISTY	8+700	16-10-1984	400.17	3.84	2.02	55.50	51.59	47.69	3.38	.206	.165	23.00	.86	1.18
221	MH-DISTY	8+700	27-11-1984	344.37	3.46	1.78	59.00	55.79	52.57	3.11	.191	.169	16.00	.86	1.00
222	MH-DISTY	49+350	15-09-1984	389.75	3.54	1.81	63.50	60.92	58.34	3.21	.157	.157	30.50	.83	.63
223	MH-DISTY	49+350	16-09-1984	388.91	3.61	1.77	63.50	61.00	58.51	3.27	.162	.170	29.50	.76	.63
224	MH-DISTY	51+800	28-11-1984	321.60	3.41	1.76	57.00	53.52	50.04	3.06	.177	.165	16.00	.97	1.07
225	MH-DISTY	59+500	16-10-1984	336.94	3.89	1.75	53.00	49.57	46.13	3.41	.180	.165	24.00	.71	1.05

General hydraulic data, EQ-measurements

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (10**-3) St.rch	Slope (10**-3) Str.str	Tempe-rature (C)	Side slope left	Side slope right
226	MH-DISTY	59+500	28-11-1984	283.46	3.70	1.54	55.00	49.87	44.74	3.21	.168	.165	16.00	1.03	1.74
227	MH-DISTY	75+000	16-10-1984	304.06	3.94	1.79	46.00	43.16	40.32	3.39	.152	.166	24.50	.86	.58
228	MH-DISTY	75+000	28-11-1984	263.19	3.73	1.60	47.50	44.20	40.90	3.24	.153	.151	16.00	.83	.94
229	ML-CANAL	160+000	24-08-1984	3436.40	9.35	2.97	133.00	123.76	114.52	8.19	.085	.170	30.00	.63	1.35
230	ML-CANAL	186+000	15-10-1984	2978.86	7.86	2.69	148.80	140.75	132.71	7.12	.084	.089	23.00	1.20	.85
231	ML-CANAL	186+000	25-11-1984	2596.03	7.21	2.56	150.00	140.86	131.71	6.54	.105	.102	18.00	1.67	.87
232	ML-CANAL	219+000	25-08-1984	2991.18	8.08	2.91	132.50	127.45	122.41	7.26	.086	.086	30.00	.37	.88
233	ML-CANAL	219+000	25-11-1984	2473.43	7.75	2.53	132.00	126.34	120.68	6.99	.083	.083	17.00	.51	.95
234	ML-DISTY	0+200	26-07-1984	58.34	2.57	1.21	20.50	18.66	16.82	2.07	.210	.203	31.00	.71	.71
235	ML-DISTY	16+050	26-07-1984	37.84	1.71	1.27	19.00	17.37	15.74	1.45	.187	.203	32.00	1.00	.91
236	ML-DISTY	29+800	19-11-1984	26.12	2.31	1.41	11.50	8.03	4.56	1.34	.289	.286	20.00	1.33	1.67
237	AH-MINOR	0+000	16-05-1984	29.88	1.96	1.26	13.50	12.08	10.65	1.52	.239	.230	28.50	.67	.79
238	AH-MINOR	0+500	19-08-1984	45.10	2.44	1.53	13.50	12.09	10.69	1.81	.241	.235	30.00	.50	.65
239	AH-MINOR	0+500	26-09-1984	47.49	2.44	1.52	14.00	12.78	11.56	1.83	.241	.238	29.00	.53	.48
240	AJ-BRANCH	0+000	15-05-1984	351.23	4.27	1.92	46.00	42.91	39.82	3.64	.201	.109	29.00	.66	.79
241	AJ-BRANCH	0+650	15-08-1984	389.96	4.23	1.95	50.00	47.18	44.36	3.66	.131	.129	32.00	.66	.68
242	AJ-BRANCH	4+000	30-11-1983	374.51	4.35	1.75	52.00	49.04	46.08	3.77	.118	.127	20.00	.53	.83
243	AJ-BRANCH	16+790	23-09-1984	423.97	4.55	1.98	50.00	46.96	43.92	3.90	.116	.115	28.00	.64	.69
244	AL-BRANCH	0+000	01-12-1983	253.75	4.34	1.62	39.00	36.13	33.26	3.59	.121	.121	18.50	.68	.65
245	AL-BRANCH	0+000	19-11-1983	289.90	4.04	1.97	39.00	36.48	33.95	3.38	.125	.125	20.00	.71	.54
246	AL-BRANCH	3+000	29-08-1984	321.87	4.09	2.12	40.00	37.12	34.24	3.43	.162	.126	27.00	.71	.69
247	AL-BRANCH	3+800	04-09-1984	245.87	3.85	1.72	40.00	37.17	34.33	3.26	.136	.136	28.50	.71	.76
248	AL-BRANCH	3+800	17-04-1984	288.53	4.45	1.86	38.00	34.82	31.65	3.64	.129	.129	27.50	.60	.83
249	AL-BRANCH	3+800	29-02-1984	272.53	4.45	1.84	38.00	33.31	28.62	3.56	.122	.128	15.00	.86	1.25
250	AL-BRANCH	22+000	17-04-1984	259.34	4.38	1.82	36.00	32.46	28.92	3.54	.125	.135	27.50	.69	.92
251	AL-BRANCH	22+100	21-05-1984	265.95	4.18	1.83	40.00	34.84	29.67	3.39	.124	.135	32.00	1.28	1.19
252	DL-DISTY	0+000	18-06-1984	46.45	2.16	1.35	17.50	15.91	14.31	1.74	.192	.221	29.00	.69	.79
253	DL-DISTY	0+000	20-08-1984	55.65	2.56	1.38	17.00	15.77	14.54	2.00	.187	.223	30.00	.53	.43
254	DL-DISTY	0+000	17-05-1984	44.54	2.04	1.35	17.50	16.24	14.97	1.67	.189	.218	28.50	.71	.53
255	DL-DISTY	5+000	27-09-1984	57.02	2.38	1.52	17.00	15.73	14.47	1.88	.203	.222	26.50	.59	.48
256	DL-DISTY	29+[illegible]0	27-09-1984	13.26	1.49	1.15	9.00	7.72	6.45	1.11	.202	.195	26.00	1.00	.71
257	HB-CANAL	4+[illegible]	09-12-1984	305.24	4.29	1.52	50.00	46.80	43.60	3.70	.107	.106	18.50	.74	.76
258	HB-CANAL	39+500	09-12-1984	253.02	3.91	1.48	47.50	43.66	39.82	3.36	.142	.139	18.50	1.04	.93
259	JM-DISTY	0+000	20-06-1984	172.61	3.09	1.73	34.00	32.38	30.75	2.65	.157	.186	30.00	.38	.67
260	JM-DISTY	7+000	21-03-1[illegible]	185.69	3.35	1.79	34.00	31.03	28.05	2.80	.153	.163	22.50	.67	1.11
261	KH-MINOR	1+000	21-04-1984	36.58	3.52	1.33	10.00	7.84	5.68	1.98	.285	.266	29.00	.71	.51
262	KR-DISTY	0+000	01-11-1983	142.20	3.59	1.81	25.00	21.81	18.61	2.77	.132	.168	22.00	1.04	.74
263	KR-DISTY	0+000	02-12-1983	139.85	3.57	1.78	25.00	22.01	19.02	2.77	.178	.170	19.00	.71	.96
264	KR-DISTY	2+500	02-12-1983	169.11	3.85	2.02	25.00	21.77	18.54	2.93	.178	.170	19.00	.71	.96
265	KR-DISTY	3+000	01-03-1984	144.97	3.44	1.56	29.00	27.11	25.21	2.82	.124	.150	17.00	.48	.63
266	KR-DISTY	3+000	17-04-1984	146.86	3.16	1.83	28.00	25.43	22.87	2.59	.148	.175	27.50	.71	.91
267	KR-DISTY	3+000	23-05-1984	152.61	3.35	1.79	28.00	25.49	22.97	2.72	.162	.171	28.00	.67	.83
268	KR-DISTY	3+000	23-06-1984	145.02	3.37	1.83	27.00	23.51	20.02	2.66	.164	.175	29.50	1.07	1.00
269	KR-DISTY	3+000	30-08-1984	131.07	2.91	1.77	28.00	25.47	22.94	2.42	.172	.174	28.50	.74	1.00
270	MK-MINOR	1+000	24-04-1984	48.21	1.97	1.41	19.50	17.42	15.34	1.63	.250	.241	28.00	.94	1.18

General hydraulic data, EQ-measurements

No.	Experi-ment	Reach	Date	Discharge (ft**3/s)	Depth (ft)	Velocity (ft/s)	Top width (ft)	Average width (ft)	Bed width (ft)	Hydraulic radius (ft)	Slope (10**-3) St.rch	Slope (10**-3) Str.str	Tempe-rature (C)	Side slope left	Side slope right
271	MK-MINOR	1+000	28-05-1984	56.19	2.06	1.54	20.00	17.71	15.42	1.69	.268	.260	28.00	1.11	1.11
272	NS-BRANCH	2+775	08-10-1984	2620.05	9.31	2.70	109.50	104.32	99.13	8.07	.097	.098	27.50	.53	.58
273	NS-BRANCH	2+775	20-09-1984	2849.03	9.81	2.80	110.00	103.72	97.45	8.43	.128	.128	30.00	.64	.64
274	NS-BRANCH	2+775	30-09-1984	2863.76	9.39	2.93	109.50	104.26	99.02	8.12	.092	.092	27.50	.60	.52
275	SB-DISTY	0+258	12-12-1984	50.28	2.50	1.32	17.50	15.18	12.85	1.93	.140	.141	17.00	.86	1.00
276	SF-BRANCH	3+000	25-08-1984	441.26	4.23	2.21	50.00	47.18	44.36	3.66	.136	.132	27.00	.66	.68
277	SF-BRANCH	18+055	24-05-1984	325.46	3.80	1.95	48.00	43.99	39.98	3.28	.169	.136	29.50	1.00	1.11
278	SK-DISTY	0+000	01-12-1983	86.82	3.30	1.53	19.10	17.20	15.30	2.41	.193	.192	19.50	1.11	.04
279	SK-DISTY	2+000	20-11-1983	114.68	3.34	1.76	22.00	19.53	17.05	2.57	.196	.194	20.00	.74	.74
280	SK-DISTY	2+000	22-05-1984	149.24	3.66	2.08	22.00	19.56	17.12	2.76	.171	.211	33.00	.67	.67
281	SK-DISTY	2+000	22-06-1984	77.84	2.94	1.30	24.00	20.40	16.79	2.30	.155	.155	32.00	1.20	1.25
282	TA-DISTY	3+500	11-12-1984	132.37	3.53	1.27	33.00	29.48	25.95	2.90	.114	.113	17.50	1.04	.95
283	TA-DISTY	57+000	11-12-1984	66.38	3.02	1.33	18.00	16.49	14.98	2.29	.103	.110	18.50	.50	.50
284	ZD-MINOR	2+000	27-05-1984	47.63	2.55	1.58	14.00	11.82	9.65	1.84	.169	.237	28.50	.91	.80
285	MY-DISTY	2+240	08-05-1984	79.31	2.33	1.32	27.00	25.80	24.60	2.01	.225	.209	23.00	.48	.56
286	MY-DISTY	2+240	13-06-1984	101.51	2.47	1.66	25.53	24.76	23.99	2.09	.225	.204	20.50	.53	.09
287	MY-DISTY	2+240	14-05-1984	86.97	2.49	1.44	25.50	24.19	22.89	2.12	.144	.186	25.75	.49	.56
288	MY-DISTY	2+240	23-10-1984	86.59	2.35	1.40	27.00	26.30	25.60	2.02	.217	.205	22.00	.33	.26
289	MY-DISTY	2+240	10-07-1984	89.09	2.54	1.42	26.37	24.73	23.09	2.15	.212	.189	24.00	.43	.86
290	MY-DISTY	2+240	27-07-1984	89.41	2.51	1.46	25.33	24.32	23.30	2.13	.193	.200	25.83	.43	.38
291	MY-DISTY	29+940	08-05-1984	64.64	2.79	1.38	18.00	16.77	15.54	2.16	.133	.189	28.00	.50	.38
292	MY-DISTY	29+950	23-10-1984	66.24	2.94	1.38	17.00	16.34	15.68	2.21	.200	.200	23.00	.25	.20
AVERAGE														.79	.78
STANDARD DEVIATION														.36	.41

General hydraulic data, EQ-measurements

	Bedmaterial				Suspended load(concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
		(microns)				(ppm)			(ppm)		(microns)				(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
1	273	326	522	1.4	19	131	178	328	178	74	108	129	215	1.5	1
2	110	122	182	1.4	12	105	283	400	283	90	113	128	216	1.4	8
3	162	193	383	1.7	20	141	202	363	202	78	105	119	214	1.5	7
4	215	254	438	1.5	27	162	250	439	250	79	107	123	225	1.5	5
5	250	313	613	1.7	83	452	125	660	125	68	86	104	167	1.5	1
6	305	357	555	1.4	81	502	124	707	124	66	76	82	120	1.3	0
7	232	274	431	1.4	24	137	190	351	190	75	100	113	192	1.4	2
8	153	172	295	1.5	0	121	115	236	115	72	99	117	213	1.5	8
9	227	274	470	1.5	39	388	328	755	328	81	124	156	288	1.6	10
10	166	200	380	1.6	0	183	222	405	222	72	96	109	167	1.4	5
11	275	304	462	1.4	51	107	93	251	93	78	112	135	244	1.6	4
12	175	217	367	1.5	44	541	170	755	170	67	81	91	162	1.4	3
13	83	94	174	1.5	14	77	87	178	87	72	101	120	225	1.6	11
14	149	167	358	1.7	77	603	310	990	310	97	129	157	341	1.7	11
15	125	138	197	1.3	42	233	125	400	125	80	105	118	173	1.4	8
16	118	151	345	1.9	49	646	381	1076	381	69	89	106	259	1.8	19
17	202	246	420	1.5	15	104	206	325	206	78	106	121	238	1.6	7
18	203	244	393	1.4	52	91	91	234	91	73	104	125	173	1.4	2
19	201	235	389	1.5	48	572	91	711	91	65	74	80	141	1.3	5
20	150	173	280	1.5	129	606	9	744	9	66	78	85	156	1.5	0
21	83	95	148	1.4	0	0	0	0	0	64	71	75	85	1.1	0
22	88	96	128	1.2	13	98	82	193	82	73	99	112	257	1.6	6
23	135	178	380	1.8	8	238	56	302	56	66	76	82	160	1.3	6
24	121	137	216	1.4	9	75	90	174	90	74	103	118	165	1.4	2
25	108	119	180	1.4	51	527	43	621	43	67	82	94	155	1.4	5
26	95	107	165	1.4	14	146	56	216	56	68	85	104	161	1.5	6
27	123	144	233	1.5	0	0	0	0	0	64	71	75	85	1.1	0
28	98	107	147	1.3	31	57	48	136	48	68	84	102	160	1.5	7
29	125	146	242	1.5	66	433	36	535	36	66	77	84	146	1.4	3
30	162	185	305	1.5	80	616	20	716	20	68	83	97	157	1.4	1
31	106	122	202	1.5	56	216	98	370	98	69	90	110	162	1.4	4
32	93	111	200	1.6	0	0	0	0	0	64	71	75	85	1.1	0
33	93	104	151	1.3	0	0	0	0	0	64	71	75	85	1.1	0
34	83	89	118	1.2	34	796	95	925	95	66	77	84	150	1.3	7
35	155	183	330	1.6	69	472	46	587	46	68	83	101	160	1.5	2
36	107	128	252	1.7	28	802	71	901	71	67	80	90	154	1.4	4
37	97	106	149	1.3	28	87	36	151	36	67	82	96	158	1.4	5
38	73	83	142	1.5	63	284	119	466	119	67	81	92	152	1.3	9
39	105	113	157	1.3	45	234	45	324	45	72	104	128	272	1.7	8
40	77	90	162	1.6	5	176	249	430	249	68	84	101	159	1.4	4
41	146	188	412	1.8	4	57	10	71	10	67	80	88	153	1.4	0
42	90	109	244	1.7	3	269	69	341	69	66	79	86	222	1.7	6
43	108	125	200	1.4	0	0	0	0	0	64	71	75	85	1.1	0
44	114	129	203	1.4	61	596	51	708	51	67	80	90	155	1.4	5
45	67	84	180	1.8	120	211	55	386	55	66	77	84	144	1.4	5

Grainsize distributions and sediment concentration

	Bedmaterial				Suspended load (concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
	(microns)				(ppm)				(ppm)	(microns)					(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
46	86	106	205	1.7	7	1467	93	1657	93	67	81	91	155	1.4	9
47	103	111	150	1.3	6	202	54	262	54	65	75	81	135	1.3	6
48	97	107	154	1.3	19	152	67	238	67	66	79	86	147	1.4	7
49	95	106	154	1.3	6	166	48	220	48	66	78	86	149	1.4	5
50	111	124	223	1.5	31	193	63	287	63	66	77	84	150	1.4	4
51	85	92	122	1.2	11	652	80	743	80	65	75	81	137	1.3	6
52	109	120	187	1.4	23	103	122	248	122	91	109	121	172	1.3	2
53	88	99	151	1.4	13	1026	79	1118	79	68	84	98	205	1.5	14
54	102	114	183	1.4	103	615	167	885	167	67	79	87	123	1.3	9
55	84	92	130	1.3	52	331	103	486	103	68	63	101	281	1.9	13
56	101	114	186	1.5	123	1060	151	1334	151	69	88	101	153	1.4	8
57	82	93	150	1.4	0	0	0	0	0	64	71	75	85	1.1	0
58	84	97	162	1.5	19	339	255	613	255	68	83	94	124	1.3	7
59	109	123	199	1.4	66	114	78	258	78	66	77	84	140	1.3	4
60	122	137	202	1.4	23	165	69	257	69	66	78	85	147	1.4	4
61	220	258	417	1.4	40	97	217	354	217	90	115	133	217	1.4	6
62	209	242	367	1.4	30	0	188	218	188	89	116	133	153	1.3	0
63	201	229	336	1.3	28	65	399	492	399	98	132	151	229	1.4	10
64	240	268	386	1.3	21	102	364	487	364	95	123	140	210	1.3	2
65	208	236	342	1.3	18	107	359	484	359	93	120	140	225	1.4	9
66	198	223	317	1.3	26	90	439	555	439	96	130	155	240	1.5	10
67	206	226	301	1.3	19	159	541	719	541	98	148	182	246	1.5	8
68	221	241	311	1.2	16	131	455	602	455	77	109	128	215	1.5	4
69	182	203	291	1.3	20	101	539	660	539	90	113	128	214	1.4	16
70	110	120	166	1.3	0	0	67	67	67	68	85	104	161	1.5	5
71	87	97	135	1.3	0	0	0	0	0	64	71	75	85	1.1	0
72	103	110	136	1.2	220	1187	52	1459	52	66	76	82	154	1.3	4
73	107	116	167	1.3	224	1183	46	1453	46	65	75	81	164	1.4	5
74	97	105	138	1.2	43	298	77	418	77	65	75	81	121	1.3	8
75	90	98	130	1.2	0	0	0	0	0	64	71	75	85	1.1	0
76	76	83	172	1.6	0	0	0	0	0	64	71	75	85	1.1	0
77	92	103	161	1.4	0	0	0	0	0	64	71	75	85	1.1	0
78	133	144	198	1.3	56	814	83	953	83	66	76	82	158	1.3	8
79	88	98	140	1.3	0	0	0	0	0	64	71	75	85	1.1	0
80	102	114	170	1.4	231	0	355	586	355	62	73	81	122	1.4	11
81	81	87	157	1.4	31	584	102	717	102	68	83	98	158	1.4	10
82	83	92	131	1.3	156	1989	634	2779	634	71	93	106	160	1.4	14
83	90	100	138	1.3	15	385	185	585	185	69	86	98	146	1.3	7
84	60	68	103	1.4	141	1535	405	2081	405	68	83	96	205	1.6	15
85	110	120	166	1.3	259	1865	265	2389	265	68	83	94	146	1.3	14
86	75	82	115	1.3	214	1954	210	2378	210	69	89	103	162	1.4	12
87	122	138	208	1.4	85	263	466	814	466	72	95	106	158	1.4	7
88	92	101	136	1.3	54	562	253	869	253	68	84	96	149	1.3	6
89	90	98	137	1.3	14	241	166	421	166	67	82	91	120	1.3	7
90	118	130	184	1.3	99	897	590	1586	590	66	78	85	119	1.3	5

Grainsize distributions and sediment concentration

	Bedmaterial				Suspended load(concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
	(microns)				(ppm)				(ppm)	(microns)					(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
91	93	101	132	1.2	135	1260	277	1672	277	67	82	93	139	1.3	7
92	89	97	130	1.3	7	139	94	240	94	66	78	85	185	1.5	6
93	84	90	115	1.2	185	1929	472	2586	472	66	78	86	146	1.3	8
94	86	94	120	1.2	83	1046	300	1429	300	68	83	93	134	1.3	8
95	81	88	119	1.3	32	379	50	461	50	71	98	117	246	1.7	9
96	85	92	120	1.2	59	620	390	1069	390	69	86	98	143	1.3	8
97	86	94	129	1.3	21	547	297	865	297	73	96	106	154	1.3	9
98	85	93	122	1.2	0	0	73	73	73	66	79	86	149	1.4	5
99	87	96	130	1.3	0	0	0	0	0	64	71	75	85	1.1	0
100	87	98	140	1.3	207	1414	67	1688	67	65	75	81	169	1.3	7
101	95	107	155	1.3	0	0	94	94	94	66	79	86	148	1.4	4
102	91	100	143	1.3	395	1671	7713	9779	7713	65	72	77	105	1.1	8
103	76	80	103	1.2	47	574	78	699	78	67	82	96	158	1.4	10
104	94	105	154	1.3	0	0	0	0	0	64	71	75	85	1.1	0
105	88	98	134	1.3	0	0	0	0	0	64	71	75	85	1.1	0
106	84	90	118	1.2	40	579	59	678	59	68	85	100	156	1.4	7
107	108	127	214	1.5	121	1046	61	1228	61	67	82	94	227	1.6	4
108	92	105	161	1.4	63	610	97	770	97	65	75	80	122	1.3	5
109	81	86	128	1.3	0	0	0	0	0	64	71	75	85	1.1	0
110	75	80	106	1.2	16	789	80	885	80	65	75	81	129	1.3	6
111	81	87	122	1.3	0	0	0	0	0	64	71	75	85	1.1	0
112	79	84	108	1.2	22	269	42	333	42	66	78	85	150	1.4	7
113	87	96	131	1.3	0	0	0	0	0	64	71	75	85	1.1	0
114	78	83	124	1.3	349	2423	501	3273	501	62	73	80	128	1.3	8
115	82	88	121	1.3	75	263	1289	1627	1289	88	116	150	266	1.6	9
116	86	96	143	1.4	68	396	151	615	151	67	80	87	157	1.4	9
117	124	135	188	1.3	166	1266	52	1484	52	65	75	80	129	1.3	7
118	85	97	151	1.4	0	0	0	0	0	65	72	77	150	1.1	0
119	83	93	143	1.4	36	254	168	458	168	69	87	100	158	1.4	6
120	86	108	211	1.7	267	1915	231	2413	231	70	92	103	160	1.4	9
121	110	120	161	1.3	34	132	43	209	43	68	83	109	248	1.8	4
122	108	116	151	1.2	288	1634	223	2145	223	68	83	96	182	1.4	7
123	88	97	137	1.3	228	1407	158	1793	158	66	76	83	122	1.3	5
124	92	100	130	1.2	0	0	0	0	0	64	71	75	85	1.1	0
125	73	81	121	1.4	202	1611	113	1926	113	66	76	82	144	1.3	9
126	85	93	133	1.3	95	509	87	691	87	66	78	86	148	1.4	8
127	160	171	223	1.2	0	42	55	97	55	81	129	151	277	1.6	4
128	148	166	235	1.3	35	257	44	336	44	67	80	90	192	1.5	2
129	149	162	218	1.3	108	933	193	1234	193	68	83	98	162	1.5	8
130	152	163	216	1.2	2	60	50	112	50	72	99	116	243	1.6	5
131	158	169	221	1.2	33	171	328	532	328	76	132	154	232	1.6	8
132	143	154	205	1.2	117	1018	196	1331	196	73	99	114	165	1.4	5
133	148	158	203	1.2	78	326	84	488	84	71	105	130	166	1.5	3
134	164	176	241	1.3	41	153	378	572	378	102	134	148	213	1.3	9
135	166	184	259	1.3	11	84	175	270	175	88	110	124	174	1.3	7

Grainsize distributions and sediment concentration

	Bedmaterial				Suspended load(concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
		(microns)				(ppm)			(ppm)		(microns)				(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
136	163	179	258	1.3	33	104	150	287	150	75	107	126	167	1.4	6
137	153	168	237	1.3	144	945	245	1334	245	74	108	129	173	1.4	6
138	162	175	241	1.3	3	64	175	242	175	66	78	85	168	1.5	5
139	163	179	253	1.3	53	267	229	549	229	93	127	141	192	1.3	6
140	142	159	226	1.3	126	1164	264	1554	264	74	104	121	185	1.4	7
141	158	170	220	1.2	1	92	153	246	153	76	108	126	207	1.5	7
142	141	154	218	1.3	31	119	212	362	212	83	114	131	178	1.4	8
143	167	187	276	1.4	38	195	44	277	44	66	76	82	163	1.4	10
144	134	147	197	1.3	70	93	80	243	80	68	85	102	197	1.5	3
145	86	94	128	1.3	338	2912	121	3371	121	65	75	80	142	1.3	10
146	102	108	133	1.2	19	333	239	591	239	67	82	91	124	1.3	10
147	95	101	129	1.2	209	1446	272	1927	272	65	75	81	117	1.3	9
148	100	107	140	1.2	41	218	297	556	297	68	85	96	144	1.3	11
149	91	99	134	1.3	209	1627	344	2180	344	66	76	82	119	1.3	12
150	97	105	136	1.2	0	404	288	692	288	73	94	103	124	1.2	12
151	82	90	129	1.3	70	2094	214	2378	214	66	76	82	116	1.3	11
152	87	95	128	1.3	69	271	171	511	171	67	80	89	144	1.3	5
153	78	85	113	1.3	294	4512	391	5197	391	66	78	85	123	1.3	22
154	75	81	112	1.3	0	0	0	0	0	64	71	75	85	1.1	0
155	193	224	364	1.5	13	68	80	161	80	67	82	95	154	1.4	0
156	143	164	248	1.4	219	1519	55	1792	55	66	78	85	150	1.4	2
157	153	169	249	1.4	11	157	68	236	68	67	79	87	151	1.4	2
158	99	109	152	1.3	295	1497	178	1970	178	67	80	87	150	1.4	9
159	96	106	150	1.3	156	1839	218	2213	218	66	79	86	148	1.4	7
160	89	108	181	1.5	339	1601	92	2032	92	66	78	85	190	1.6	4
161	73	77	95	1.2	0	0	0	0	0	64	71	75	85	1.1	0
162	87	96	131	1.3	0	0	0	0	0	64	71	75	85	1.1	0
163	74	82	112	1.3	228	4228	86	4542	86	65	75	81	155	1.4	10
164	78	84	113	1.3	0	0	0	0	0	64	71	76	87	1.1	0
165	80	86	113	1.2	0	0	0	0	0	64	71	75	85	1.1	0
166	68	73	96	1.2	0	0	0	0	0	64	71	75	85	1.1	0
167	68	76	117	1.4	10	123	79	212	79	68	85	100	238	1.6	13
168	148	165	233	1.3	210	1182	113	1505	113	64	77	85	145	1.4	1
169	135	151	227	1.4	224	1607	93	1924	93	66	76	83	180	1.4	2
170	72	78	104	1.2	196	1592	120	1908	120	66	76	83	147	1.3	13
171	273	307	462	1.4	47	93	16	156	16	70	98	127	165	1.5	0
172	117	125	223	1.4	56	114	25	195	25	72	107	130	166	1.4	2
173	163	175	230	1.2	54	118	719	891	719	113	147	162	233	1.3	8
174	182	199	273	1.3	37	116	595	748	595	114	150	167	234	1.3	4
175	174	192	264	1.3	0	0	0	0	0	64	71	75	85	1.1	0
176	160	170	238	1.3	5	316	114	435	114	71	98	121	232	1.6	6
177	119	132	185	1.3	203	1225	558	1986	558	68	83	96	153	1.4	11
178	99	111	175	1.4	85	488	663	1236	663	79	107	123	172	1.4	18
179	125	139	195	1.3	30	200	189	419	189	68	85	105	161	1.5	8
180	152	169	248	1.3	9	122	169	300	169	73	104	123	228	1.6	9

Grainsize distributions and sediment concentration

	Bedmaterial				Suspended load(concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
	(microns)				(ppm)				(ppm)	(microns)					(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
181	167	185	265	1.3	28	0	95	123	95	79	121	137	173	1.4	2
182	115	130	197	1.4	67	360	74	501	74	69	90	113	163	1.4	3
183	131	144	199	1.3	163	1556	125	1844	125	66	76	82	170	1.4	6
184	124	141	225	1.4	0	0	0	0	0	64	71	75	85	1.1	0
185	[illegible]	74	97	1.2	0	0	0	0	0 *	60	60	61	61	1.0	0
186	84	90	113	1.2	74	243	144	461	144	67	82	96	158	1.4	8
187	144	157	210	1.3	0	0	0	0	0 *	60	60	60	61	1.0	0
188	139	150	197	1.2	0	0	0	0	0 *	60	60	60	61	1.0	0
189	149	158	197	1.2	0	0	0	0	0 *	60	60	61	61	1.0	0
190	78	83	104	1.2	0	0	0	0	0 *	60	60	61	61	1.0	0
191	105	112	141	1.2	0	0	0	0	0 *	60	60	60	61	1.0	0
192	121	135	210	1.4	0	0	0	0	0 *	60	60	61	61	1.0	0
193	159	169	211	1.2	0	0	0	0	0 *	59	60	60	61	1.0	0
194	117	124	159	1.2	0	0	0	0	0 *	60	60	61	61	1.0	0
195	123	135	192	1.3	0	0	0	0	0 *	59	60	60	61	1.0	0
196	87	94	120	1.2	0	0	0	0	0	64	71	75	85	1.1	0
197	64	72	106	1.4	0	0	0	0	0	64	71	75	85	1.1	0
198	87	95	137	1.3	0	0	0	0	0 *	60	61	61	61	1.0	0
199	84	92	126	1.3	0	0	0	0	0 *	59	60	60	61	1.0	0
200	85	92	122	1.2	0	0	0	0	0	64	71	75	85	1.1	0
201	79	86	117	1.3	0	0	0	0	0 *	60	61	61	61	1.0	0
202	85	93	125	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
203	70	75	101	1.3	0	0	0	0	0	64	71	75	85	1.1	0
204	132	154	262	1.5	0	0	0	0	0 *	59	60	60	61	1.0	0
205	108	131	231	1.6	0	0	0	0	0 *	59	60	60	61	1.0	0
206	83	89	118	1.2	0	0	0	0	0	64	71	75	85	1.1	0
207	80	99	191	1.7	0	0	0	0	0 *	60	60	61	61	1.0	0
208	76	80	103	1.2	0	0	0	0	0	64	71	75	85	1.1	0
209	81	91	132	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
210	83	87	133	1.3	0	0	0	0	0	64	71	75	85	1.1	0
211	62	70	108	1.4	0	0	0	0	0 *	60	60	61	61	1.0	0
212	102	111	155	1.3	0	0	0	0	0 *	59	60	60	61	1.0	0
213	89	96	136	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
214	132	145	193	1.2	156	225	88	469	88	67	80	88	154	1.4	6
215	99	114	167	1.3	0	0	0	0	0 *	60	60	60	61	1.0	0
216	90	97	132	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
217	81	86	117	1.2	0	0	0	0	0	64	71	75	85	1.1	0
218	106	113	144	1.2	0	0	0	0	0 *	59	60	60	61	1.0	0
219	177	192	252	1.2	0	0	0	0	0 *	59	60	60	61	1.0	0
220	76	88	137	1.4	0	0	0	0	0 *	60	60	60	61	1.0	0
221	98	107	149	1.3	0	0	0	0	0 *	59	60	60	61	1.0	0
222	95	104	154	1.4	0	0	0	0	0 *	60	60	61	61	1.0	0
223	97	108	158	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
224	136	154	234	1.4	0	0	0	0	0 *	60	60	60	61	1.0	0
225	73	85	135	1.4	0	0	0	0	0 *	60	60	61	61	1.0	0

Grainsize distributions and sediment concentration

	Bedmaterial				Suspended load(concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
		(microns)				(ppm)			(ppm)		(microns)				(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
226	136	149	208	1.3	0	0	0	0	0 *	60	60	60	61	1.0	0
227	109	121	172	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
228	145	160	230	1.3	0	0	0	0	0 *	60	60	60	61	1.0	0
229	120	129	163	1.2	0	0	0	0	0	64	71	75	85	1.1	0
230	85	94	130	1.3	0	0	0	0	0 *	59	60	60	61	1.0	0
231	203	220	286	1.2	0	0	0	0	0 *	60	60	60	61	1.0	0
232	117	125	181	1.3	0	0	0	0	0 *	60	60	61	61	1.0	0
233	180	198	277	1.3	0	0	0	0	0 *	59	60	60	61	1.0	0
234	64	74	127	1.5	0	0	0	0	0	67	81	89	117	1.3	0
235	120	130	176	1.3	0	0	0	0	0	223	626	868	583	1.8	0
236	146	159	206	1.2	0	0	0	0	0 *	60	60	60	61	1.0	0
237	90	96	120	1.2	174	322	608	1104	608	85	117	137	214	1.4	5
238	59	68	106	1.4	139	2262	162	2563	162	67	81	89	123	1.3	6
239	71	78	110	1.3	134	1531	160	1825	160	65	75	80	118	1.3	6
240	84	91	121	1.2	58	384	155	597	155	66	76	82	120	1.3	8
241	87	94	123	1.2	73	2236	524	2833	524	66	77	84	120	1.3	7
242	96	105	146	1.3	57	629	496	1182	496	65	75	80	120	1.3	6
243	98	105	131	1.2	93	1661	516	2270	516	68	84	95	125	1.3	7
244	89	96	124	1.2	66	300	145	511	145	69	87	100	188	1.5	4
245	89	96	123	1.2	51	295	135	481	135	70	90	101	153	1.3	8
246	88	96	129	1.3	728	2042	542	3312	542	67	80	87	154	1.4	9
247	89	96	123	1.2	131	2410	256	2797	256	70	91	101	141	1.3	6
248	93	101	131	1.2	45	362	153	560	153	70	90	101	147	1.3	6
249	82	89	119	1.3	62	344	220	626	220	66	78	85	120	1.3	6
250	80	87	117	1.3	0	0	0	0	0	68	85	95	119	1.3	0
251	85	93	125	1.3	124	552	487	1163	487	70	90	101	153	1.3	6
252	82	90	120	1.3	216	841	30	1087	30	67	81	92	187	1.5	6
253	72	81	119	1.3	132	2340	588	3060	588	67	80	88	144	1.3	5
254	82	90	122	1.3	69	369	113	551	113	70	90	101	149	1.3	6
255	76	82	106	1.2	0	0	0	0	0	92	103	110	144	1.2	0
256	79	88	121	1.3	151	1176	374	1701	374	67	82	94	156	1.4	6
257	114	123	164	1.3	59	379	90	528	90	75	97	107	183	1.4	3
258	86	97	144	1.4	78	375	124	577	124	67	81	90	138	1.3	5
259	76	84	116	1.3	422	1844	612	2878	612	68	83	94	144	1.3	7
260	82	88	118	1.3	77	586	352	1015	352	66	78	86	121	1.3	11
261	85	93	125	1.3	0	0	0	0	0	67	82	91	118	1.3	0
262	73	81	115	1.3	110	426	148	684	148	65	74	80	116	1.3	6
263	92	89	118	1.2	59	278	137	474	137	67	82	93	150	1.3	7
264	82	89	118	1.2	44	206	120	370	120	67	82	93	150	1.3	8
265	85	93	125	1.3	103	391	224	718	224	65	74	80	114	1.3	5
266	80	87	116	1.3	72	900	204	1176	204	68	83	93	133	1.3	12
267	87	94	122	1.2	184	537	228	949	228	65	73	79	113	1.2	8
268	61	67	94	1.3	282	1091	72	1445	72	69	86	96	121	1.3	3
269	86	94	126	1.3	623	2254	151	3028	151	67	81	90	122	1.3	9
270	79	84	108	1.2	62	435	172	669	172	66	78	85	152	1.4	11

Grainsize distributions and sediment concentration

	Bedmaterial				Suspended load(concentration)					Suspended Load (Grainsize distribution)					Computed Bedload
					(- - - - Sampled - - - - -)					(- - - - - - - - >62 - - - - - - -)					
	(microns)				(ppm)				(ppm)	(microns)					(ppm)
No.	D35	D50	D90	Sigma	<2	2-62	>62	Total	>62	D10	D35	D50	D90	Sigma	
271	82	90	126	1.3	90	418	166	674	166	75	96	105	141	1.2	9
272	139	157	227	1.3	111	509	398	1018	398	65	75	81	122	1.3	5
273	146	159	206	1.2	242	1997	495	2734	495	66	77	83	121	1.3	6
274	85	94	133	1.3	115	1578	571	2264	571	66	79	86	147	1.3	6
275	78	83	110	1.3	0	0	0	0	0	64	71	75	85	1.1	0
276	92	98	123	1.2	120	2465	484	3069	484	65	75	81	153	1.4	9
277	95	102	129	1.2	107	770	164	1041	164	69	88	99	144	1.3	9
278	64	71	104	1.3	61	278	137	476	137	66	76	82	121	1.3	4
279	57	64	94	1.3	61	373	108	542	108	65	74	79	112	1.2	3
280	84	92	126	1.3	192	577	211	980	211	65	74	79	117	1.3	9
281	89	96	122	1.2	166	977	19	1162	19	68	86	106	269	1.8	3
282	66	81	159	1.7	145	329	112	586	112	67	81	90	138	1.3	5
283	82	88	133	1.3	0	0	0	0	0	64	71	75	85	1.1	0
284	75	83	114	1.3	115	589	278	982	278	66	79	86	121	1.3	7
285	114	133	225	1.5	9	211	67	287	67	67	81	92	245	1.6	5
286	147	167	281	1.5	99	612	46	757	46	67	80	90	155	1.4	3
287	141	161	272	1.5	0	0	0	0	0	64	71	75	85	1.1	0
288	146	175	319	1.6	10	66	82	158	82	68	83	98	158	1.4	1
289	88	96	126	1.2	398	3188	63	3649	63	66	77	84	140	1.3	7
290	81	86	111	1.2	0	0	0	0	0	64	71	75	85	1.1	0
291	133	149	221	1.4	12	195	45	252	45	68	84	95	128	1.3	2
292	160	187	314	1.5	0	0	0	0	0	64	71	75	85	1.1	0

* Computed by linear interpolation,based on insufficient data.

Grainsize distributions and sediment concentration

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No.	62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
1	178	124	42	111	71	161	112	3.22	3.07	2.75	2.74	2.45	2.75	2.82
2	283	377	109	708	278	178	753	3.02	2.67	4.44	3.14	3.37	3.11	3.22
3	202	234	70	273	149	201	288	3.01	2.82	3.21	2.86	3.06	2.88	2.96
4	250	188	61	164	116	153	168	3.03	2.99	3.02	2.82	2.89	2.85	2.91
5	125	93	33	83	54	139	83	2.93	3.12	2.54	2.57	2.20	2.57	2.63
6	124	148	59	97	88	147	98	2.99	3.20	2.95	2.82	2.54	2.90	2.95
7	190	154	47	112	83	110	116	3.00	3.01	2.95	2.81	2.80	2.87	2.95
8	115	271	74	267	181	203	296	3.21	2.85	3.82	2.99	3.41	3.13	3.21
9	328	124	43	106	72	147	111	3.16	3.04	2.78	2.67	2.57	2.75	2.82
10	222	182	54	210	114	211	221	3.11	2.85	2.99	2.77	2.88	2.77	2.84
11	93	160	55	101	94	137	101	3.06	3.11	3.04	2.83	2.67	2.94	3.01
12	170	234	71	202	146	132	216	2.95	2.91	3.29	2.87	3.14	2.99	3.06
13	87	362	123	1938	290	429	2418	3.04	2.52	4.05	3.07	2.71	2.85	2.91
14	310	201	58	217	136	232	236	3.05	2.79	3.10	2.75	2.98	2.78	2.84
15	125	348	102	517	263	258	583	3.23	2.73	4.53	3.10	3.47	3.12	3.20
16	381	328	101	672	253	424	768	3.27	2.73	4.21	2.87	3.39	3.09	3.16
17	206	116	33	87	60	77	94	2.61	2.89	2.59	2.59	2.46	2.54	2.60
18	91	301	96	191	182	127	199	2.97	2.97	3.62	3.06	3.43	3.28	3.35
19	91	207	64	140	122	110	149	2.87	2.93	3.18	2.84	3.01	2.94	3.01
20	9	83	20	16	25	18	20	1.18	1.32	1.19	1.48	1.16	1.37	1.20
21	0	459	124	166	75	33	445	1.31	1.06	1.57	1.75	1.29	1.65	1.51
22	82	133	38	32	33	11	48	1.21	1.20	1.25	1.56	1.11	1.43	1.20
23	56	223	56	58	49	61	87	1.38	1.20	1.36	1.61	1.37	1.57	1.48
24	90	58	12	7	14	11	11	1.23	1.36	1.13	1.46	1.07	1.36	1.15
25	43	106	27	27	27	39	44	1.52	1.41	1.36	1.64	1.28	1.55	1.39
26	56	53	13	4	9	37	8	1.49	1.36	1.11	1.47	1.02	1.38	1.16
27	0	157	45	50	45	31	72	1.41	1.37	1.45	1.71	1.39	1.60	1.43
28	48	290	106	135	68	31	247	1.51	1.29	1.70	1.94	1.36	1.77	1.64
29	36	185	48	60	49	41	85	1.49	1.38	1.53	1.76	1.48	1.67	1.57
30	20	142	38	39	40	51	54	1.49	1.38	1.40	1.67	1.37	1.59	1.47
31	98	236	70	71	51	23	133	1.30	1.21	1.47	1.72	1.33	1.61	1.44
32	0	101	19	6	15	0	16	.85	.98	.98	1.30	.93	1.22	.99
33	0	189	61	56	42	9	95	1.21	1.20	1.39	1.69	1.19	1.54	1.34
34	95	165	55	46	38	12	82	1.21	1.17	1.31	1.61	1.09	1.47	1.22
35	46	117	35	30	35	99	41	1.44	1.18	1.16	1.45	1.14	1.37	1.21
36	71	172	48	45	41	45	75	1.34	1.17	1.28	1.55	1.25	1.46	1.30
37	36	217	68	36	33	13	97	1.31	1.14	1.36	1.71	1.13	1.59	1.42
38	119	295	104	139	50	19	412	1.29	1.11	1.49	1.76	1.08	1.61	1.44
39	45	115	34	8	17	12	20	1.27	1.13	1.13	1.53	1.00	1.44	1.19
40	249	184	57	42	28	2	119	1.06	1.05	1.22	1.57	.98	1.44	1.20
41	10	69	13	5	13	17	9	1.14	1.16	1.06	1.38	1.00	1.29	1.13
42	69	156	36	24	25	23	44	1.22	1.11	1.18	1.48	1.11	1.42	1.30
43	0	132	29	12	21	15	29	1.19	1.09	1.12	1.44	1.07	1.38	1.22
44	51	69	19	22	24	50	27	1.56	1.60	1.31	1.60	1.25	1.49	1.30
45	55	176	56	84	30	14	236	1.23	1.16	1.33	1.64	1.04	1.51	1.32

Measured, predicted concentration and
measured, predicted velocity

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No.	62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
46	93	88	27	9	18	55	18	1.27	1.08	1.00	1.32	.95	1.24	1.02
47	54	70	19	18	21	29	22	1.47	1.57	1.30	1.62	1.22	1.48	1.27
48	67	136	52	60	44	20	76	1.41	1.50	1.48	1.78	1.27	1.60	1.37
49	48	103	28	28	24	24	53	1.53	1.50	1.45	1.78	1.29	1.64	1.47
50	63	205	54	97	61	47	134	1.69	1.57	1.84	1.96	1.70	1.87	1.81
51	80	257	69	162	65	22	283	1.49	1.41	1.84	1.99	1.48	1.82	1.72
52	122	137	34	36	31	9	63	1.31	1.44	1.50	1.79	1.36	1.66	1.50
53	79	251	90	185	85	63	281	1.62	1.36	1.70	1.87	1.42	1.71	1.53
54	167	355	131	268	127	83	372	1.68	1.41	1.94	2.01	1.69	1.87	1.74
55	103	225	106	141	63	17	218	1.31	1.25	1.50	1.80	1.11	1.60	1.33
56	151	225	62	43	40	64	80	1.43	1.08	1.24	1.52	1.18	1.47	1.36
57	0	266	88	20	34	0	58	.75	.73	.94	1.27	.81	1.19	.89
58	255	392	143	215	76	21	517	1.23	1.07	1.55	1.78	1.19	1.63	1.42
59	78	169	35	20	19	54	75	1.65	1.31	1.32	1.68	1.23	1.67	1.60
60	69	79	24	10	24	21	13	1.20	1.24	1.07	1.38	1.03	1.28	1.02
61	217	163	54	122	87	113	127	2.59	2.62	2.55	2.55	2.42	2.49	2.54
62	188	142	45	114	75	121	122	2.66	2.59	2.46	2.51	2.35	2.43	2.48
63	399	208	65	160	109	132	177	2.74	2.52	2.74	2.66	2.61	2.61	2.68
64	364	195	67	130	104	110	134	2.53	2.54	2.58	2.58	2.46	2.51	2.56
65	359	210	67	153	109	122	163	2.64	2.48	2.68	2.62	2.55	2.56	2.63
66	439	248	78	179	127	114	195	2.61	2.44	2.80	2.69	2.66	2.63	2.70
67	541	235	72	148	115	90	162	2.51	2.42	2.75	2.66	2.62	2.60	2.67
68	455	262	86	174	131	139	194	2.70	2.36	2.75	2.67	2.61	2.62	2.70
69	539	372	133	309	197	179	343	2.62	2.18	2.85	2.68	2.66	2.61	2.68
70	67	251	82	63	56	21	111	1.28	1.14	1.42	1.69	1.28	1.57	1.37
71	0	115	30	59	36	31	86	1.59	1.58	1.57	1.82	1.39	1.67	1.51
72	52	109	25	38	30	32	56	1.64	1.59	1.56	1.81	1.46	1.69	1.59
73	46	95	22	29	25	39	46	1.62	1.54	1.45	1.71	1.37	1.62	1.49
74	77	148	42	66	42	61	113	1.79	1.54	1.65	1.88	1.49	1.75	1.64
75	0	186	45	56	37	54	111	1.66	1.33	1.51	1.79	1.33	1.69	1.61
76	0	221	72	98	47	15	211	1.19	1.15	1.43	1.68	1.12	1.52	1.30
77	0	398	112	125	68	36	286	1.40	1.13	1.21	1.80	1.36	1.70	1.61
78	83	170	44	70	51	82	102	1.92	1.50	1.72	1.91	1.64	1.85	1.80
79	0	254	58	81	46	20	199	1.37	1.23	1.56	1.78	1.34	1.67	1.54
80	355	215	80	179	91	122	216	1.93	1.63	1.89	2.01	1.68	1.85	1.75
81	102	218	73	153	64	139	290	1.86	1.46	1.78	1.94	1.43	1.80	1.70
82	634	223	82	166	78	87	235	1.69	1.38	1.67	1.86	1.39	1.69	1.52
83	185	151	52	59	44	16	84	1.30	1.32	1.40	1.68	1.22	1.53	1.30
84	405	361	176	256	75	102	726	1.51	1.04	1.50	1.74	.99	1.57	1.39
85	265	227	83	132	86	88	170	1.73	1.44	1.69	1.86	1.55	1.73	1.58
86	210	286	125	245	93	36	347	1.35	1.22	1.60	1.79	1.21	1.59	1.36
87	466	126	34	126	67	129	145	2.51	2.38	2.32	2.33	2.21	2.21	2.21
88	253	198	59	251	88	59	334	2.07	1.99	2.36	2.36	1.99	2.15	2.12
89	166	237	68	339	107	120	486	2.26	1.93	2.46	2.41	2.03	2.21	2.20
90	590	152	40	114	64	97	144	2.23	2.02	2.15	2.21	2.03	2.10	2.09

Measured, predicted concentration and
measured, predicted velocity

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No.	62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
91	277	189	57	210	83	114	294	2.24	1.94	2.28	2.30	1.96	2.12	2.09
92	94	129	32	104	45	41	154	1.85	1.85	1.94	2.11	1.68	1.91	1.83
93	472	197	58	257	86	147	374	2.25	1.90	2.30	2.31	1.88	2.10	2.08
94	300	232	72	363	103	152	532	2.32	1.93	2.45	2.44	1.94	2.21	2.22
95	50	249	82	466	119	210	692	2.36	1.90	2.54	2.43	1.93	2.20	2.19
96	290	228	67	346	100	108	512	2.21	1.91	2.42	2.40	1.93	2.17	2.16
97	297	263	82	479	123	152	700	2.34	1.94	2.64	2.49	2.01	2.26	2.27
98	73	157	46	69	42	12	103	1.32	1.36	1.50	1.77	1.26	1.60	1.41
99	0	172	45	61	38	20	123	1.45	1.33	1.51	1.79	1.29	1.65	1.50
100	67	202	52	108	52	29	155	1.55	1.42	1.70	1.89	1.46	1.75	1.64
101	94	141	38	34	31	12	63	1.26	1.26	1.34	1.64	1.22	1.52	1.32
102	713	284	92	185	87	52	299	1.66	1.40	1.85	1.96	1.57	1.82	1.71
103	78	129	47	25	29	24	42	1.27	1.13	1.18	1.52	.99	1.38	1.12
104	0	177	56	81	53	24	114	1.38	1.37	1.53	1.76	1.36	1.61	1.43
105	0	233	69	155	73	31	220	1.48	1.40	1.73	1.90	1.47	1.73	1.58
106	59	156	46	88	47	40	143	1.64	1.50	1.66	1.89	1.39	1.72	1.57
107	61	91	20	28	24	22	42	1.46	1.54	1.42	1.68	1.36	1.59	1.46
108	97	184	50	108	53	27	176	1.56	1.52	1.76	1.92	1.55	1.79	1.67
109	0	140	39	46	34	20	80	1.39	1.32	1.42	1.69	1.21	1.55	1.37
110	00	93	24	14	16	15	34	1.33	1.28	1.23	1.59	1.05	1.46	1.24
111	0	97	25	30	23	37	50	1.56	1.49	1.43	1.74	1.24	1.60	1.44
112	42	77	20	16	18	34	27	1.49	1.44	1.30	1.65	1.14	1.50	1.29
113	0	106	20	18	18	6	40	1.27	1.32	1.31	1.63	1.17	1.53	1.38
114	501	204	64	91	50	28	172	1.41	1.25	1.51	1.75	1.23	1.60	1.42
115	1289	178	57	90	49	27	150	1.48	1.36	1.57	1.82	1.28	1.65	1.47
116	151	181	50	70	45	27	123	1.40	1.27	1.45	1.71	1.27	1.58	1.40
117	52	303	86	309	175	109	347	2.56	2.34	3.29	2.73	2.84	2.67	2.75
118	0	313	87	912	175	63	1189	2.39	2.21	3.76	2.74	2.46	2.56	2.63
119	168	436	118	1473	202	59	2369	2.30	2.09	3.87	2.92	2.37	2.72	2.82
120	231	358	94	937	179	177	1379	2.68	2.20	3.96	2.77	2.75	2.75	2.88
121	43	148	34	115	58	51	158	2.18	2.17	2.36	2.37	2.17	2.24	2.27
122	223	166	42	163	79	138	209	2.61	2.23	2.50	2.43	2.32	2.32	2.38
123	158	134	28	145	54	97	221	2.30	2.13	2.29	2.31	2.04	2.15	2.16
124	0	198	63	69	48	25	119	1.43	1.27	1.49	1.75	1.29	1.61	1.44
125	113	236	74	141	54	37	305	1.52	1.27	1.61	1.83	1.26	1.67	1.54
126	87	209	62	54	44	23	111	1.27	1.09	1.30	1.58	1.14	1.47	1.26
127	55	187	45	107	80	45	122	2.19	2.35	2.62	2.56	2.48	2.45	2.53
128	44	49	9	21	17	27	25	1.95	2.33	1.76	2.00	1.67	1.90	1.88
129	193	149	46	117	81	109	127	2.28	2.24	2.20	2.25	2.10	2.12	2.08
130	50	235	73	153	105	41	166	1.86	2.13	2.38	2.41	2.18	2.22	2.18
131	328	188	59	134	103	96	139	2.26	2.24	2.36	2.32	2.24	2.22	2.21
132	196	217	60	139	106	59	150	2.08	2.21	2.52	2.42	2.38	2.31	2.33
133	84	206	60	137	103	62	150	2.07	2.19	2.42	2.38	2.28	2.25	2.23
134	378	275	93	187	152	99	194	2.15	2.21	2.52	2.40	2.39	2.31	2.30
135	175	174	58	123	92	85	130	2.10	2.21	2.17	2.24	2.08	2.11	2.05

Measured, predicted concentration and
measured, predicted velocity

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No.	62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
136	150	205	65	142	104	87	157	2.17	2.17	2.33	2.33	2.22	2.22	2.19
137	245	235	73	158	121	86	168	2.15	2.14	2.44	2.36	2.32	2.27	2.27
138	175	163	49	99	74	55	112	2.03	2.13	2.15	2.26	2.04	2.12	2.08
139	229	219	68	141	109	82	149	2.14	2.15	2.38	2.34	2.27	2.25	2.25
140	264	173	50	108	80	62	119	1.92	1.99	2.09	2.14	1.99	2.03	1.98
141	153	181	58	109	79	59	120	2.00	1.99	2.09	2.22	1.97	2.07	2.02
142	212	162	50	109	75	73	125	2.02	1.98	2.03	2.15	1.92	2.01	1.94
143	44	195	63	129	96	103	134	2.17	2.05	2.20	2.22	2.10	2.15	2.13
144	80	128	31	45	41	23	57	1.55	1.67	1.68	1.88	1.61	1.77	1.68
145	121	165	50	38	38	25	61	1.28	1.10	1.23	1.52	1.10	1.41	1.20
146	239	151	52	82	54	80	113	1.80	1.58	1.67	1.90	1.49	1.73	1.58
147	272	154	51	90	56	66	125	1.75	1.56	1.67	1.88	1.49	1.71	1.56
148	297	234	84	168	87	73	235	1.82	1.55	1.89	2.04	1.62	1.86	1.74
149	344	266	87	241	106	100	345	1.90	1.54	1.98	2.06	1.67	1.88	1.77
150	288	451	173	380	147	66	603	1.73	1.39	2.12	2.16	1.66	1.97	1.87
151	214	500	180	634	169	76	1072	1.74	1.37	2.21	2.17	1.63	1.99	1.88
152	171	192	62	50	46	8	78	1.09	1.08	1.25	1.54	1.09	1.40	1.15
153	391	346	177	230	110	92	364	1.51	1.10	1.52	1.73	1.17	1.55	1.31
154	0	201	72	40	39	15	85	1.14	.98	1.17	1.48	.97	1.36	1.11
155	86	239	56	78	68	54	96	2.10	2.07	2.42	2.38	2.29	2.45	2.56
156	55	191	40	85	57	66	120	2.21	2.00	2.23	2.25	2.13	2.27	2.37
157	68	221	50	93	71	57	121	2.11	1.97	2.32	2.29	2.21	2.30	2.38
158	178	248	78	210	96	84	291	1.96	1.67	2.10	2.14	1.84	2.00	1.94
159	218	162	54	87	57	36	112	1.54	1.48	1.59	1.80	1.43	1.65	1.48
160	92	183	38	24	23	9	70	1.13	1.08	1.20	1.50	1.11	1.45	1.30
161	0	257	79	46	35	13	148	1.22	1.00	1.27	1.60	.99	1.48	1.29
162	0	179	48	78	45	19	132	1.39	1.34	1.55	1.79	1.33	1.64	1.48
163	86	192	64	108	52	47	182	1.54	1.31	1.55	1.79	1.26	1.63	1.47
164	0	151	42	35	31	18	70	1.29	1.15	1.27	1.56	1.09	1.44	1.24
165	0	173	53	45	35	37	95	1.44	1.19	1.36	1.66	1.13	1.54	1.35
166	0	209	73	53	37	6	132	1.08	.99	1.22	1.53	.94	1.39	1.14
167	79	398	207	670	96	25	1443	1.34	1.15	1.73	1.95	1.02	1.69	1.49
168	113	97	22	18	25	20	24	1.25	1.29	1.23	1.50	1.19	1.43	1.29
169	93	98	21	28	29	22	38	1.46	1.61	1.50	1.74	1.45	1.65	1.55
170	120	399	165	316	105	66	655	1.57	1.15	1.72	1.88	1.24	1.70	1.53
171	16	57	16	26	23	59	27	1.72	1.96	1.53	1.80	1.33	1.70	1.61
172	25	115	33	44	40	30	53	1.50	1.63	1.52	1.73	1.45	1.64	1.48
173	719	135	43	68	58	72	76	1.83	1.77	1.71	1.91	1.65	1.79	1.69
174	595	171	49	69	64	45	74	1.74	1.81	1.89	2.05	1.83	1.95	1.90
175	0	157	43	58	57	36	65	1.61	1.75	1.79	1.96	1.74	1.87	1.79
176	114	251	77	117	100	66	130	1.82	1.75	2.08	2.14	1.98	2.04	1.98
177	558	211	73	142	90	74	169	1.81	1.66	1.87	2.00	1.74	1.85	1.73
178	663	300	141	218	114	88	276	1.60	1.32	1.67	1.85	1.43	1.68	1.48
179	189	221	86	105	85	70	128	1.53	1.36	1.53	1.75	1.46	1.61	1.42
180	169	186	64	75	70	77	89	1.59	1.42	1.52	1.75	1.50	1.64	1.49

Measured, predicted concentration and
measured, predicted velocity

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No. >	62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
181	95	159	44	39	46	35	46	1.36	1.31	1.38	1.64	1.37	1.56	1.42
182	74	194	56	54	52	24	71	1.25	1.22	1.38	1.62	1.33	1.52	1.35
183	125	100	24	47	35	73	59	1.96	1.80	1.67	1.88	1.61	1.79	1.74
184	0	116	28	57	39	68	74	1.92	1.79	1.73	1.92	1.66	1.84	1.79
185	0	303	96	91	43	1	287	.99	.95	1.31	1.60	.96	1.45	1.21
186	144	262	83	124	69	30	201	1.40	1.21	1.57	1.78	1.30	1.62	1.45
187	0	152	37	31	37	27	41	1.35	1.28	1.35	1.62	1.33	1.54	1.43
188	0	172	44	29	37	23	47	1.32	1.20	1.32	1.62	1.28	1.54	1.38
189	0	162	42	108	73	55	128	2.27	2.31	2.46	2.47	2.31	2.33	2.36
190	0	316	97	865	174	54	1153	2.16	2.07	3.54	2.70	2.12	2.40	2.43
191	0	172	57	200	82	69	230	2.12	2.13	2.30	2.38	1.94	2.13	2.09
192	0	229	69	248	109	86	310	2.30	2.17	2.60	2.53	2.31	2.36	2.39
193	0	155	42	94	72	55	106	2.15	2.24	2.30	2.36	2.19	2.22	2.22
194	0	131	34	92	61	54	107	2.02	2.10	2.10	2.16	1.98	2.02	1.97
195	0	194	59	183	92	72	214	2.19	2.15	2.41	2.42	2.17	2.24	2.23
196	0	213	76	133	77	74	175	1.63	1.35	1.60	1.80	1.38	1.63	1.45
197	0	481	253	2400	260	370	3688	2.29	1.61	3.16	2.47	1.55	2.16	2.10
198	0	298	102	410	140	183	562	2.16	1.69	2.26	2.24	1.85	2.05	1.98
199	0	308	100	382	119	92	577	1.97	1.60	2.21	2.21	1.75	2.03	1.97
200	0	274	90	278	106	112	411	1.94	1.54	2.03	2.10	1.67	1.91	1.82
201	0	324	106	392	110	61	651	1.83	1.50	2.13	2.17	1.62	1.97	1.90
202	0	311	100	318	112	104	489	1.96	1.53	2.11	2.15	1.69	1.98	1.92
203	0	296	124	438	107	44	637	1.56	1.39	1.89	2.01	1.33	1.77	1.59
204	0	74	17	20	22	25	26	1.49	1.61	1.37	1.68	1.32	1.57	1.42
205	0	163	48	69	48	22	99	1.34	1.42	1.52	1.77	1.41	1.63	1.45
206	0	150	43	63	43	22	99	1.40	1.35	1.46	1.71	1.27	1.56	1.36
207	0	207	70	73	43	23	142	1.21	1.09	1.28	1.58	1.10	1.46	1.25
208	0	316	119	355	106	53	606	1.71	1.40	1.98	2.09	1.43	1.85	1.72
209	0	390	118	293	94	117	671	1.89	1.34	1.94	2.04	1.52	1.92	1.89
210	0	189	62	124	64	41	177	1.58	1.45	1.69	1.87	1.40	1.69	1.53
211	0	309	133	429	74	55	1210	1.60	1.25	1.75	1.96	1.12	1.74	1.59
212	0	322	106	372	139	132	514	2.28	1.84	2.54	2.45	2.12	2.28	2.31
213	0	352	102	507	159	99	727	2.20	1.81	2.85	2.47	2.11	2.29	2.31
214	88	246	69	167	110	109	202	2.26	1.95	2.39	2.31	2.25	2.25	2.28
215	0	330	95	378	142	105	532	2.26	1.88	2.63	2.44	2.30	2.35	2.41
216	0	351	110	522	173	125	707	2.24	1.82	2.80	2.46	2.10	2.27	2.26
217	0	378	137	756	195	144	1038	2.22	1.77	3.03	2.47	1.94	2.23	2.21
218	0	267	83	226	105	48	298	1.88	1.78	2.29	2.30	1.94	2.11	2.06
219	0	136	38	61	54	48	71	1.86	1.91	1.86	2.06	1.80	1.94	1.88
220	0	400	168	1341	187	96	1869	2.02	1.68	2.73	2.40	1.72	2.14	2.06
221	0	240	96	254	95	49	326	1.78	1.69	2.05	2.18	1.63	1.95	1.83
222	0	187	63	164	82	64	201	1.81	1.72	1.92	2.02	1.70	1.84	1.72
223	0	186	61	160	80	51	196	1.77	1.73	1.92	2.02	1.72	1.85	1.73
224	0	146	44	78	57	48	92	1.76	1.78	1.78	1.98	1.69	1.84	1.74
225	0	292	108	772	116	51	1136	1.75	1.62	2.19	2.23	1.58	1.98	1.87

Measured, predicted concentration and
measured, predicted velocity

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No.	> 62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
226	0	129	34	49	43	20	58	1.54	1.73	1.71	1.94	1.61	1.79	1.68
227	0	169	49	101	61	49	134	1.79	1.69	1.86	2.00	1.71	1.87	1.78
228	0	111	28	38	36	25	48	1.60	1.73	1.63	1.89	1.57	1.77	1.66
229	0	165	43	191	101	164	219	2.97	2.56	2.81	2.61	2.68	2.53	2.60
230	0	179	55	434	109	220	541	2.69	2.37	2.85	2.61	2.22	2.34	2.37
231	0	96	28	71	51	87	74	2.56	2.67	2.27	2.36	2.14	2.28	2.29
232	0	153	43	187	95	190	218	2.91	2.49	2.63	2.49	2.50	2.39	2.43
233	0	79	20	57	38	80	64	2.53	2.60	2.14	2.29	2.04	2.19	2.19
234	0	265	89	280	60	14	599	1.21	1.18	1.59	1.78	1.15	1.60	1.40
235	0	101	28	21	29	28	28	1.27	1.21	1.16	1.45	1.12	1.35	1.16
236	0	272	60	39	42	35	49	1.41	1.17	1.39	1.68	1.37	1.64	1.64
237	608	233	65	61	49	19	112	1.26	1.11	1.37	1.63	1.19	1.51	1.32
238	162	481	212	742	103	56	2347	1.53	1.12	1.80	1.94	1.08	1.74	1.60
239	160	408	151	315	90	50	783	1.52	1.16	1.73	1.90	1.23	1.73	1.59
240	155	387	126	595	160	64	855	1.92	1.65	2.62	2.36	1.87	2.15	2.11
241	524	196	57	184	78	89	257	1.95	1.69	2.00	2.09	1.71	1.91	1.83
242	496	137	40	85	45	39	124	1.75	1.71	1.79	2.01	1.57	1.83	1.72
243	516	157	45	108	58	86	149	1.98	1.75	1.91	2.05	1.72	1.90	1.83
244	145	150	40	79	40	20	140	1.62	1.58	1.74	1.99	1.45	1.81	1.69
245	135	181	58	130	58	108	213	1.97	1.62	1.87	2.07	1.54	1.88	1.79
246	542	290	93	332	116	142	495	2.12	1.64	2.21	2.23	1.80	2.05	2.01
247	256	175	47	111	58	42	164	1.72	1.57	1.80	1.97	1.55	1.80	1.69
248	153	186	52	118	59	57	182	1.86	1.63	1.90	2.04	1.66	1.89	1.83
249	220	192	65	158	51	60	310	1.84	1.58	1.89	2.13	1.40	1.91	1.83
250	0	203	57	159	61	63	277	1.82	1.56	1.90	2.05	1.55	1.87	1.80
251	487	178	47	123	57	67	181	1.83	1.58	1.83	1.98	1.58	1.83	1.76
252	30	196	59	66	46	26	120	1.35	1.18	1.39	1.65	1.19	1.52	1.33
253	588	238	73	120	52	26	271	1.38	1.19	1.52	1.75	1.20	1.60	1.43
254	113	179	56	56	43	27	101	1.35	1.17	1.34	1.62	1.16	1.49	1.28
255	0	282	105	160	68	46	336	1.52	1.20	1.60	1.83	1.22	1.66	1.49
256	374	166	48	16	24	15	43	1.15	.95	1.06	1.40	.93	1.32	1.10
257	90	87	20	27	25	14	38	1.52	1.70	1.54	1.83	1.44	1.69	1.56
258	124	156	44	115	46	16	174	1.48	1.58	1.74	1.97	1.43	1.77	1.63
259	612	220	78	208	76	77	330	1.73	1.45	1.79	1.95	1.42	1.76	1.61
260	352	221	79	178	71	78	288	1.79	1.48	1.83	2.01	1.43	1.82	1.69
261	0	637	113	139	58	16	486	1.33	1.14	1.80	1.93	1.40	1.87	1.93
262	148	223	77	156	53	118	361	1.81	1.39	1.73	1.97	1.30	1.79	1.70
263	137	308	107	264	80	57	540	1.78	1.41	1.95	2.12	1.42	1.92	1.85
264	120	371	135	389	102	127	824	2.02	1.46	2.12	2.24	1.50	2.03	2.02
265	224	139	41	51	32	28	103	1.56	1.43	1.53	1.85	1.26	1.68	1.52
266	204	218	73	150	66	116	255	1.83	1.42	1.74	1.93	1.42	1.76	1.65
267	228	235	70	153	71	73	250	1.79	1.45	1.81	1.97	1.52	1.81	1.72
268	72	352	156	734	108	120	1574	1.83	1.36	2.02	2.12	1.24	1.87	1.78
269	151	231	75	156	74	88	240	1.77	1.41	1.74	1.92	1.47	1.76	1.64
270	172	295	116	172	82	37	275	1.41	1.17	1.58	1.79	1.22	1.61	1.41

Measured, predicted concentration and
measured, predicted velocity

	Concentration (ppm)							Velocity (ft/s)						
	(Measured)	(- - - - - - - - - Predicted - - - - - - - - - -)						(Measured)	(- - - - - - - Predicted - - - - - - - - -)					
No.	62 Microns	EH	YG	AW	KK	VR	HDC		Lacey	EH	AW	KK	VR	HDC
271	166	344	133	256	104	62	395	1.54	1.22	1.70	1.86	1.35	1.69	1.53
272	398	153	38	130	80	114	154	2.70	2.53	2.67	2.53	2.57	2.50	2.58
273	495	247	62	186	138	110	214	2.80	2.57	3.20	2.80	3.04	2.84	2.93
274	571	258	70	678	161	260	950	2.93	2.36	3.84	2.81	2.59	2.62	2.70
275	0	145	47	23	23	14	63	1.32	1.18	1.28	1.66	1.01	1.51	1.29
276	484	223	71	232	97	172	321	2.21	1.74	2.13	2.20	1.80	2.01	1.95
277	164	249	85	229	104	79	295	1.95	1.66	2.10	2.15	1.79	1.97	1.89
278	137	375	156	648	78	28	2135	1.53	1.26	1.89	2.09	1.09	1.84	1.72
279	108	482	269	2377	127	62	7684	1.76	1.29	2.39	2.28	.99	1.95	1.86
280	211	344	101	264	99	188	497	2.08	1.44	2.00	2.07	1.64	1.96	1.95
281	19	149	33	42	34	12	65	1.30	1.30	1.42	1.68	1.27	1.56	1.41
282	112	116	33	74	23	7	172	1.27	1.38	1.42	1.73	1.11	1.57	1.37
283	0	98	23	9	13	16	29	1.33	1.24	1.19	1.57	1.03	1.47	1.27
284	278	249	77	82	46	78	208	1.58	1.17	1.45	1.72	1.18	1.61	1.49
285	67	157	44	55	47	25	75	1.32	1.37	1.45	1.69	1.39	1.57	1.40
286	46	164	50	66	56	73	87	1.66	1.49	1.56	1.79	1.53	1.69	1.57
287	0	76	18	19	23	40	26	1.44	1.44	1.26	1.55	1.21	1.45	1.30
288	82	121	33	38	39	38	49	1.40	1.46	1.40	1.67	1.39	1.56	1.41
289	63	228	73	124	65	25	193	1.42	1.33	1.63	1.85	1.36	1.67	1.49
290	0	227	80	134	66	30	224	1.46	1.30	1.62	1.84	1.29	1.65	1.46
291	45	81	17	14	18	27	23	1.38	1.35	1.22	1.52	1.16	1.45	1.32
292	0	126	27	25	28	25	40	1.38	1.41	1.39	1.67	1.36	1.61	1.51

Measured, predicted concentration and
measured, predicted velocity

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted - - - - -) Top width Lacey	Top width HDC	Bed width HDC	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width	Bed width HDC
1	153.00	132.08	170.64	170.81	152.01	2.55	1.12	1.12		1.15
2	174.00	130.75	181.88	181.15	163.29	2.55	1.05	1.04		1.25
3	171.67	145.63	171.82	170.91	154.54	2.55	1.00	1.00		1.06
4	183.00	160.21	176.97	175.76	159.55	2.55	.97	.96		1.00
5	184.00	162.23	182.41	182.09	163.18	2.55	.99	.99		1.01
6	182.00	169.49	183.94	182.64	165.91	2.55	1.01	1.00		.98
7	151.00	128.75	174.65	174.84	155.58	2.55	1.16	1.16		1.21
8	151.00	134.68	186.41	186.21	166.60	2.55	1.23	1.23		1.24
9	150.00	135.93	179.50	180.06	159.41	2.55	1.20	1.20		1.17
10	166.00	137.75	173.42	173.20	155.03	2.55	1.04	1.04		1.13
11	166.00	148.15	183.04	182.45	164.13	2.55	1.10	1.10		1.11
12	166.00	153.54	176.77	175.67	159.22	2.55	1.06	1.06		1.04
13	165.33	150.71	174.07	173.32	156.34	2.55	1.05	1.05		1.04
14	168.33	152.65	178.70	178.19	160.15	2.55	1.06	1.06		1.05
15	158.00	141.15	182.68	181.98	163.95	2.55	1.16	1.15		1.16
16	157.00	145.65	175.36	174.37	157.82	2.55	1.12	1.11		1.08
17	163.00	148.41	162.51	162.22	145.39	2.55	1.00	1.00		.98
18	163.00	148.25	177.10	175.60	160.09	2.55	1.09	1.08		1.08
19	162.00	151.29	174.54	173.62	157.00	2.55	1.08	1.07		1.04
20	23.50	19.73	18.62	19.27	15.75	2.55	.79	.82		.80
21	9.00	7.73	12.81	13.70	10.26	2.55	1.42	1.52		1.33
22	23.00	18.66	18.81	19.53	15.80	2.55	.82	.85		.85
23	11.50	8.24	13.87	14.77	11.19	2.55	1.21	1.28		1.36
24	26.00	24.70	22.79	23.69	19.13	2.55	.88	.91		.77
25	25.00	22.60	27.18	28.40	22.61	2.55	1.09	1.14		1.00
26	25.80	23.59	25.99	27.41	21.31	2.55	1.01	1.06		.90
27	23.40	21.38	22.73	23.47	19.29	2.55	.97	1.00		.90
28	19.50	15.29	21.99	22.91	18.38	2.55	1.13	1.17		1.20
29	21.00	16.22	23.09	24.10	19.25	2.55	1.10	1.15		1.19
30	18.00	16.24	20.34	21.24	16.95	2.55	1.13	1.18		1.04
31	15.00	13.47	16.94	17.72	14.07	2.55	1.13	1.18		1.04
32	9.60	8.42	9.46	10.15	7.52	2.55	.99	1.06		.89
33	19.83	14.95	17.99	18.75	15.03	2.55	.91	.95		1.01
34	19.50	17.80	17.88	18.61	14.97	2.55	.92	.95		.84
35	12.50	10.32	12.85	13.61	10.45	2.55	1.03	1.09		1.01
36	14.00	11.73	15.14	15.99	12.37	2.55	1.08	1.14		1.05
37	13.00	9.05	15.43	16.50	12.35	2.55	1.19	1.27		1.36
38	13.50	9.98	15.89	16.90	12.84	2.55	1.18	1.25		1.29
39	13.00	10.82	14.46	15.47	11.57	2.55	1.11	1.19		1.07
40	13.17	9.85	13.00	13.81	10.53	2.55	.99	1.05		1.07
41	12.00	8.47	12.11	13.04	9.59	2.55	1.01	1.09		1.13
42	13.50	6.43	13.80	14.99	10.75	2.55	1.02	1.11		1.67
43	10.50	7.75	12.28	13.30	9.61	2.55	1.17	1.27		1.24
44	50.50	48.09	38.48	39.24	33.31	2.55	.76	.78		.69
45	18.00	12.44	18.16	19.24	14.78	2.55	1.01	1.07		1.19

Measured, predicted width and ratios
predicted/measured width.

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted Top width Lacey	Top width HDC	- - - - -) Bed width HDC	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width HDC
46	14.00	11.82	12.78	13.59	10.33	2.55	.91	.97	.87
47	54.00	48.38	38.55	39.29	33.40	2.55	.71	.73	.69
48	53.00	47.23	34.78	35.12	30.57	2.55	.66	.66	.65
49	32.50	29.27	34.75	36.10	29.20	2.55	1.07	1.11	1.00
50	33.00	25.49	36.97	38.20	31.33	2.55	1.12	1.16	1.23
51	27.50	21.24	30.59	31.73	25.76	2.55	1.11	1.15	1.21
52	27.60	24.67	28.58	29.57	24.16	2.55	1.04	1.07	.98
53	27.00	25.87	26.80	27.51	22.96	2.55	.99	1.02	.89
54	27.00	24.75	27.94	28.57	24.08	2.55	1.03	1.06	.97
55	28.00	25.54	21.76	22.22	18.78	2.55	.78	.79	.74
56	10.00	6.03	12.30	13.40	9.53	2.55	1.23	1.34	1.58
57	5.00	3.41	4.24	4.62	3.30	2.55	.85	.92	.97
58	11.50	10.24	13.32	13.99	10.99	2.55	1.16	1.22	1.07
59	11.50	10.41	21.36	23.32	16.50	2.55	1.86	2.03	1.59
60	28.00	25.16	17.24	17.64	14.03	2.55	.62	.63	.59
61	128.00	114.49	118.35	117.92	106.19	2.55	.92	.92	.93
62	120.00	108.27	118.77	118.79	105.95	2.55	.99	.99	.98
63	101.00	91.71	111.89	112.1[illegible]	99.56	2.55	1.11	1.11	1.09
64	120.00	107.01	106.75	105.[illegible]	96.04	2.55	.89	.88	.90
65	102.00	88.00	104.80	104.85	93.43	2.55	1.03	1.03	1.06
66	97.00	85.45	102.67	102.69	91.58	2.55	1.06	1.06	1.07
67	94.00	83.81	100.60	100.69	89.63	2.55	1.07	1.07	1.07
68	76.00	69.90	89.47	89.84	79.33	2.55	1.18	1.18	1.14
69	72.00	63.98	76.82	76.88	68.47	2.55	1.07	1.07	1.07
70	13.50	11.53	14.46	15.17	11.96	2.55	1.07	1.12	1.04
71	46.80	41.53	42.62	43.68	36.60	2.55	.91	.93	.88
72	36.50	30.53	40.45	42.05	33.96	2.55	1.11	1.15	1.11
73	31.00	28.79	36.17	37.74	30.17	2.55	1.17	1.22	1.05
74	30.00	28.66	37.41	38.88	31.40	2.55	1.25	1.30	1.10
75	19.80	13.23	25.32	27.00	20.37	2.55	1.28	1.36	1.54
76	17.00	16.26	17.73	18.52	14.77	2.55	1.04	1.09	.91
77	11.00	8.31	15.22	16.26	12.21	2.55	1.38	1.48	1.47
78	26.20	23.19	35.62	37.18	29.70	2.55	1.36	1.42	1.28
79	14.40	13.03	19.99	21.18	16.25	2.55	1.39	1.47	1.25
80	48.00	39.31	42.76	43.47	37.20	2.55	.89	.91	.95
81	28.00	25.06	35.16	36.60	29.45	2.55	1.26	1.31	1.18
82	31.00	26.34	28.99	29.80	24.77	2.55	.94	.96	.94
83	30.50	27.04	24.17	24.79	20.73	2.55	.79	.81	.77
84	12.00	8.75	14.46	15.48	11.55	2.55	1.20	1.29	1.32
85	30.00	27.14	28.63	29.31	24.61	2.55	.95	.98	.91
86	27.00	23.34	21.33	21.83	18.37	2.55	.79	.81	.79
87	124.00	111.08	121.61	122.30	107.57	2.55	.98	.99	.97
88	82.00	72.94	83.19	84.02	73.09	2.55	1.01	1.02	1.00
89	66.00	59.71	77.15	78.35	67.20	2.55	1.17	1.19	1.13
90	67.00	58.11	76.78	78.25	66.51	2.55	1.15	1.17	1.14

Measured, predicted width and ratios
predicted/measured width.

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted Top width Lacey	Top width HDC	Bed width HDC - - - - -)	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width	Bed width HDC
91	67.00	60.92	77.09	78.45	66.95	2.55	1.15	1.17		1.10
92	66.00	59.69	68.28	69.62	59.12	2.55	1.03	1.05		.99
93	67.00	59.26	76.95	78.41	66.67	2.55	1.15	1.17		1.13
94	67.00	57.23	78.70	80.10	68.33	2.55	1.17	1.20		1.19
95	66.00	59.68	77.78	79.06	67.66	2.55	1.18	1.20		1.13
96	66.00	58.97	76.57	77.86	66.57	2.55	1.16	1.18		1.13
97	67.00	59.34	79.15	80.35	68.[illegible]9	2.55	1.18	1.20		1.16
98	33.00	25.72	27.97	28.71	23.75	2.55	.84	.87		.92
99	22.00	18.65	25.41	26.63	21.04	2.55	1.16	1.21		1.13
100	26.00	22.51	30.54	31.77	25.60	2.55	1.17	1.22		1.14
101	19.50	17.65	20.55	21.52	17.05	2.55	1.05	1.10		.97
102	24.50	21.87	28.83	29.84	24.36	2.55	1.18	1.22		1.11
103	20.00	16.82	17.00	17.79	14.12	2.55	.85	.89		.84
104	30.00	26.36	26.34	27.04	22.55	2.55	.88	.90		.86
105	32.00	26.47	29.53	30.29	25.32	2.55	.92	.95		.96
106	36.50	33.44	37.93	39.08	32.30	2.55	1.04	1.07		.97
107	33.00	30.03	34.46	35.73	29.03	2.55	1.04	1.08		.97
108	33.00	30.01	36.39	37.50	30.98	2.55	1.10	1.14		1.03
109	26.50	21.38	26.00	27.14	21.68	2.55	.98	1.02		1.01
110	23.00	20.04	24.54	25.94	20.03	2.55	1.07	1.13		1.00
111	39.50	29.08	37.44	38.96	31.36	2.55	.95	.99		1.08
112	38.00	32.20	34.81	36.21	29.20	2.55	.92	.95		.91
113	23.00	16.40	25.09	26.63	20.34	2.55	1.09	1.16		1.24
114	21.00	17.83	22.62	23.67	18.78	2.55	1.08	1.13		1.05
115	29.00	24.73	28.62	29.61	24.20	2.55	.99	1.02		.98
116	21.00	17.65	22.03	23.03	18.32	2.55	1.05	1.10		1.04
117	109.00	91.68	116.72	116.86	103.95	2.55	1.07	1.07		1.13
118	109.00	91.91	116.38	116.74	103.34	2.55	1.07	1.07		1.12
119	76.00	64.62	99.83	100.87	87.65	2.55	1.31	1.33		1.36
120	78.00	61.17	109.32	111.05	95.20	2.55	1.40	1.42		1.56
121	81.00	70.28	98.90	100.71	85.79	2.55	1.22	1.24		1.22
122	85.00	70.74	108.09	110.18	93.61	2.55	1.27	1.30		1.32
123	81.00	72.39	103.29	105.68	88.94	2.55	1.28	1.30		1.23
124	20.00	16.49	21.44	22.43	17.82	2.55	1.07	1.12		1.08
125	20.50	15.80	24.07	25.33	19.79	2.55	1.17	1.24		1.25
126	13.00	11.12	14.28	15.13	11.61	2.55	1.10	1.16		1.04
127	99.00	81.29	105.28	105.88	93.11	2.55	1.06	1.07		1.15
128	99.00	82.51	104.34	106.67	89.95	2.55	1.05	1.08		1.09
129	112.00	103.57	93.69	93.66	83.63	2.55	.84	.84		.81
130	112.00	100.71	80.57	79.95	72.74	2.55	.72	.71		.72
131	112.00	97.02	91.61	91.42	82.00	2.55	.82	.82		.85
132	103.00	88.52	91.57	91.52	81.75	2.55	.89	.89		.92
133	104.00	94.05	88.25	88.07	78.99	2.55	.85	.85		.84
134	119.00	108.89	86.37	85.54	78.22	2.55	.73	.72		.72
135	118.00	108.94	83.85	83.31	75.56	2.55	.71	.71		.69

Measured, predicted width and ratios
predicted/measured width.

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted Top width Lacey	Top width HDC	- - - - -) Bed width HDC	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width HDC	Bed width
136	93.00	88.14	80.53	80.39	72.04	2.55	.87	.86	.82	
137	94.00	81.67	80.50	80.39	71.97	2.55	.86	.86	.88	
138	91.00	83.79	77.14	77.19	68.76	2.55	.85	.85	.82	
139	91.00	79.35	78.77	78.73	70.33	2.55	.87	.87	.89	
140	78.00	67.21	65.94	66.26	58.40	2.55	.85	.85	.87	
141	75.50	64.33	63.69	63.95	56.49	2.55	.84	.85	.88	
142	77.00	70.74	66.39	66.72	58.80	2.55	.86	.87	.83	
143	75.00	61.78	67.21	67.57	59.47	2.55	.90	.90	.96	
144	42.00	35.60	41.09	42.09	35.32	2.55	.98	1.00	.99	
145	16.00	11.22	14.61	15.44	11.93	2.55	.91	.97	1.06	
146	41.50	39.71	40.04	40.92	34.54	2.55	.96	.99	.87	
147	40.50	39.13	39.64	40.56	34.12	2.55	.98	1.00	.87	
148	37.00	33.78	37.95	38.78	32.74	2.55	1.03	1.05	.97	
149	36.00	34.65	38.89	39.74	33.55	2.55	1.08	1.10	.97	
150	23.50	21.95	27.88	28.61	23.88	2.55	1.19	1.22	1.09	
151	24.00	22.32	28.97	29.76	24.79	2.55	1.21	1.24	1.11	
152	16.90	13.62	13.52	14.06	11.33	2.55	.80	.83	.83	
153	16.00	14.53	15.25	15.83	12.82	2.55	.95	.99	.88	
154	11.30	8.95	10.92	11.63	8.81	2.55	.97	1.03	.98	
155	42.00	34.85	62.90	64.55	53.88	2.55	1.50	1.54	1.55	
156	42.00	34.98	66.24	68.63	55.88	2.55	1.58	1.63	1.60	
157	44.00	36.70	62.68	64.41	53.60	2.55	1.42	1.46	1.46	
158	42.00	37.01	47.16	48.22	40.65	2.55	1.12	1.15	1.10	
159	40.00	35.01	33.11	33.77	28.64	2.55	.83	.84	.82	
160	10.00	7.18	12.68	13.81	9.85	2.55	1.27	1.38	1.37	
161	10.00	6.71	12.12	13.19	9.41	2.55	1.21	1.32	1.40	
162	25.50	21.52	26.17	27.19	22.00	2.55	1.03	1.07	1.02	
163	26.00	19.14	26.08	27.23	21.74	2.55	1.00	1.05	1.14	
164	16.50	13.80	17.56	18.61	14.28	2.55	1.06	1.13	1.03	
165	17.20	13.38	19.48	20.68	15.78	2.55	1.13	1.20	1.18	
166	12.00	9.80	11.97	12.74	9.67	2.55	1.00	1.06	.99	
167	18.50	14.55	18.24	18.93	15.34	2.55	.99	1.02	1.05	
168	18.00	14.56	17.89	18.81	14.73	2.55	.99	1.05	1.01	
169	34.00	30.64	35.88	37.08	30.39	2.55	1.06	1.09	.99	
170	15.00	12.83	18.32	19.24	15.11	2.55	1.22	1.28	1.18	
171	53.20	46.04	45.43	46.20	39.50	2.55	.85	.87	.86	
172	54.00	47.93	40.92	41.48	35.74	2.55	.76	.77	.75	
173	53.00	47.26	44.36	44.89	38.87	2.55	.84	.85	.82	
174	49.00	39.02	44.52	45.13	38.89	2.55	.91	.92	1.00	
175	46.00	38.48	41.18	41.79	35.93	2.55	.90	.91	.93	
176	46.50	38.47	43.68	44.20	38.27	2.55	.94	.95	.99	
177	49.00	44.93	42.18	42.64	37.00	2.55	.86	.87	.82	
178	29.00	25.81	23.29	23.70	20.24	2.55	.80	.82	.78	
179	28.50	26.95	22.70	23.09	19.73	2.55	.80	.81	.73	
180	26.50	27.11	23.24	23.80	19.99	2.55	.88	.70	.87	

Measured, predicted width and ratios
predicted/measured width.

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted - - - - -) Top width Lacey	Top width HDC	Bed width HDC	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width HDC	Bed width HDC
181	19.00	13.84	17.58	18.29	14.74	2.55	.93	.96	1.07	
182	19.00	13.94	16.72	17.39	14.02	2.55	.88	.92	1.01	
183	45.50	37.16	51.43	53.19	43.52	2.55	1.13	1.17	1.17	
184	45.00	36.47	50.77	52.41	43.09	2.55	1.13	1.16	1.18	
185	9.50	7.59	10.53	11.28	8.41	2.55	1.11	1.19	1.11	
186	19.40	15.40	19.80	20.66	16.52	2.55	1.02	1.06	1.07	
187	17.20	11.78	17.92	18.89	14.68	2.55	1.04	1.10	1.25	
188	13.20	10.48	15.10	15.99	12.28	2.55	1.14	1.21	1.17	
189	98.00	88.08	104.11	104.77	92.00	2.55	1.06	1.07	1.04	
190	103.00	92.07	102.62	102.81	91.31	2.55	1.00	1.00	.99	
191	120.00	100.60	96.16	96.20	85.75	2.55	.80	.80	.85	
192	88.50	81.06	93.00	93.43	82.40	2.55	1.05	1.06	1.02	
193	98.00	85.80	91.91	92.27	81.52	2.55	.94	.94	.95	
194	97.50	86.94	87.86	88.50	77.51	2.55	.90	.91	.89	
195	97.50	84.47	90.25	90.54	80.13	2.55	.93	.93	.95	
196	31.00	26.00	27.04	27.76	23.15	2.55	.87	.90	.89	
197	47.80	42.96	51.98	52.71	45.38	2.55	1.09	1.10	1.06	
198	48.00	43.95	51.94	52.81	45.15	2.55	1.08	1.10	1.03	
199	39.50	33.71	45.34	46.44	38.97	2.55	1.15	1.18	1.16	
200	36.00	32.08	40.42	41.49	34.64	2.55	1.12	1.15	1.08	
201	33.00	27.25	38.81	39.98	33.05	2.55	1.18	1.21	1.21	
202	33.00	26.86	39.17	40.38	33.32	2.55	1.19	1.22	1.24	
203	37.50	31.54	32.61	33.26	28.21	2.55	.87	.89	.89	
204	40.00	34.84	35.59	36.59	30.40	2.55	.89	.91	.87	
205	30.00	27.74	26.37	26.98	22.70	2.55	.88	.90	.82	
206	29.20	26.82	27.26	28.16	23.12	2.55	.93	.96	.86	
207	15.00	10.62	13.73	14.47	11.28	2.55	.92	.96	1.06	
208	29.20	26.75	32.71	33.66	27.90	2.55	1.12	1.15	1.04	
209	17.80	14.25	26.98	28.49	22.06	2.55	1.52	1.60	1.55	
210	38.30	34.40	34.83	35.65	29.98	2.55	.91	.93	.87	
211	19.50	16.86	24.58	25.80	20.31	2.55	1.26	1.32	1.20	
212	51.00	43.45	62.47	63.58	54.23	2.55	1.22	1.25	1.25	
213	53.00	46.34	64.37	65.42	56.01	2.55	1.21	1.23	1.21	
214	53.50	46.87	64.93	66.05	56.42	2.55	1.21	1.23	1.20	
215	51.00	44.85	66.12	67.30	57.40	2.55	1.30	1.32	1.28	
216	57.50	51.56	65.26	66.07	57.12	2.55	1.13	1.15	1.11	
217	59.00	52.59	63.86	64.58	56.00	2.55	1.08	1.09	1.06	
218	54.50	48.20	56.09	56.80	49.08	2.55	1.03	1.04	1.02	
219	56.00	50.67	53.08	53.74	46.46	2.55	.95	.96	.92	
220	55.50	47.69	53.41	53.90	46.99	2.55	.96	.97	.99	
221	59.00	52.57	49.55	49.92	43.70	2.55	.84	.85	.83	
222	63.50	58.34	52.71	53.19	46.37	2.55	.83	.84	.79	
223	63.50	58.51	52.65	53.11	46.36	2.55	.83	.84	.79	
224	57.00	50.04	47.88	48.40	42.01	2.55	.84	.85	.84	
225	53.00	46.13	49.01	49.63	42.89	2.55	.92	.94	.93	

Measured, predicted width and ratios
predicted/measured width.

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted Top width Lacey	Top width HDC	- - - - -) Bed width HDC	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width	Bed width HDC
226	55.00	44.74	44.95	45.58	39.26	2.55	.82	.83		.88
227	46.00	40.32	46.56	47.55	40.20	2.55	1.01	1.03		1.00
228	47.50	40.90	43.32	44.16	37.50	2.55	.91	.93		.92
229	133.00	114.52	156.52	157.77	137.95	2.55	1.18	1.19		1.20
230	148.80	132.71	145.73	146.06	129.57	2.55	.98	.98		.98
231	150.00	131.71	136.04	136.11	121.29	2.55	.91	.91		.92
232	132.50	122.41	146.03	146.86	129.15	2.55	1.10	1.11		1.06
233	132.00	120.68	132.79	133.68	117.27	2.55	1.01	1.01		.97
234	20.50	16.82	20.39	21.25	17.05	2.55	.99	1.04		1.01
235	19.00	15.74	16.43	17.17	13.65	2.55	.86	.90		.87
236	11.50	4.56	13.65	14.84	10.61	2.55	1.19	1.29		2.33
237	13.50	10.65	14.59	15.45	11.88	2.55	1.08	1.14		1.12
238	13.50	10.69	17.93	19.01	14.56	2.55	1.33	1.41		1.36
239	14.00	11.56	18.40	19.45	15.02	2.55	1.31	1.39		1.30
240	46.00	39.82	50.04	50.81	43.59	2.55	1.09	1.10		1.09
241	50.00	44.36	52.73	53.87	45.49	2.55	1.05	1.08		1.03
242	52.00	46.08	51.67	52.80	44.57	2.55	.99	1.02		.97
243	50.00	43.92	54.98	56.36	47.18	2.55	1.10	1.13		1.07
244	39.00	33.26	42.53	43.89	36.12	2.55	1.09	1.13		1.09
245	39.00	33.95	45.46	46.90	38.63	2.55	1.17	1.20		1.14
246	40.00	34.24	47.90	49.14	41.07	2.55	1.20	1.23		1.20
247	40.00	34.33	41.87	43.05	35.76	2.55	1.05	1.08		1.04
248	38.00	31.65	45.35	46.89	38.40	2.55	1.19	1.23		1.21
249	38.00	28.62	44.08	45.69	37.17	2.55	1.16	1.20		1.30
250	36.00	28.92	43.00	44.60	36.22	2.55	1.19	1.24		1.25
251	40.00	29.67	43.54	45.07	36.79	2.55	1.09	1.13		1.24
252	17.50	14.31	18.20	19.14	14.98	2.55	1.04	1.09		1.05
253	17.00	14.54	19.92	20.99	16.34	2.55	1.17	1.23		1.12
254	17.50	14.97	17.82	18.71	14.70	2.55	1.02	1.07		.98
255	17.00	14.47	20.16	21.19	16.61	2.55	1.19	1.25		1.15
256	9.00	6.45	9.72	10.59	7.55	2.55	1.08	1.18		1.17
257	50 00	43.60	46.65	47.81	40.05	2.55	.93	.96		.92
258	47.50	39.82	42.47	43.35	36.71	2.55	.89	.91		.92
259	34.00	30.75	35.08	36.08	29.95	2.55	1.03	1.06		.97
260	34.00	28.05	36.38	37.54	30.91	2.55	1.07	1.10		1.10
261	10.00	5.68	16.15	17.57	12.54	2.55	1.61	1.76		2.21
262	25.00	18.61	31.84	33.53	26.16	2.55	1.27	1.34		1.41
263	25.00	19.02	31.57	32.93	26.36	2.55	1.26	1.32		1.39
264	25.00	18.54	34.72	36.28	28.90	2.55	1.39	1.45		1.56
265	29.00	25.21	32.15	33.48	26.90	2.55	1.11	1.15		1.07
266	28.00	22.87	32.36	33.68	27.09	2.55	1.16	1.20		1.18
267	28.00	22.97	32.98	34.27	27.70	2.55	1.18	1.22		1.21
268	27.00	20.02	32.15	33.51	26.87	2.55	1.19	1.24		1.34
269	28.00	22.94	30.57	31.69	25.77	2.55	1.09	1.13		1.12
270	19.50	15.34	18.54	19.27	15.56	2.55	.95	.99		1.01

Measured, predicted width and ratios
predicted/measured width.

No.	Width (ft) (- - - Measured - - -) Top width	Bed width	(- - - - - - Predicted Top width Lacey	Top width HDC	- - - - -) Bed width HDC	KS HDC	Ratio Predicted / Measured Top width Lacey	Top width HDC	Ratio Predicted / Measured Bed width	Bed width HDC
271	20.00	15.42	20.01	20.78	16.84	2.55	1.00	1.04		1.09
272	109.50	99.13	136.67	138.05	120.06	2.55	1.25	1.26		1.21
273	110.00	97.45	142.51	143.36	126.01	2.55	1.30	1.30		1.29
274	109.50	99.02	142.88	144.32	125.54	2.55	1.30	1.32		1.27
275	17.50	12.85	18.93	20.17	15.25	2.55	1.06	1.15		1.19
276	50.00	44.36	56.09	57.29	48.41	2.55	1.12	1.15		1.09
277	48.00	39.98	48.17	49.06	41.77	2.55	1.00	1.02		1.04
278	19.10	15.30	24.88	26.13	20.53	2.55	1.30	1.37		1.34
279	22.00	17.05	28.59	29.86	23.82	2.55	1.30	1.36		1.40
280	22.00	17.12	32.62	34.32	26.83	2.55	1.48	1.56		1.57
281	24.00	16.79	23.56	24.71	19.48	2.55	.98	1.03		1.16
282	33.00	25.95	30.72	31.95	25.76	2.55	.93	.97		.99
283	18.00	14.98	21.75	23.33	17.33	2.55	1.21	1.30		1.16
284	14.00	9.65	18.43	19.85	14.57	2.55	1.32	1.42		1.51
285	27.00	24.60	23.78	24.41	20.36	2.55	.88	.90		.83
286	25.53	23.99	26.90	27.71	22.91	2.55	1.05	1.09		.96
287	25.50	22.89	24.90	25.94	20.83	2.55	.98	1.02		.91
288	27.00	25.60	24.84	25.53	21.25	2.55	.92	.95		.83
289	26.37	23.09	25.20	25.96	21.47	2.55	.96	.98		.93
290	25.33	23.30	25.25	26.07	21.42	2.55	1.00	1.03		.92
291	18.00	15.54	21.47	22.83	17.35	2.55	1.19	1.27		1.12
292	17.00	15.68	21.73	22.86	17.88	2.55	1.28	1.34		1.14
AVERAGE						2.55	1.05	1.09		1.07
STD						.00	.17	.19		.21

Measured, predicted width and ratios
predicted/measured width.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
1	.70	.24	.62	.40	.90	.63	.95	.85	.85	.76	.85	.88
2	1.33	.39	2.50	.98	.63	2.66	.88	1.47	1.04	1.12	1.03	1.07
3	1.16	.35	1.35	.74	1.00	1.43	.94	1.07	.95	1.02	.96	.98
4	.75	.24	.66	.46	.61	.67	.99	1.00	.93	.95	.94	.96
5	.74	.26	.66	.43	1.11	.66	1.07	.87	.88	.75	.88	.90
6	1.19	.48	.78	.71	1.19	.79	1.07	.99	.94	.85	.97	.99
7	.81	.25	.59	.44	.58	.61	1.00	.98	.94	.93	.95	.98
8	2.36	.64	2.32	1.57	1.77	2.57	.89	1.19	.93	1.06	.97	1.00
9	.38	.13	.32	.22	.45	.34	.96	.88	.85	.81	.87	.89
10	.82	.24	.95	.51	.95	1.00	.92	.96	.89	.92	.89	.91
11	1.72	.59	1.09	1.01	1.47	1.09	1.02	.99	.93	.87	.96	.98
12	1.38	.42	1.19	.86	.78	1.27	.99	1.12	.98	1.07	1.02	1.04
13	4.16	1.41	22.28	3.33	4.93	27.79	.83	1.33	1.01	.89	.94	.96
14	.65	.19	.70	.44	.75	.76	.92	1.02	.90	.98	.91	.93
15	2.78	.82	4.14	2.10	2.06	4.66	.84	1.40	.96	1.07	.97	.99
16	.86	.27	1.76	.66	1.11	2.02	.84	1.29	.88	1.04	.95	.97
17	.56	.16	.42	.29	.37	.46	1.11	.99	.99	.94	.97	1.00
18	3.31	1.05	2.10	2.00	1.40	2.19	1.00	1.22	1.03	1.15	1.11	1.13
19	2.27	.70	1.54	1.34	1.21	1.64	1.02	1.11	.99	1.05	1.03	1.05
20	9.22	2.22	1.78	2.78	2.00	2.22	1.12	1.01	1.25	.98	1.16	1.01
21	100.00	100.00	100.00	100.00	100.00	100.00	.80	1.20	1.34	.98	1.26	1.15
22	1.62	.46	.39	.40	.13	.59	1.00	1.04	1.30	.92	1.19	.99
23	3.98	1.00	1.04	.88	1.09	1.55	.87	.98	1.16	.99	1.13	1.07
24	.64	.13	.08	.16	.12	.12	1.10	.92	1.18	.87	1.11	.93
25	2.47	.63	.63	.63	.91	1.02	.92	.89	1.08	.84	1.02	.91
26	.95	.23	.07	.16	.66	.14	.92	.74	.99	.69	.93	.78
27	100.00	100.00	100.00	100.00	100.00	100.00	.97	1.03	1.21	.99	1.14	1.02
28	6.04	2.21	2.81	1.42	.65	5.15	.86	1.13	1.29	.90	1.17	1.08
29	5.14	1.33	1.67	1.36	1.14	2.36	.92	1.03	1.18	.99	1.12	1.05
30	7.10	1.90	1.95	2.00	2.55	2.70	.92	.94	1.12	.92	1.06	.98
31	2.41	.71	.72	.52	.23	1.36	.93	1.13	1.33	1.02	1.24	1.11
32	100.00	100.00	100.00	100.00	100.00	100.00	1.15	1.15	1.52	1.09	1.44	1.17
33	100.00	100.00	100.00	100.00	100.00	100.00	1.00	1.15	1.40	.99	1.28	1.11
34	1.74	.58	.48	.40	.13	.86	.96	1.08	1.33	.90	1.21	1.01
35	2.54	.76	.65	.76	2.15	.89	.82	.81	1.01	.79	.95	.84
36	2.42	.68	.63	.58	.63	1.06	.88	.96	1.16	.93	1.10	.97
37	6.03	1.89	1.00	.92	.36	2.69	.87	1.04	1.31	.86	1.22	1.09
38	2.48	.87	1.17	.42	.16	3.46	.86	1.16	1.37	.84	1.25	1.12
39	2.56	.76	.18	.38	.27	.44	.89	.89	1.21	.79	1.13	.94
40	.74	.23	.17	.11	.01	.48	.99	1.15	1.47	.92	1.35	1.13
41	6.90	1.30	.50	1.30	1.70	.90	1.02	.93	1.21	.87	1.13	.99
42	2.26	.52	.35	.36	.33	.64	.91	.97	1.21	.91	1.16	1.07
43	100.00	100.00	100.00	100.00	100.00	100.00	.92	.94	1.21	.90	1.16	1.02
44	1.35	.37	.43	.47	.98	.53	1.03	.84	1.02	.80	.95	.83
45	3.20	1.02	1.53	.55	.25	4.29	.94	1.08	1.34	.85	1.23	1.07

Ratios predicted/measured concentration and velocities.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
46	.95	.29	.10	.19	.59	.19	.85	.79	1.04	.75	.98	.81
47	1.30	.35	.33	.39	.54	.41	1.06	.80	1.10	.83	1.01	.86
48	2.03	.78	.90	.66	.30	1.13	1.06	1.05	1.26	.90	1.13	.97
49	2.15	.58	.58	.50	.50	1.10	.98	.95	1.16	.84	1.07	.96
50	3.25	.86	1.54	.97	.75	2.13	.93	1.09	1.16	1.01	1.11	1.07
51	3.21	.86	2.03	.81	.28	3.54	.94	1.23	1.34	.99	1.22	1.15
52	1.12	.28	.30	.25	.07	.52	1.09	1.15	1.37	1.04	1.27	1.15
53	3.18	1.14	2.37	1.08	.80	3.56	.84	1.05	1.16	.88	1.05	.95
54	2.13	.78	1.60	.76	.50	2.23	.84	1.16	1.20	1.00	1.11	1.03
55	2.18	1.03	1.37	.61	.17	2.12	.96	1.14	1.37	.85	1.22	1.01
56	1.49	.41	.28	.26	.42	.53	.75	.87	1.07	.82	1.03	.95
57	100.00	100.00	100.00	100.00	100.00	100.00	.97	1.25	1.69	1.08	1.58	1.18
58	1.54	.56	.84	.30	.08	2.03	.87	1.26	1.45	.96	1.32	1.15
59	2.17	.45	.26	.24	.69	.96	.79	.80	1.02	.75	1.01	.97
60	1.14	.35	.14	.35	.30	.19	1.03	.89	1.15	.86	1.07	.85
61	.75	.25	.56	.40	.52	.59	1.01	.98	.99	.94	.96	.98
62	.76	.24	.61	.40	.64	.65	.97	.92	.94	.88	.91	.93
63	.52	.16	.40	.27	.33	.44	.92	1.00	.97	.95	.95	.98
64	.54	.18	.36	.29	.30	.37	1.00	1.02	1.02	.97	.99	1.01
65	.58	.19	.43	.30	.34	.45	.94	1.01	.99	.96	.97	1.00
66	.56	.18	.41	.29	.26	.44	.93	1.07	1.03	1.02	1.01	1.03
67	.43	.13	.27	.21	.17	.30	.96	1.10	1.06	1.04	1.07	1.06
68	.53	.19	.38	.29	.31	.43	.87	1.02	.99	.97	.97	1.00
69	.69	.25	.57	.37	.33	.64	.83	1.09	1.02	1.01	.99	1.02
70	3.75	1.22	.94	.84	.31	1.66	.90	1.11	1.33	1.00	1.23	1.08
71	100.00	100.00	100.00	100.00	100.00	100.00	1.00	.99	1.15	.88	1.05	.95
72	2.10	.48	.73	.58	.62	1.08	.97	.95	1.10	.89	1.03	.97
73	2.07	.48	.63	.54	.85	1.00	.95	.89	1.05	.85	1.00	.92
74	1.92	.35	.86	.55	.79	1.47	.86	.92	1.05	.83	.98	.91
75	100.00	100.00	100.00	100.00	100.00	100.00	.80	.91	1.08	.80	1.02	.97
76	100.00	100.00	100.00	100.00	100.00	100.00	.97	1.20	1.41	.94	1.28	1.09
77	100.00	100.00	100.00	100.00	100.00	100.00	.81	1.15	1.28	.97	1.22	1.15
78	2.05	.53	.84	.61	.99	1.23	.83	.89	.99	.85	.96	.93
79	100.00	100.00	100.00	100.00	100.00	100.00	.90	1.13	1.29	.97	1.22	1.12
80	.61	.23	.50	.26	.34	.61	.84	.98	1.04	.87	.96	.91
81	2.14	.72	1.50	.63	1.36	2.84	.79	.96	1.05	.77	.97	.91
82	.35	.13	.26	.12	.14	.37	.82	.99	1.10	.82	1.00	.90
83	.82	.28	.32	.24	.09	.45	1.01	1.08	1.29	.94	1.17	1.00
84	.89	.43	.63	.19	.25	1.79	.69	.99	1.16	.66	1.04	.92
85	.86	.31	.50	.32	.33	.64	.83	.98	1.08	.90	1.00	.91
86	1.36	.60	1.17	.44	.17	1.65	.90	1.18	1.32	.90	1.17	1.01
87	.27	.07	.27	.14	.28	.31	.95	.92	.93	.88	.88	.88
88	.78	.23	.99	.35	.23	1.32	.96	1.14	1.14	.96	1.04	1.02
89	1.43	.41	2.04	.64	.72	2.93	.86	1.09	1.06	.90	.98	.97
90	.26	.07	.19	.11	.16	.24	.91	.96	.99	.91	.94	.94

Ratios predicted/measured concentration and velocities.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
91	.68	.21	.76	.30	.41	1.06	.87	1.02	1.03	.88	.95	.94
92	1.37	.34	1.11	.48	.44	1.64	1.00	1.04	1.14	.90	1.03	.99
93	.42	.12	.54	.18	.31	.79	.85	1.02	1.03	.84	.94	.92
94	.77	.24	1.21	.34	.51	1.77	.83	1.06	1.05	.83	.95	.95
95	4.98	1.64	9.32	2.38	4.20	13.84	.81	1.08	1.03	.82	.93	.93
96	.59	.17	.89	.26	.28	1.31	.86	1.10	1.09	.87	.98	.98
97	.89	.28	1.61	.41	.51	2.36	.83	1.13	1.06	.86	.97	.97
98	2.15	.63	.95	.58	.16	1.41	1.03	1.14	1.34	.95	1.21	1.07
99	100.00	100.00	100.00	100.00	100.00	100.00	.92	1.04	1.23	.89	1.14	1.03
100	3.01	.78	1.61	.78	.43	2.91	.91	1.09	1.21	.94	1.13	1.05
101	1.50	.40	.36	.33	.13	.67	1.00	1.06	1.29	.96	1.20	1.05
102	.04	.01	.02	.01	.01	.04	.84	1.11	1.18	.95	1.10	1.03
103	1.65	.60	.32	.37	.31	.54	.89	.93	1.19	.78	1.08	.88
104	100.00	100.00	100.00	100.00	100.00	100.00	.99	1.11	1.27	.99	1.17	1.03
105	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.17	1.28	.99	1.17	1.06
106	2.64	.78	1.49	.80	.68	2.42	.92	1.02	1.15	.85	1.05	.96
107	1.49	.33	.46	.39	.36	.69	1.06	.97	1.15	.93	1.09	1.00
108	1.90	.52	1.11	.55	.28	1.81	.98	1.13	1.24	1.00	1.15	1.07
109	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.02	1.22	.87	1.12	.99
110	1.16	.30	.17	.20	.19	.43	.96	.93	1.20	.79	1.10	.94
111	100.00	100.00	100.00	100.00	100.00	100.00	.96	.92	1.12	.80	1.02	.92
112	1.83	.48	.38	.43	.81	.64	.97	.88	1.11	.77	1.01	.87
113	100.00	100.00	100.00	100.00	100.00	100.00	1.05	1.04	1.29	.93	1.21	1.09
114	.41	.13	.18	.10	.06	.34	.88	1.07	1.24	.87	1.13	1.00
115	.18	.04	.07	.04	.02	.12	.92	1.06	1.22	.86	1.11	.99
116	1.20	.33	.46	.30	.18	.81	.90	1.04	1.22	.90	1.12	1.00
117	5.83	1.65	5.94	3.37	2.10	6.67	.91	1.28	1.07	1.11	1.04	1.07
118	100.00	100.00	100.00	100.00	100.00	100.00	.93	1.57	1.15	1.02	1.07	1.10
119	2.60	.70	8.77	1.20	.35	14.10	.91	1.69	1.27	1.03	1.18	1.23
120	1.55	.41	4.06	.77	.77	5.97	.82	1.47	1.03	1.03	1.03	1.07
121	3.44	.79	2.67	1.35	1.19	3.67	1.00	1.08	1.09	1.00	1.03	1.04
122	.74	.19	.73	.35	.62	.94	.85	.96	.93	.89	.89	.91
123	.85	.18	.92	.34	.61	1.40	.92	.99	1.01	.89	.94	.94
124	100.00	100.00	100.00	100.00	100.00	100.00	.89	1.04	1.23	.91	1.13	1.01
125	2.09	.65	1.25	.48	.33	2.70	.84	1.06	1.20	.83	1.10	1.01
126	2.40	.71	.62	.51	.26	1.28	.86	1.02	1.24	.89	1.15	.99
127	3.40	.82	1.95	1.45	.82	2.22	1.07	1.20	1.17	1.13	1.12	1.15
128	1.11	.20	.48	.39	.61	.57	1.19	.90	1.02	.86	.97	.96
129	.77	.24	.61	.42	.56	.66	.98	.96	.98	.92	.93	.91
130	4.70	1.46	3.06	2.10	.82	3.32	1.15	1.28	1.29	1.17	1.19	1.17
131	.57	.18	.41	.31	.29	.42	.99	1.04	1.03	.99	.99	.98
132	1.11	.31	.71	.54	.30	.77	1.06	1.21	1.16	1.15	1.11	1.12
133	2.45	.71	1.63	1.23	.74	1.79	1.06	1.17	1.15	1.10	1.08	1.08
134	.73	.25	.49	.40	.26	.51	1.03	1.17	1.12	1.11	1.08	1.07
135	.99	.33	.70	.53	.49	.74	1.05	1.03	1.06	.99	1.00	.98

Ratios predicted/measured concentration and velocities.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
136	1.37	.43	.95	.69	.58	1.05	1.00	1.08	1.08	1.02	1.03	1.01
137	.96	.30	.64	.49	.35	.69	1.00	1.14	1.10	1.08	1.06	1.06
138	.93	.28	.57	.42	.31	.64	1.05	1.06	1.11	1.00	1.04	1.02
139	.96	.30	.62	.48	.36	.65	1.00	1.11	1.09	1.06	1.05	1.05
140	.66	.19	.41	.30	.23	.45	1.03	1.08	1.11	1.04	1.06	1.03
141	1.18	.38	.71	.52	.39	.78	.99	1.05	1.11	.98	1.04	1.01
142	.76	.24	.51	.35	.34	.59	.98	1.01	1.07	.95	1.00	.96
143	4.43	1.43	2.93	2.18	2.34	3.05	.95	1.01	1.02	.97	.99	.98
144	1.60	.39	.56	.51	.29	.71	1.08	1.08	1.22	1.04	1.14	1.08
145	1.36	.41	.31	.31	.21	.50	.86	.96	1.19	.86	1.10	.94
146	.63	.22	.34	.23	.33	.47	.88	.93	1.05	.83	.96	.88
147	.57	.19	.33	.21	.24	.46	.89	.96	1.07	.85	.98	.89
148	.79	.28	.57	.29	.25	.79	85	1.04	1.12	.89	1.02	.96
149	.77	.25	.70	.31	.29	1.00	.81	1.04	1.09	.88	.99	.93
150	1.57	.60	1.32	.51	.23	2.09	.81	1.23	1.25	.96	1.14	1.08
151	3.34	.84	2.96	.79	.36	5.01	.79	1.27	1.25	.94	1.15	1.08
152	1.12	.36	.29	.27	.05	.46	.98	1.14	1.41	.99	1.28	1.06
153	.88	.45	.59	.28	.24	.93	.73	1.01	1.15	.78	1.03	.87
154	100.00	100.00	100.00	100.00	100.00	100.00	.86	1.02	1.30	.85	1.19	.98
155	2.99	.70	.98	.85	.68	1.20	.99	1.15	1.13	1.09	1.17	1.22
156	3.47	.73	1.55	1.04	1.20	2.18	.90	1.01	1.02	.96	1.03	1.07
157	3.25	.74	1.37	1.04	.84	1.78	.94	1.10	1.09	1.05	1.09	1.13
158	1.39	.44	1.18	.54	.47	1.63	.85	1.07	1.09	.94	1.02	.99
159	.75	.25	.40	.26	.17	.51	.96	1.04	1.17	.93	1.07	.96
160	1.99	.41	.26	.25	.10	.76	.95	1.06	1.33	.99	1.28	1.15
161	100.00	100.00	100.00	100.00	100.00	100.00	.82	1.05	1.32	.82	1.21	1.06
162	100.00	100.00	100.00	100.00	100.00	100.00	.96	1.11	1.28	.95	1.17	1.06
163	2.23	.74	1.26	.60	.55	2.12	.85	1.01	1.16	.82	1.06	.95
164	100.00	100.00	100.00	100.00	100.00	100.00	.90	.98	1.22	.85	1.12	.97
165	100.00	100.00	100.00	100.00	100.00	100.00	.83	.94	1.15	.79	1.07	.94
166	100.00	100.00	100.00	100.00	100.00	100.00	.91	1.13	1.42	.87	1.28	1.05
167	5.04	2.62	8.48	1.22	.32	18.27	.86	1.29	1.45	.76	1.26	1.11
168	.86	.19	.16	.22	.18	.21	1.04	.98	1.21	.95	1.14	1.02
169	1.05	.23	.30	.31	.24	.41	1.10	1.03	1.19	.99	1.13	1.06
170	3.33	1.38	2.63	.88	.55	5.46	.73	1.09	1.20	.79	1.08	.98
171	3.56	1.00	1.63	1.44	3.69	1.69	1.14	.89	1.05	.77	.99	.94
172	4.60	1.32	1.76	1.60	1.20	2.12	1.08	1.01	1.16	.97	1.09	.99
173	.19	.06	.09	.08	.10	.11	.97	.93	1.05	.90	.98	.92
174	.29	.08	.12	.11	.08	.12	1.04	1.09	1.18	1.05	1.12	1.09
175	100.00	100.00	100.00	100.00	100.00	100.00	1.09	1.11	1.22	1.08	1.16	1.11
176	2.20	.68	1.03	.88	.58	1.14	.96	1.14	1.17	1.09	1.12	1.09
177	.38	.13	.25	.16	.13	.30	.92	1.03	1.10	.96	1.02	.96
178	.45	.21	.33	.17	.13	.42	.83	1.05	1.16	.90	1.05	.93
179	1.17	.46	.56	.45	.37	.68	.89	1.00	1.14	.95	1.05	.92
180	1.10	.38	.44	.41	.46	.53	.89	.96	1.11	.94	1.03	.94

Ratios predicted/measured concentration and velocities.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
181	1.67	.46	.41	.48	.37	.48	.97	1.02	1.21	1.01	1.15	1.05
182	2.62	.76	.73	.70	.32	.96	.97	1.10	1.30	1.06	1.21	1.07
183	.80	.19	.38	.28	.58	.47	.92	.85	.96	.82	.92	.89
184	100.00	100.00	100.00	100.00	100.00	100.00	.93	.91	1.00	.87	.96	.94
185	100.00	100.00	100.00	100.00	100.00	100.00	.96	1.31	1.61	.96	1.46	1.22
186	1.82	.58	.86	.48	.21	1.40	.87	1.12	1.27	.93	1.16	1.03
187	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.00	1.20	.98	1.15	1.06
188	100.00	100.00	100.00	100.00	100.00	100.00	.91	.99	1.22	.97	1.16	1.05
189	100.00	100.00	100.00	100.00	100.00	100.00	1.02	1.08	1.09	1.02	1.03	1.04
190	100.00	100.00	100.00	100.00	100.00	100.00	.96	1.64	1.25	.98	1.11	1.12
191	100.00	100.00	100.00	100.00	100.00	100.00	1.00	1.08	1.12	.92	1.01	.98
192	100.00	100.00	100.00	100.00	100.00	100.00	.94	1.13	1.10	1.00	1.03	1.04
193	100.00	100.00	100.00	100.00	100.00	100.00	1.04	1.07	1.10	1.02	1.03	1.03
194	100.00	100.00	100.00	100.00	100.00	100.00	1.04	1.04	1.07	.98	1.00	.97
195	100.00	100.00	100.00	100.00	100.00	100.00	.98	1.10	1.10	.99	1.02	1.02
196	100.00	100.00	100.00	100.00	100.00	100.00	.83	.98	1.10	.84	1.00	.89
197	100.00	100.00	100.00	100.00	100.00	100.00	.70	1.38	1.08	.68	.94	.92
198	100.00	100.00	100.00	100.00	100.00	100.00	.78	1.05	1.04	.86	.95	.92
199	100.00	100.00	100.00	100.00	100.00	100.00	.81	1.12	1.12	.89	1.03	1.00
200	100.00	100.00	100.00	100.00	100.00	100.00	.79	1.04	1.08	.86	.98	.94
201	100.00	100.00	100.00	100.00	100.00	100.00	.82	1.17	1.19	.88	1.08	1.04
202	100.00	100.00	100.00	100.00	100.00	100.00	.78	1.07	1.10	.86	1.01	.98
203	100.00	100.00	100.00	100.00	100.00	100.00	.89	1.21	1.29	.85	1.13	1.02
204	100.00	100.00	100.00	100.00	100.00	100.00	1.08	.92	1.13	.89	1.05	.96
205	100.00	100.00	100.00	100.00	100.00	100.00	1.06	1.13	1.32	1.05	1.21	1.08
206	100.00	100.00	100.00	100.00	100.00	100.00	.96	1.04	1.22	.90	1.11	.97
207	100.00	100.00	100.00	100.00	100.00	100.00	.90	1.06	1.30	.90	1.20	1.03
208	100.00	100.00	100.00	100.00	100.00	100.00	.82	1.16	1.22	.84	1.09	1.01
209	100.00	100.00	100.00	100.00	100.00	100.00	.71	1.03	1.08	.81	1.02	1.00
210	100.00	100.00	100.00	100.00	100.00	100.00	.92	1.07	1.18	.89	1.07	.97
211	100.00	100.00	100.00	100.00	100.00	100.00	.78	1.10	1.23	.70	1.09	1.00
212	100.00	100.00	100.00	100.00	100.00	100.00	.81	1.11	1.07	.93	1.00	1.01
213	100.00	100.00	100.00	100.00	100.00	100.00	.83	1.30	1.13	.96	1.04	1.05
214	2.80	.78	1.90	1.25	1.24	2.30	.86	1.06	1.02	.99	1.00	1.01
215	100.00	100.00	100.00	100.00	100.00	100.00	.83	1.17	1.08	1.02	1.04	1.07
216	100.00	100.00	100.00	100.00	100.00	100.00	.81	1.25	1.10	.94	1.01	1.01
217	100.00	100.00	100.00	100.00	100.00	100.00	.80	1.37	1.11	.87	1.00	.99
218	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.22	1.22	1.03	1.12	1.10
219	100.00	100.00	100.00	100.00	100.00	100.00	1.03	1.00	1.11	.97	1.05	1.01
220	100.00	100.00	100.00	100.00	100.00	100.00	.83	1.35	1.19	.85	1.06	1.03
221	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.15	1.22	.91	1.09	1.03
222	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.06	1.12	.94	1.02	.95
223	100.00	100.00	100.00	100.00	100.00	100.00	.98	1.09	1.14	.97	1.05	.98
224	100.00	100.00	100.00	100.00	100.00	100.00	1.01	1.01	1.13	.96	1.05	.99
225	100.00	100.00	100.00	100.00	100.00	100.00	.93	1.25	1.27	.90	1.13	1.07

Ratios predicted/measured concentration and velocities.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
226	100.00	100.00	100.00	100.00	100.00	100.00	1.13	1.11	1.26	1.05	1.17	1.10
227	100.00	100.00	100.00	100.00	100.00	100.00	.95	1.04	1.12	.96	1.04	1.00
228	100.00	100.00	100.00	100.00	100.00	100.00	1.08	1.02	1.19	.98	1.11	1.04
229	100.00	100.00	100.00	100.00	100.00	100.00	.86	.95	.88	.90	.85	.88
230	100.00	100.00	100.00	100.00	100.00	100.00	.68	1.06	.97	.83	.87	.88
231	100.00	100.00	100.00	100.00	100.00	100.00	1.04	.89	.93	.84	.89	.90
232	100.00	100.00	100.00	100.00	100.00	100.00	.86	.91	.86	.86	.82	.84
233	100.00	100.00	100.00	100.00	100.00	100.00	1.03	.85	.91	.81	.87	.87
234	100.00	100.00	100.00	100.00	100.00	100.00	.97	1.31	1.47	.94	1.31	1.16
235	100.00	100.00	100.00	100.00	100.00	100.00	.95	.91	1.14	.88	1.06	.91
236	100.00	100.00	100.00	100.00	100.00	100.00	.84	.99	1.19	.97	1.16	1.16
237	.38	.11	.10	.08	.03	.18	.87	1.08	1.29	.94	1.19	1.04
238	2.97	1.31	4.58	.64	.35	14.49	.73	1.18	1.27	.71	1.14	1.05
239	2.55	.94	1.97	.56	.31	4.89	.76	1.14	1.25	.81	1.13	1.04
240	2.50	.81	3.84	1.03	.41	5.52	.86	1.37	1.23	.98	1.12	1.10
241	.37	.11	.35	.15	.17	.49	.87	1.03	1.07	.87	.98	.93
242	.28	.08	.17	.09	.08	.25	.97	1.02	1.14	.89	1.04	.98
243	.30	.09	.21	.11	.17	.29	.88	.96	1.03	.87	.96	.92
244	1.03	.28	.54	.28	.14	.97	.98	1.08	1.23	.89	1.12	1.05
245	1.34	.43	.96	.43	.80	1.58	.82	.95	1.05	.78	.95	.91
246	.54	.17	.61	.21	.26	.91	.78	1.04	1.05	.85	.97	.95
247	.68	.18	.43	.23	.16	.64	.91	1.05	1.15	.90	1.05	.98
248	1.22	.34	.77	.39	.37	1.19	.87	1.02	1.10	.89	1.02	.98
249	.87	.30	.72	.23	.27	1.41	.86	1.03	1.16	.76	1.04	1.00
250	100.00	100.00	100.00	100.00	100.00	100.00	.86	1.04	1.12	.85	1.03	.99
251	.37	.10	.25	.12	.14	.37	.87	1.00	1.08	.87	1.00	.96
252	6.53	1.97	2.20	1.53	.87	4.00	.87	1.03	1.22	.88	1.12	.98
253	.40	.12	.20	.09	.04	.46	.87	1.10	1.27	.87	1.16	1.04
254	1.58	.50	.50	.38	.24	.89	.87	.99	1.20	.86	1.10	.95
255	100.00	100.00	100.00	100.00	100.00	100.00	.79	1.05	1.20	.80	1.09	.97
256	.44	.13	.04	.06	.04	.11	.82	.92	1.21	.80	1.14	.95
257	.97	.22	.30	.28	.16	.42	1.12	1.01	1.20	.95	1.11	1.03
258	1.26	.35	.93	.37	.13	1.40	1.06	1.17	1.33	.96	1.19	1.10
259	.36	.13	.34	.12	.13	.54	.84	1.04	1.13	.82	1.02	.93
260	.63	.22	.51	.20	.22	.82	.83	1.02	1.12	.80	1.01	.95
261	100.00	100.00	100.00	100.00	100.00	100.00	.86	1.36	1.46	1.06	1.41	1.46
262	1.51	.52	1.05	.36	.80	2.44	.77	.95	1.08	.72	.99	.94
263	2.25	.78	1.93	.58	.42	3.94	.79	1.09	1.19	.80	1.08	1.04
264	3.09	1.13	3.24	.85	1.06	6.87	.72	1.05	1.11	.74	1.01	1.00
265	.62	.18	.23	.14	.13	.46	.92	.98	1.19	.81	1.08	.97
266	1.07	.36	.74	.32	.57	1.25	.78	.95	1.06	.77	.96	.90
267	1.03	.31	.67	.31	.32	1.10	.81	1.01	1.10	.85	1.01	.96
268	4.89	2.17	10.19	1.50	1.67	21.86	.74	1.10	1.16	.68	1.02	.97
269	1.53	.50	1.03	.49	.58	1.59	.80	.99	1.08	.83	.99	.93
270	1.72	.67	1.00	.48	.22	1.60	.83	1.12	1.27	.87	1.14	1.00

Ratios predicted/measured concentration and velocities.

No.	Ratio Predicted Concentration / Measured Concentration EH	YG	AW	KK	VR	HDC	Ratio Predicted Velocity / Measured Velocity Lacey	EH	AW	KK	VR	HDC
271	2.07	.90	1.54	.63	.37	2.38	.79	1.10	1.21	.88	1.10	.99
272	.38	.10	.33	.20	.29	.39	.94	.99	.94	.95	.93	.96
273	.50	.13	.38	.28	.22	.43	.92	1.14	1.00	1.09	1.02	1.05
274	.45	.12	1.19	.28	.46	1.66	.81	1.31	.96	.89	.90	.92
275	100.00	100.00	100.00	100.00	100.00	100.00	.89	.97	1.25	.76	1.14	.98
276	.46	.15	.48	.20	.36	.66	.79	.96	.99	.82	.91	.88
277	1.52	.52	1.40	.63	.48	1.80	.85	1.08	1.10	.92	1.01	.97
278	2.74	1.14	4.73	.57	.20	15.58	.82	1.24	1.37	.71	1.20	1.12
279	4.46	2.49	22.01	1.18	.57	71.15	.74	1.36	1.30	.56	1.11	1.06
280	1.67	.49	1.25	.47	.59	2.36	.69	.96	.99	.79	.94	.94
281	3.34	1.74	2.21	1.79	.67	3.42	1.00	1.10	1.39	.98	1.20	1.08
282	1.04	.29	.66	.21	.06	1.54	1.08	1.11	1.36	.87	1.24	1.08
283	100.00	100.00	100.00	100.00	100.00	100.00	.93	.99	1.17	.77	1.11	.95
284	.96	.28	.29	.17	.28	.75	.74	.92	1.09	.74	1.02	.94
285	2.34	.66	.82	.70	.37	1.12	1.04	1.10	1.28	1.05	1.19	1.06
286	3.57	1.09	1.47	1.22	1.59	1.89	.90	.94	1.08	.92	1.02	.95
287	100.00	100.00	100.00	100.00	100.00	100.00	1.00	.87	1.07	.84	1.01	.90
288	1.48	.40	.46	.48	.46	.60	1.04	1.09	1.19	.99	1.11	1.00
289	2.62	1.16	1.97	1.03	.40	3.36	.94	1.15	1.30	.96	1.18	1.05
290	100.00	100.00	100.00	100.00	100.00	100.00	.89	1.11	1.26	.88	1.13	1.00
291	1.99	.38	.31	.40	.60	.51	.93	.88	1.10	.84	1.05	.95
292	100.00	100.00	100.00	100.00	100.00	100.00	1.02	1.01	1.21	.98	1.17	1.09
AVERAGE	1.81	.55	1.34	.60	.58	2.29	.92	1.06	1.15	.91	1.07	1.00
STD.DEVIATION	1.53	.48	2.52	.54	.64	5.88	.10	.13	.13	.10	.11	.08

Ratios predicted/measured concentration and velocities.

Table 3.7

DISCREPANCY RATIOS

EH	YG	AW	KK	VR	HDC	EH	YG	AW	KK	VR	HDC	EH	YG	AW	KK	VR	HDC	EH	YG	AW	KK	VR	HDC
0.667 <R<1.50						0.50 <R<2.00						0.33 <R<3.00						R<0.33 & R>3.00					
35	24	28	20	19	28	53	37	52	38	35	51	79	57	73	63	55	78	21	43	27	37	45	22

Discrepancy ratios sediment transport predictors.

Table 3.8

	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
1	55.984	.021	.207	.047	.238	.095	3	9	.127	.117
2	48.157	.024	.146	.131	.128	.113	5	5	.139	.051
3	49.280	.023	.160	.132	.128	.108	5	5	.146	.076
4	48.710	.024	.153	.153	.129	.129	3	2	.153	.094
5	53.705	.022	.245	-.027	.108	.108	3	2	.109	.111
6	45.272	.026	.805	-.483	.187	.187	3	2	.161	.123
7	48.499	.024	.266	-.006	.189	.145	3	11	.130	.101
8	50.610	.024	.207	.053	.147	.123	3	4	.130	.067
9	55.820	.021	.195	.023	.168	.104	3	4	.109	.100
10	55.307	.021	.171	.073	.137	.121	3	5	.122	.078
11	47.369	.025	.220	.069	.147	.123	3	4	.145	.108
12	44.842	.026	.341	-.030	.168	.104	3	4	.155	.082
13	54.267	.021	.136	.102	.168	.107	5	4	.119	.041
14	54.019	.022	.122	.111	.188	.106	5	4	.116	.066
15	51.536	.023	.168	.108	.193	.102	3	4	.138	.056
16	52.927	.022	.260	.032	.157	.122	3	4	.146	.061
17	46.546	.025	.194	.038	.119	.119	3	2	.116	.094
18	39.920	.029	.215	.177	.193	.102	3	4	.196	.091
19	43.692	.027	.192	.113	.157	.122	3	4	.152	.089
20	35.911	.025	.371	.034	.197	.197	3	2	.203	.145
21	33.435	.026	.343	.307	.326	.326	3	2	.325	.100
22	38.186	.023	.299	.063	.183	.171	3	9	.181	.089
23	35.628	.025	.368	.263	.296	.212	3	5	.315	.164
24	43.162	.021	.124	.124	.124	.124	2	2	.124	.112
25	47.665	.020	.948	-.483	.151	.151	3	2	.132	.094
26	60.958	.015	.237	-.071	.086	.086	3	2	.083	.087
27	37.038	.025	.237	.213	.224	.224	3	2	.225	.116
28	37.300	.025	.296	.190	.287	.196	3	3	.243	.092
29	37.943	.025	.393	.050	.228	.228	3	2	.221	.117
30	39.826	.023	.313	.152	.238	.233	3	3	.232	.149
31	33.379	.027	.270	.270	.250	.240	2	7	.270	.112
32	29.525	.029	.853	-.445	.228	.228	3	2	.204	.126
33	33.433	.027	.374	.080	.324	.123	3	5	.227	.096
34	37.196	.024	.229	.160	.327	.131	3	5	.195	.084
35	47.022	.018	.362	.130	.301	.228	3	10	.246	.172
36	39.376	.022	.247	.223	.239	.233	3	5	.235	.121
37	38.038	.024	.346	.081	.231	.213	3	6	.214	.102
38	35.803	.025	.389	.064	.241	.213	3	5	.227	.083
39	44.255	.020	.371	-.040	.255	.233	3	11	.166	.111
40	32.534	.027	.264	.173	.255	.225	3	11	.219	.175
41	40.276	.021	.238	.127	.227	.193	3	6	.182	.179
42	40.667	.022	.203	.166	.217	.192	3	6	.184	.109
43	39.673	.022	.198	.187	.192	.192	3	2	.193	.127
44	51.871	.018	.268	-.043	.107	.107	3	2	.113	.089
45	37.889	.024	.264	.076	.203	.153	3	4	.170	.080

Roughness coefficients, confidence limits and slopes.

No.	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
46	51.308	.016	.301	.014	.164	.164	3	2	.157	.109
47	49.590	.019	.138	.076	.426	-.141	3	3	.107	.079
48	39.755	.024	.347	.003	.182	.110	3	4	.175	.079
49	46.463	.021	.153	.069	.110	.110	3	2	.111	.078
50	39.866	.025	.278	.072	.177	.137	3	4	.175	.087
51	35.927	.027	.340	.027	.179	.163	3	4	.183	.073
52	34.231	.028	.314	.014	.180	.147	3	4	.164	.093
53	42.281	.022	.597	-.156	.208	.208	3	2	.221	.081
54	37.240	.025	.781	-.204	.273	.273	3	2	.289	.090
55	35.352	.025	1.050	-.555	.223	.212	3	7	.247	.082
56	45.697	.019	.266	.194	.228	.228	3	2	.230	.118
57	24.878	.030	.494	.452	.472	.472	3	2	.473	.142
58	30.637	.028	.348	.346	.347	.347	3	2	.347	.100
59	52.574	.018	1.437	-1.166	.164	.164	3	2	.135	.105
60	43.279	.020	.310	.084	.199	.199	3	2	.197	.122
61	45.470	.024	.307	.038	.175	.171	3	4	.173	.109
62	50.187	.022	.369	-.078	.151	.151	3	2	.145	.103
63	47.089	.023	.238	.108	.170	.170	3	2	.173	.101
64	12.781	.025	.440	-.020	.265	.150	3	3	.210	.116
65	45.504	.024	.191	.184	.188	.188	3	2	.188	.105
66	43.198	.025	.413	-.010	.200	.200	3	2	.202	.101
67	41.382	.026	.223	.176	.200	.200	3	2	.199	.103
68	44.980	.024	.264	.174	.217	.217	3	2	.219	.113
69	43.043	.024	.323	.223	.271	.271	3	2	.273	.103
70	33.597	.026	.332	.268	.355	.325	3	10	.300	.117
71	45.962	.022	.134	.095	.115	.115	3	2	.114	.068
72	47.456	.021	.150	.062	.152	.054	3	3	.106	.077
73	49.683	.020	.115	.096	.105	.105	3	2	.105	.084
74	50.996	.019	.156	.093	.123	.123	3	2	.124	.076
75	49.687	.019	.149	.133	.294	.075	3	4	.141	.082
76	33.553	.027	.270	.160	.213	.213	3	2	.215	.080
77	35.266	.025	.601	-.028	.278	.278	3	2	.286	.101
78	49.495	.020	.217	.095	.158	.158	3	2	.156	.100
79	36.782	.025	.203	.197	.200	.200	3	2	.200	.088
80	48.295	.020	.240	.125	.180	.180	3	2	.182	.078
81	51.238	.019	.209	.071	.193	.124	3	4	.140	.066
82	46.745	.020	.249	.127	.185	.185	3	2	.188	.074
83	37.446	.024	.262	.118	.189	.183	3	4	.190	.084
84	46.755	.019	.232	.215	.223	.223	3	2	.224	.072
85	44.311	.021	.270	.183	.215	.208	3	10	.227	.093
86	35.924	.025	.549	-.024	.255	.245	3	3	.262	.075
87	57.088	.020	.110	.076	.139	.092	3	4	.093	.064
88	45.435	.024	.151	.087	.113	.105	3	5	.119	.056
89	49.877	.022	.274	-.026	.106	.092	3	6	.124	.057
90	51.686	.021	.117	.107	.098	.089	3	6	.112	.071

Roughness coefficients, confidence limits and slopes.

Table 3.8

	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
91	52.506	.020	.190	.029	.100	.089	3	6	.110	.058
92	47.541	.022	.113	.078	.222	.051	3	8	.095	.058
93	54.219	.020	.115	.093	.095	.089	3	6	.104	.052
94	52.890	.020	.180	.049	.105	.093	3	6	.115	.054
95	54.292	.020	.212	.022	.105	.095	3	6	.117	.051
96	49.904	.022	.148	.085	.104	.094	3	6	.116	.053
97	50.935	.021	.194	.057	.106	.090	3	6	.126	.054
98	36.907	.026	.165	.165	.165	.165	2	2	.165	.075
99	41.186	.023	.155	.155	.180	.137	2	3	.155	.080
100	40.516	.024	.216	.107	.160	.160	3	2	.162	.077
101	37.254	.025	.173	.173	.173	.173	3	2	.173	.094
102	40.368	.024	.287	.130	.433	.045	3	4	.208	.080
103	45.691	.019	.159	.159	.217	.090	2	3	.159	.079
104	36.791	.025	.197	.197	.197	.197	2	2	.197	.085
105	36.821	.026	.206	.206	.206	.206	2	2	.206	.078
106	46.069	.021	.129	.129	.252	.039	2	3	.129	.067
107	42.590	.023	.122	.117	.119	.119	3	2	.119	.091
108	38.692	.026	.166	.150	.158	.158	3	2	.158	.077
109	42.619	.022	.160	.114	.138	.138	3	2	.137	.073
110	47.507	.020	.100	.099	.100	.100	3	2	.100	.070
111	51.415	.019	.093	.093	.140	.061	2	3	.093	.065
112	53.188	.018	.085	.085	.085	.085	2	2	.085	.064
113	40.081	.024	.273	-.046	.273	-.046	3	3	.114	.080
114	40.887	.023	.212	.132	.170	.170	3	2	.172	.074
115	41.935	.023	.227	.088	.154	.154	3	2	.157	.072
116	40.454	.023	.220	.137	.177	.177	3	2	.179	.084
117	44.271	.025	.415	-.101	.148	.148	3	2	.157	.064
118	43.940	.026	.155	.108	.116	.070	3	6	.131	.049
119	38.626	.029	.196	.106	.149	.149	3	2	.151	.049
120	48.314	.024	.164	.094	.130	.130	3	2	.129	.054
121	47.263	.024	.099	.087	.092	.092	3	2	.093	.061
122	58.682	.019	.115	.061	.090	.090	3	2	.088	.058
123	56.017	.020	.073	.072	.072	.072	3	2	.072	.051
124	40.035	.023	.199	.186	.192	.192	3	2	.193	.088
125	43.010	.022	.254	.078	.170	.170	3	2	.166	.071
126	39.014	.022	.302	.141	.219	.219	3	2	.222	.095
127	38.972	.029	.812	-.527	.152	.152	3	2	.143	.081
128	51.574	.022	.473	-.354	.380	-.196	3	3	.060	.079
129	49.393	.021	.383	-.102	.183	.169	3	7	.141	.080
130	33.188	.031	.755	-.304	.193	.163	3	6	.226	.085
131	44.926	.023	.272	.067	.174	.153	3	6	.169	.083
132	37.988	.028	.199	.146	.202	.184	3	7	.172	.078
133	38.899	.027	.268	.088	.203	.186	3	8	.178	.080
134	37.688	.027	1.651	-1.155	.203	.186	3	8	.248	.088
135	42.492	.024	.593	-.208	.323	.048	3	3	.193	.092

Roughness coefficients, confidence limits and slopes.

Table 3.8

	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
136	41.401	.025	.198	.193	.237	.149	3	3	.196	.091
137	39.828	.026	.250	.157	.281	.115	3	3	.203	.087
138	41.424	.025	.183	.159	.174	.168	3	3	.171	.091
139	39.971	.026	.239	.167	.250	.149	3	3	.203	.092
140	40.413	.025	.231	.123	.211	.199	3	7	.177	.089
141	41.993	.024	.202	.178	.205	.198	3	7	.190	.095
142	44.658	.023	.196	.133	.272	.070	3	3	.165	.086
143	43.968	.023	.357	.037	.207	.203	3	7	.197	.101
144	37.464	.027	.224	.089	.154	.154	3	2	.157	.097
145	42.591	.020	.267	.135	.458	-.024	3	3	.201	.095
146	50.432	.019	.152	.137	.145	.145	3	2	.144	.076
147	49.098	.020	.223	.058	.316	.019	3	3	.141	.072
148	44.512	.022	.220	.154	.314	.021	3	3	.187	.077
149	46.506	.021	.224	.149	.185	.185	3	2	.187	.072
150	36.751	.026	.323	.267	.340	.251	3	3	.295	.083
151	37.228	.025	.522	.034	.457	-.013	3	3	.278	.072
152	32.659	.026	.317	.212	.262	.262	3	2	.265	.098
153	43.317	.020	.316	.291	.303	.303	3	2	.304	.085
154	38.376	.022	.243	.224	.233	.233	3	2	.233	.092
155	36.091	.030	.319	.073	.319	.073	3	3	.196	.120
156	45.984	.024	.765	-.507	.469	-.091	3	4	.129	.091
157	40.923	.026	.762	-.443	.162	.162	3	2	.160	.095
158	45.002	.022	.264	.074	.165	.165	3	2	.169	.073
159	41.651	.023	.272	.079	.179	.179	3	2	.175	.080
160	34.895	.025	.206	.197	.202	.202	3	2	.202	.111
161	39.158	.022	.226	.188	.206	.206	3	2	.207	.086
162	38.038	.025	.195	.145	.181	.159	3	3	.170	.079
163	45.970	.020	.175	.134	.154	.154	3	2	.154	.070
164	42.523	.021	.186	.128	.156	.156	3	2	.157	.081
165	46.449	.020	.175	.136	.367	-.019	3	3	.156	.080
166	35.035	.025	.242	.191	.436	-.108	3	3	.216	.082
167	33.585	.027	.283	.283	.283	.283	3	2	.283	.074
168	37.379	.024	.434	-.054	.181	.181	3	2	.190	.141
169	38.452	.026	.171	.105	.212	.072	3	3	.138	.104
170	42.152	.021	.337	.163	.253	.253	3	2	.250	.075
171	44.447	.022	.293	.010	.236	.149	3	4	.151	.173
172	40.424	.024	.363	-.060	.257	.134	3	4	.152	.085
173	44.628	.022	.431	-.055	.265	.165	3	4	.188	.110
174	36.093	.027	.712	-.260	.215	.209	3	3	.226	.122
175	34.445	.029	.338	.105	.258	.189	3	3	.222	.121
176	36.069	.027	.481	.036	.252	.252	3	2	.259	.107
177	42.347	.023	.642	-.221	.198	.198	3	2	.211	.088
178	40.139	.022	.657	-.040	.271	.259	3	12	.308	.093
179	39.349	.022	.476	.128	.312	.272	3	3	.302	.113
180	40.069	.022	.368	.197	.313	.261	3	4	.282	.132

Roughness coefficients, confidence limits and slopes.

	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
181	35.242	.025	.415	.159	.321	.204	3	4	.287	.156
182	33.593	.026	.399	.153	.342	.217	3	3	.276	.119
183	53.834	.019	.142	.069	.135	.084	3	3	.105	.089
184	50.146	.020	.140	.091	.115	.115	3	2	.116	.087
185	28.771	.030	1.402	-.857	.254	.254	3	2	.272	.087
186	37.814	.024	.302	.152	.224	.224	3	2	.227	.082
187	37.249	.024	.360	.092	.221	.221	3	2	.226	.135
188	36.951	.024	.310	.187	.246	.246	3	2	.248	.138
189	44.580	.025	.125	.125	.125	.125	2	2	.125	.076
190	41.460	.027	.177	.090	.132	.132	3	2	.133	.044
191	47.528	.023	.393	-.148	.154	.082	3	3	.122	.059
192	44.359	.025	.328	-.031	.142	.142	3	2	.148	.069
193	43.055	.025	.143	.141	.142	.142	3	2	.142	.083
194	46.818	.023	.110	.108	.139	.116	3	5	.109	.065
195	44.768	.024	.146	.141	.143	.143	3	2	.143	.070
196	46.252	.020	.196	.196	.196	.196	3	2	.196	.077
197	51.332	.019	.449	-.069	.201	.165	3	3	.190	.050
198	50.101	.020	.170	.170	.170	.170	3	2	.170	.063
199	45.296	.022	.275	.070	.211	.138	3	3	.172	.064
200	47.876	.021	.173	.168	.171	.171	3	2	.171	.066
201	42.679	.023	.179	.178	.179	.179	3	2	.179	.063
202	46.718	.021	.232	.125	.176	.176	3	2	.178	.068
203	39.297	.024	.396	.005	.193	.193	3	2	.201	.060
204	43.974	.022	.144	.108	.126	.126	3	2	.126	.106
205	33.768	.028	.230	.212	.221	.221	3	2	.221	.102
206	41.416	.023	.240	.066	.186	.147	3	3	.153	.074
207	36.581	.024	.482	.016	.350	.105	3	3	.249	.101
208	42.017	.023	.219	.163	.276	.125	3	4	.191	.064
209	47.200	.020	.232	.161	.905	-.452	3	3	.197	.075
210	42.719	.023	.204	.115	.170	.143	3	3	.160	.067
211	44.078	.021	.226	.124	.173	.173	3	2	.175	.062
212	46.869	.022	.252	.087	.186	.143	3	3	.169	.067
213	44.578	.024	.177	.153	.164	.164	3	2	.165	.059
214	45.718	.023	.251	.087	.170	.160	3	3	.169	.082
215	44.378	.024	.249	.086	.164	.164	3	2	.168	.067
216	46.060	.023	.534	-.192	.160	.160	3	2	.171	.059
217	46.687	.022	.406	-.064	.163	.163	3	2	.171	.054
218	38.733	.027	.369	-.006	.174	.174	3	2	.181	.070
219	41.066	.025	.359	-.006	.170	.170	3	2	.177	.111
220	42.230	.024	.660	-.248	.168	.162	3	7	.206	.058
221	40.332	.025	.613	-.230	.197	.141	3	3	.191	.070
222	44.372	.022	.161	.154	.157	.157	3	2	.157	.067
223	42.329	.024	.166	.158	.236	.103	3	3	.162	.069
224	41.777	.024	.668	-.314	.165	.165	3	2	.177	.096
225	39.027	.026	.265	.094	.168	.162	3	7	.180	.058

Roughness coefficients, confidence limits and slopes.

No.	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
226	36.499	.027	.249	.087	.165	.165	3	2	.168	.095
227	43.401	.023	.219	.086	.505	-.174	3	3	.152	.079
228	39.520	.025	.221	.086	.151	.151	3	2	.153	.103
229	62.094	.019	.085	.085	.170	.170	3	2	.085	.056
230	60.814	.019	.134	.034	.149	.030	3	3	.084	.044
231	53.849	.021	.167	.042	.102	.102	3	2	.105	.091
232	64.326	.018	.086	.086	.086	.086	3	2	.086	.055
233	57.719	.020	.083	.083	.083	.083	3	2	.083	.084
234	32.163	.029	.210	.210	.222	.185	2	4	.210	.069
235	42.731	.020	.225	.149	.222	.185	3	4	.187	.119
236	38.075	.023	.364	.213	.286	.286	3	2	.289	.149
237	36.564	.024	.309	.169	.292	.169	3	3	.239	.097
238	40.448	.022	.312	.170	.265	.205	3	3	.241	.067
239	40.027	.023	.312	.171	.238	.238	3	2	.241	.075
240	39.119	.026	.894	-.492	.125	.093	3	4	.201	.061
241	49.324	.021	.162	.099	.129	.129	3	2	.131	.062
242	45.901	.022	.239	-.003	.133	.121	3	5	.118	.068
243	51.495	.020	.144	.088	.115	.115	3	2	.116	.067
244	42.764	.024	.137	.105	.121	.121	3	2	.121	.068
245	52.921	.019	.126	.123	.125	.125	3	2	.125	.066
246	49.689	.020	.669	-.346	.148	.105	3	5	.162	.065
247	44.977	.022	.141	.132	.136	.136	3	2	.136	.068
248	47.428	.021	.202	.056	.141	.116	3	8	.129	.069
249	48.735	.021	.190	.053	.144	.113	3	7	.122	.063
250	47.751	.021	.417	-.166	.157	.113	3	3	.125	.062
251	49.323	.020	.417	-.170	.145	.124	3	3	.124	.065
252	40.825	.022	.216	.169	.546	-.105	3	3	.192	.085
253	39.395	.023	.508	-.135	.586	-.139	3	3	.187	.076
254	41.894	.021	.209	.168	.557	-.121	3	3	.189	.086
255	42.999	.021	.249	.158	.417	.026	3	3	.203	.076
256	42.574	.020	.372	.031	.195	.195	3	2	.202	.102
257	42.182	.024	.109	.105	.117	.095	3	3	.107	.080
258	37.567	.027	.214	.069	.139	.139	3	2	.142	.068
259	46.716	.021	1.165	-.851	.218	.155	3	6	.157	.064
260	47.693	.020	.442	-.136	.177	.149	3	5	.153	.066
261	30.792	.030	.884	-.314	.270	.262	3	3	.285	.091
262	52.325	.019	.132	.132	.194	.142	2	3	.132	.064
263	44.229	.022	.459	-.102	.185	.155	3	3	.178	.070
264	48.655	.020	.459	-.102	.170	.170	3	2	.178	.068
265	45.941	.021	.288	-.040	.162	.138	3	8	.124	.072
266	51.473	.019	.206	.091	.305	.044	3	3	.148	.068
267	46.996	.021	.280	.044	.236	.106	3	3	.162	.072
268	48.300	.020	.231	.097	.241	.109	3	3	.164	.055
269	47.930	.020	.221	.122	.190	.157	3	3	.172	.074
270	38.444	.023	.422	.078	.263	.219	3	3	.250	.080

Roughness coefficients, confidence limits and slopes.

No.	Measured Coefficient Chezy	Mannings N.	(- - - - - - - - Conf. Limits - - - - - - - -) Study Reach (10**-3)		Structure To Structure (10**-3)		NE	NH	Meas. Slope	Lacey Slope
271	39.903	.022	.453	.084	.265	.256	3	3	.268	.083
272	53.233	.022	.140	.054	.098	.098	3	2	.097	.069
273	47.079	.025	.128	.128	.128	.128	3	2	.128	.068
274	59.007	.020	.099	.086	.092	.092	3	2	.092	.044
275	44.417	.021	.147	.133	.142	.140	3	4	.140	.078
276	54.785	.019	.161	.110	.161	.104	3	3	.136	.063
277	45.690	.022	.228	.110	.282	-.009	3	3	.169	.068
278	38.591	.025	.220	.166	.192	.192	3	2	.193	.063
279	43.211	.022	.253	.140	.194	.194	3	2	.196	.055
280	52.953	.018	.264	.078	.258	.164	3	4	.171	.071
281	38.000	.025	.239	.070	.239	.070	3	3	.155	.082
282	38.591	.025	.114	.114	.116	.111	3	5	.114	.065
283	47.979	.020	.136	.070	.138	.082	3	3	.103	.078
284	49.522	.018	.449	-.111	.758	-.283	3	3	.169	.079
285	34.283	.027	.960	-.509	.209	.209	3	2	.225	.108
286	42.069	.022	.409	.041	.209	.198	3	6	.225	.125
287	45.574	.020	.154	.134	.207	.165	5	6	.144	.124
288	36.948	.025	.331	.103	.211	.199	3	6	.217	.133
289	36.546	.026	.736	-.312	.215	.164	3	6	.212	.080
290	39.797	.023	.516	-.130	.204	.195	3	6	.193	.073
291	45.175	.021	.155	.110	.216	.162	3	6	.133	.122
292	36.255	.026	.213	.187	.200	.200	3	2	.200	.147

Sum Of Deviation [95% conf. limits]	37.756	9.547
Number Of Data Sets Used	270	161

Roughness coefficients, confidence limits and slopes.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
1	153.00	132.08	170.64	162.41	174.88	127.37	1.12	1.14	1.06	.96
2	174.00	130.75	181.88	164.12	191.92	169.76	1.05	1.10	.94	1.30
3	171.67	145.63	171.82	158.96	179.69	141.23	1.00	1.05	.93	.97
4	183.00	160.21	176.97	162.86	184.24	134.27	.97	1.01	.89	.84
5	184.00	162.23	182.41	179.03	185.66	143.09	.99	1.01	.97	.88
6	182.00	169.49	183.94	164.44	190.36	126.50	1.01	1.05	.90	.75
7	151.00	128.75	174.65	159.76	179.98	135.37	1.16	1.19	1.06	1.05
8	151.00	134.68	186.41	168.66	194.40	162.29	1.23	1.29	1.12	1.20
9	150.00	135.93	179.50	172.26	183.37	145.40	1.20	1.22	1.15	1.07
10	166.00	137.75	173.42	166.69	179.55	147.89	1.04	1.08	1.00	1.07
11	166.00	148.15	183.04	164.74	189.16	134.60	1.10	1.14	.99	.91
12	166.00	153.54	176.77	158.15	184.92	138.99	1.06	1.11	.95	.91
13	165.33	150.71	174.07	168.64	183.49	180.11	1.05	1.11	1.02	1.20
14	168.33	152.65	178.70	172.58	185.45	161.21	1.06	1.10	1.03	1.06
15	158.00	141.15	182.68	166.69	192.14	165.34	1.16	1.22	1.05	1.17
16	157.00	145.65	175.36	161.92	184.54	153.16	1.12	1.18	1.03	1.05
17	163.00	148.41	162.51	157.30	166.94	133.14	1.00	1.02	.97	.90
18	163.00	148.25	177.10	148.76	186.88	127.66	1.09	1.15	.91	.86
19	162.00	151.29	174.54	156.13	182.02	135.20	1.08	1.12	.96	.89
20	23.50	19.73	18.62	23.21	19.80	14.50	.79	.84	.99	.73
21	9.00	7.73	12.81	13.84	14.17	10.29	1.42	1.57	1.54	1.33
22	23.00	18.66	18.81	23.87	20.18	17.41	.82	.88	1.04	.93
23	11.50	8.24	13.87	15.32	15.07	9.59	1.21	1.31	1.33	1.16
24	26.00	24.70	22.79	30.49	23.76	21.23	.88	.91	1.17	.86
25	25.00	22.60	27.18	34.03	28.55	25.83	1.09	1.14	1.36	1.14
26	25.80	23.59	25.99	37.51	26.70	28.53	1.01	1.03	1.45	1.21
27	23.40	21.38	22.73	26.30	24.43	18.04	.97	1.04	1.12	.84
28	19.50	15.29	21.99	24.23	23.90	18.43	1.13	1.23	1.24	1.21
29	21.00	16.22	23.09	25.81	24.78	18.35	1.10	1.18	1.23	1.13
30	18.00	16.24	20.34	23.43	21.75	15.05	1.13	1.21	1.30	.93
31	15.00	13.47	16.94	18.99	18.44	13.38	1.13	1.23	1.27	.99
32	9.60	8.42	9.46	12.21	10.14	8.21	.99	1.06	1.27	.97
33	19.83	14.95	17.99	21.10	19.49	15.45	.91	.98	1.06	1.03
34	19.50	17.80	17.88	22.28	19.30	16.60	.92	.99	1.14	.93
35	12.50	10.32	12.85	16.43	13.76	9.39	1.03	1.10	1.31	.91
36	14.00	11.73	15.14	18.25	16.33	12.22	1.08	1.17	1.30	1.04
37	13.00	9.05	15.43	18.05	16.65	13.40	1.19	1.28	1.39	1.48
38	13.50	9.98	15.89	18.27	17.32	14.45	1.18	1.28	1.35	1.45
39	13.00	10.82	14.46	18.84	15.36	13.15	1.11	1.18	1.45	1.22
40	13.17	9.85	13.00	15.82	14.10	11.66	.99	1.07	1.20	1.18
41	12.00	8.47	12.11	15.79	12.74	9.48	1.01	1.06	1.32	1.12
42	13.50	6.43	13.80	16.98	14.76	12.35	1.02	1.09	1.26	1.92
43	10.50	7.75	12.28	15.39	13.10	10.50	1.17	1.25	1.47	1.35
44	50.50	48.09	38.48	50.88	40.04	37.28	.76	.79	1.01	.78
45	18.00	12.44	18.16	22.14	19.50	17.70	1.01	1.08	1.23	1.42

Measured and predicted widths.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
46	14.00	11.82	12.78	18.30	13.55	11.97	.91	.97	1.31	1.01
47	54.00	48.38	38.55	51.33	40.16	39.32	.71	.74	.95	.81
48	53.00	47.23	34.78	42.39	37.21	31.66	.66	.70	.80	.67
49	32.50	29.27	34.75	42.93	36.32	35.52	1.07	1.12	1.32	1.21
50	33.00	25.49	36.97	39.97	39.40	32.45	1.12	1.19	1.21	1.27
51	27.50	21.24	30.59	33.27	32.92	28.53	1.11	1.20	1.21	1.34
52	27.60	24.67	28.58	32.59	30.37	25.68	1.04	1.10	1.18	1.04
53	27.00	25.87	26.80	30.99	29.06	23.45	.99	1.08	1.15	.91
54	27.00	24.75	27.94	29.71	30.61	22.07	1.03	1.13	1.10	.89
55	28.00	25.54	21.76	25.81	23.76	18.84	.78	.85	.92	.74
56	10.00	6.03	12.30	14.94	13.28	10.28	1.23	1.33	1.49	1.70
57	5.00	3.41	4.24	5.31	4.77	3.11	.85	.95	1.06	.91
58	11.50	10.24	13.32	14.59	14.77	10.47	1.16	1.28	1.27	1.02
59	11.50	10.41	21.36	25.19	22.43	20.00	1.86	1.95	2.19	1.92
60	28.00	25.16	17.24	23.77	18.40	14.32	.62	.66	.85	.57
61	128.00	114.49	118.35	113.91	123.88	86.75	.92	.97	.89	.76
62	120.00	108.27	118.77	118.19	123.44	92.34	.99	1.03	.98	.85
63	101.00	91.71	111.89	105.98	117.49	84.46	1.11	1.16	1.05	.92
64	120.00	107.01	106.75	100.77	112.75	73.83	.89	.94	.84	.69
65	102.00	88.00	104.80	99.29	110.40	76.99	1.03	1.08	.97	.87
66	97.00	85.45	102.67	95.26	108.72	75.08	1.06	1.12	.98	.88
67	94.00	83.81	100.60	93.08	106.42	73.58	1.07	1.13	.99	.88
68	76.00	69.90	89.47	83.07	94.95	62.85	1.18	1.25	1.09	.90
69	72.00	63.98	76.82	71.05	82.78	53.34	1.07	1.15	.99	.83
70	13.50	11.53	14.46	16.47	15.83	11.17	1.07	1.17	1.22	.97
71	46.80	41.53	42.62	52.11	44.72	44.22	.91	.96	1.11	1.06
72	36.50	30.53	40.45	48.64	42.15	41.43	1.11	1.15	1.33	1.36
73	31.00	28.79	36.17	44.69	37.60	36.62	1.17	1.21	1.44	1.27
74	30.00	28.66	37.41	44.48	39.34	37.25	1.25	1.31	1.48	1.30
75	19.80	13.23	25.32	30.13	26.82	24.84	1.28	1.35	1.52	1.88
76	17.00	16.26	17.73	20.92	19.27	16.31	1.04	1.13	1.23	1.00
77	11.00	8.31	15.22	16.40	16.69	12.37	1.38	1.52	1.49	1.49
78	26.20	23.19	35.62	40.00	37.59	30.97	1.36	1.43	1.53	1.34
79	14.40	13.03	19.99	22.34	21.55	17.98	1.39	1.50	1.55	1.38
80	48.00	39.31	42.76	48.62	45.78	37.90	.89	.95	1.01	.96
81	28.00	25.06	35.16	41.18	37.38	35.60	1.26	1.34	1.47	1.42
82	31.00	26.34	28.99	34.59	31.23	26.87	.94	1.01	1.12	1.02
83	30.50	27.04	24.17	29.53	26.00	21.91	.79	.85	.97	.81
84	12.00	8.75	14.46	17.64	15.82	13.87	1.20	1.32	1.47	1.59
85	30.00	27.14	28.63	32.96	30.93	23.72	.95	1.03	1.10	.87
86	27.00	23.34	21.33	25.01	23.44	18.73	.79	.87	.93	.80
87	124.00	111.08	121.61	132.79	125.32	121.73	.98	1.01	1.07	1.10
88	82.00	72.94	83.19	88.61	87.49	84.57	1.01	1.07	1.08	1.16
89	66.00	59.71	77.15	81.97	81.34	78.11	1.17	1.23	1.24	1.31
90	67.00	58.11	76.78	83.53	79.95	74.41	1.15	1.19	1.25	1.28

Measured and predicted widths.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
91	67.00	60.92	77.09	84.61	80.73	79.99	1.15	1.20	1.26	1.31
92	66.00	59.69	68.28	78.33	71.05	74.04	1.03	1.08	1.19	1.24
93	67.00	59.26	76.95	85.55	80.58	83.39	1.15	1.20	1.28	1.41
94	67.00	57.23	78.70	84.78	82.75	82.33	1.17	1.24	1.27	1.44
95	66.00	59.68	77.78	84.43	81.99	82.16	1.18	1.24	1.28	1.38
96	66.00	58.97	76.57	82.32	80.62	80.18	1.16	1.22	1.25	1.36
97	67.00	59.34	79.15	83.56	83.60	80.80	1.18	1.25	1.25	1.36
98	33.00	25.72	27.87	33.15	29.83	26.69	.84	.90	1.00	1.04
99	22.00	18.65	25.41	30.02	27.07	24.47	1.16	1.23	1.36	1.31
100	26.00	22.51	30.54	34.65	32.60	28.98	1.17	1.25	1.33	1.29
101	19.50	17.65	20.55	24.83	21.94	18.78	1.05	1.13	1.27	1.06
102	24.50	21.87	28.83	31.74	31.16	25.53	1.18	1.27	1.30	1.17
103	20.00	16.82	17.00	23.03	18.20	17.01	.85	.91	1.15	1.01
104	30.00	26.36	26.34	30.83	28.35	23.38	.88	.94	1.03	.89
105	32.00	26.47	29.53	33.20	31.91	26.36	.92	1.00	1.04	1.00
106	36.50	33.44	37.93	45.36	40.12	38.88	1.04	1.10	1.24	1.16
107	33.00	30.03	34.46	41.74	35.97	33.06	1.04	1.09	1.26	1.10
108	33.00	30.01	36.39	40.62	38.74	34.12	1.10	1.17	1.23	1.14
109	26.50	21.38	26.00	32.26	27.60	26.54	.98	1.04	1.22	1.24
110	23.00	20.04	24.54	32.69	25.65	27.64	1.07	1.12	1.42	1.38
111	39.50	29.08	37.44	48.05	38.96	41.97	.95	.99	1.22	1.44
112	38.00	32.20	34.81	47.09	36.09	40.31	.92	.95	1.24	1.25
113	23.00	16.40	25.09	30.92	26.29	26.17	1.09	1.14	1.34	1.60
114	21.00	17.83	22.62	27.11	24.31	22.00	1.08	1.16	1.29	1.23
115	29.00	24.73	28.62	34.23	30.59	28.06	.99	1.05	1.18	1.13
116	21.00	17.65	22.03	26.42	23.63	20.47	1.05	1.13	1.26	1.16
117	109.00	91.68	116.72	110.25	123.58	102.93	1.07	1.13	1.01	1.12
118	109.00	91.91	116.38	113.19	123.13	116.49	1.07	1.13	1.04	1.27
119	76.00	64.62	99.83	91.63	106.48	97.58	1.31	1.40	1.21	1.51
120	78.00	61.17	109.32	103.43	115.27	107.22	1.40	1.48	1.33	1.75
121	81.00	70.28	98.90	103.56	102.25	102.54	1.22	1.26	1.28	1.46
122	85.00	70.74	108.09	115.43	111.58	114.22	1.27	1.31	1.36	1.61
123	81.00	72.39	103.29	114.62	106.01	120.26	1.28	1.31	1.42	1.66
124	20.00	16.49	21.44	25.31	23.07	19.36	1.07	1.15	1.27	1.17
125	20.50	15.80	24.07	28.25	25.84	23.75	1.17	1.26	1.38	1.50
126	13.00	11.12	14.28	17.48	15.48	12.66	1.10	1.19	1.34	1.14
127	99.00	81.29	105.28	100.38	110.27	89.66	1.06	1.11	1.01	1.10
128	99.00	82.51	104.34	121.03	104.58	111.51	1.05	1.06	1.22	1.35
129	112.00	103.57	93.69	100.38	98.19	81.21	.84	.88	.90	.78
130	112.00	100.71	80.57	78.34	86.46	61.95	.72	.77	.70	.62
131	112.00	97.02	91.61	93.76	96.82	75.03	.82	.86	.84	.77
132	103.00	88.52	91.57	89.43	97.08	76.32	.89	.94	.87	.86
133	104.00	94.05	88.25	87.78	93.65	72.51	.85	.90	.84	.77
134	119.00	108.89	86.37	83.54	92.75	63.60	.73	.78	.70	.58
135	118.00	108.94	83.85	87.09	89.01	65.07	.71	.75	.74	.60

Measured and predicted widths.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
136	93.00	88.14	80.53	80.97	85.60	62.67	.87	.92	.87	.71
137	94.00	81.67	80.50	79.40	85.87	63.04	.86	.91	.84	.77
138	91.00	83.79	77.14	79.95	81.49	62.47	.85	.90	.88	.75
139	91.00	79.35	78.77	77.93	83.88	60.79	.87	.92	.86	.77
140	78.00	67.21	65.94	69.05	69.93	54.23	.85	.90	.89	.81
141	75.50	64.33	63.69	66.66	67.68	50.61	.84	.90	.88	.79
142	77.00	70.74	66.39	71.68	70.20	55.99	.86	.91	.93	.79
143	75.00	61.78	67.21	68.85	71.38	51.63	.90	.95	.92	.84
144	42.00	35.60	41.09	45.52	43.36	35.55	.98	1.03	1.08	1.00
145	16.00	11.22	14.61	18.70	15.76	13.27	.91	.99	1.17	1.18
146	41.50	39.71	40.04	48.17	42.40	38.12	.96	1.02	1.16	.96
147	40.50	39.13	39.64	47.65	41.99	38.61	.98	1.04	1.18	.99
148	37.00	33.78	37.95	42.57	40.73	33.96	1.03	1.10	1.15	1.01
149	36.00	34.65	38.89	43.54	41.83	35.47	1.08	1.16	1.21	1.02
150	23.50	21.95	27.88	28.76	30.64	22.39	1.19	1.30	1.22	1.02
151	24.00	22.32	28.97	29.94	31.87	24.53	1.21	1.33	1.25	1.10
152	16.90	13.62	13.52	16.62	14.79	11.43	.80	.88	.98	.84
153	16.00	14.53	15.25	18.48	16.86	12.82	.95	1.05	1.16	.88
154	11.30	8.95	10.92	14.06	11.91	9.90	.97	1.05	1.24	1.11
155	42.00	34.85	62.90	57.27	66.47	46.27	1.50	1.58	1.36	1.33
156	42.00	34.98	66.24	66.12	69.07	58.46	1.58	1.64	1.57	1.67
157	44.00	36.70	62.68	61.00	66.02	52.08	1.42	1.50	1.39	1.42
158	42.00	37.01	47.16	50.95	50.36	43.06	1.12	1.20	1.21	1.16
159	40.00	35.01	33.11	39.29	35.42	30.18	.83	.89	.98	.86
160	10.00	7.18	12.68	15.04	13.63	11.11	1.27	1.36	1.50	1.55
161	10.00	6.71	12.12	14.78	13.15	11.47	1.21	1.32	1.48	1.71
162	25.50	21.57	26.17	30.58	28.02	24.67	1.03	1.10	1.20	1.15
163	26.00	19.14	26.08	31.73	27.89	26.15	1.00	1.07	1.22	1.37
164	16.50	13.80	17.56	22.42	18.77	17.42	1.06	1.14	1.36	1.26
165	17.20	13.38	19.48	24.42	20.80	19.29	1.13	1.21	1.42	1.44
166	12.00	9.80	11.97	15.08	13.05	11.36	1.00	1.09	1.26	1.16
167	18.50	14.55	18.24	20.36	20.15	16.01	.99	1.09	1.10	1.10
168	18.00	14.56	17.89	21.81	18.97	14.32	.99	1.05	1.21	.98
169	34.00	30.64	35.88	41.31	37.57	31.79	1.06	1.10	1.21	1.04
170	15.00	12.83	18.32	20.99	20.10	16.50	1.22	1.34	1.40	1.29
171	53.20	46.04	45.43	52.67	46.96	32.97	.85	.88	.99	.72
172	54.00	47.93	40.92	48.61	43.29	37.15	.76	.80	.90	.78
173	53.00	47.26	44.36	50.20	47.05	35.06	.84	.89	.95	.74
174	49.00	39.02	44.52	45.88	47.51	32.56	.91	.97	.94	.83
175	46.00	38.48	41.18	43.11	43.94	30.55	.90	.96	.94	.79
176	46.50	38.47	43.68	44.07	47.13	32.13	.94	1.01	.95	.84
177	49.00	44.93	42.18	46.68	45.32	34.77	.86	.92	.95	.77
178	29.00	25.81	23.29	26.71	25.61	18.21	.80	.88	.92	.71
179	28.50	26.95	22.70	26.33	24.79	16.89	.80	.87	.92	.63
180	26.50	23.11	23.24	26.56	25.17	16.75	.88	.95	1.00	.72

Measured and predicted widths.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
181	19.00	13.84	17.58	19.96	19.00	12.33	.93	1.00	1.05	.89
182	19.00	13.94	16.72	19.29	18.19	12.93	.88	.96	1.02	.93
183	45.50	37.16	51.43	60.54	53.22	49.34	1.13	1.17	1.33	1.33
184	45.00	36.47	50.77	58.24	52.82	47.84	1.13	1.17	1.29	1.31
185	9.50	7.59	10.53	12.30	11.61	9.40	1.11	1.22	1.29	1.24
186	19.40	15.40	19.80	22.96	21.54	17.63	1.02	1.11	1.18	1.14
187	17.20	11.78	17.92	20.70	19.20	13.89	1.04	1.12	1.20	1.18
188	13.20	10.48	15.10	17.56	16.27	11.57	1.14	1.23	1.33	1.10
189	98.00	88.08	104.11	104.96	108.54	93.60	1.06	1.11	1.07	1.06
190	103.00	92.07	102.62	102.46	109.10	106.54	1.00	1.06	.99	1.16
191	120.00	100.60	96.16	104.04	101.00	94.58	.80	.84	.87	.94
192	88.50	81.06	93.00	93.12	98.19	83.24	1.05	1.11	1.05	1.03
193	98.00	85.80	91.91	93.91	96.27	78.67	.94	.98	.96	.92
194	97.50	86.94	87.86	96.68	91.50	86.82	.90	.94	.99	1.00
195	97.50	84.47	90.25	93.10	95.09	81.42	.93	.98	.95	.96
196	31.00	26.00	27.04	32.71	29.18	24.71	.87	.94	1.06	.95
197	47.80	42.96	51.98	55.92	56.44	51.15	1.09	1.18	1.17	1.19
198	48.00	43.95	51.94	56.80	55.67	48.98	1.08	1.16	1.18	1.11
199	39.50	33.71	45.34	48.85	48.68	43.02	1.15	1.23	1.24	1.28
200	36.00	32.08	40.42	45.25	43.36	38.41	1.12	1.20	1.26	1.20
201	33.00	27.25	38.81	41.87	41.80	37.09	1.18	1.27	1.27	1.36
202	33.00	26.86	39.17	42.75	42.10	36.71	1.19	1.28	1.30	1.37
203	37.50	31.54	32.61	37.08	35.44	31.28	.87	.95	.99	.99
204	40.00	34.84	35.59	43.85	37.08	32.07	.89	.93	1.10	.92
205	30.00	27.74	26.37	29.98	28.39	21.52	.88	.95	1.00	.78
206	29.20	26.82	27.26	33.51	29.08	26.84	.93	1.00	1.15	1.00
207	15.00	10.62	13.73	16.71	14.96	11.68	.92	1.00	1.11	1.10
208	29.20	26.75	32.71	36.46	35.41	31.26	1.12	1.21	1.25	1.17
209	17.80	14.25	26.98	29.33	29.14	24.85	1.52	1.64	1.65	1.74
210	38.30	34.40	34.83	41.20	37.28	34.12	.91	.97	1.08	.99
211	19.50	16.86	24.58	28.52	26.57	24.82	1.26	1.36	1.46	1.47
212	51.00	43.45	62.47	63.67	66.69	56.73	1.22	1.31	1.25	1.31
213	53.00	46.34	64.37	65.26	68.89	61.03	1.21	1.30	1.23	1.32
214	53.50	46.87	64.93	65.81	68.86	55.31	1.21	1.29	1.23	1.18
215	51.00	44.85	66.12	65.72	70.53	59.87	1.30	1.38	1.29	1.34
216	57.50	51.56	65.26	66.99	69.96	61.18	1.13	1.22	1.17	1.19
217	59.00	52.59	63.86	66.48	68.67	61.75	1.08	1.16	1.13	1.17
218	54.50	48.20	56.09	57.70	60.07	49.94	1.03	1.10	1.06	1.04
219	56.00	50.67	53.08	56.86	56.00	41.67	.95	1.00	1.02	.82
220	55.50	47.69	53.41	55.57	57.94	49.04	.96	1.04	1.00	1.03
221	59.00	52.57	49.55	53.90	53.27	44.09	.84	.90	.91	.84
222	63.50	58.34	52.71	59.88	56.16	49.60	.83	.88	.94	.85
223	63.50	58.51	52.65	59.09	56.12	48.75	.83	.88	.93	.83
224	57.00	50.04	47.88	53.30	50.80	39.69	.84	.89	.94	.79
225	53.00	46.13	49.01	52.63	52.83	46.89	.92	1.00	.99	1.02

Measured and predicted widths.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
226	55.00	44.74	44.95	49.68	47.61	38.08	.82	.87	.90	.85
227	46.00	40.32	46.56	51.91	49.32	42.51	1.01	1.07	1.13	1.05
228	47.50	40.90	43.32	48.88	45.56	36.82	.91	.96	1.03	.90
229	133.00	114.52	156.52	162.78	160.88	163.05	1.18	1.21	1.22	1.42
230	148.80	132.71	145.73	158.72	150.91	164.76	.98	1.01	1.07	1.24
231	150.00	131.71	136.04	143.21	139.41	117.59	.91	.93	.95	.89
232	132.50	122.41	146.03	157.23	150.27	153.05	1.10	1.13	1.19	1.25
233	132.00	120.68	132.79	145.34	134.86	124.70	1.01	1.02	1.10	1.03
234	20.50	16.82	20.39	23.36	22.21	19.46	.99	1.08	1.14	1.16
235	19.00	15.74	16.43	21.45	17.51	14.01	.86	.92	1.13	.89
236	11.50	4.56	13.65	14.82	14.80	9.93	1.19	1.29	1.29.	2.18
237	13.50	10.65	14.59	17.32	15.88	12.61	1.08	1.18	1.28	1.18
238	13.50	10.69	17.93	20.10	19.71	16.88	1.33	1.46	1.49	1.58
239	14.00	11.56	18.40	20.62	20.15	16.69	1.31	1.44	1.47	1.44
240	46.00	39.82	50.04	51.01	54.16	45.79	1.09	1.18	1.11	1.15
241	50.00	44.36	52.73	60.02	55.78	53.33	1.05	1.12	1.20	1.20
242	52.00	46.08	51.67	59.89	54.22	52.08	.99	1.04	1.15	1.13
243	50.00	43.92	54.98	63.29	57.65	55.72	1.10	1.15	1.27	1.27
244	39.00	33.26	42.53	49.01	44.78	43.54	1.09	1.15	1.26	1.31
245	39.00	33.95	45.46	52.98	47.94	46.23	1.17	1.23	1.36	1.36
246	40.00	34.24	47.90	52.14	51.20	45.66	1.20	1.28	1.30	1.33
247	40.00	34.33	41.87	48.27	44.35	41.63	1.05	1.11	1.21	1.21
248	38.00	31.65	45.35	51.12	47.85	45.17	1.19	1.26	1.35	1.43
249	38.00	28.62	44.08	50.44	46.51	45.99	1.16	1.22	1.33	1.61
250	36.00	28.92	43.00	49.01	45.47	44.76	1.19	1.26	1.36	1.55
251	40.00	29.67	43.54	50.42	45.93	44.78	1.09	1.15	1.26	1.51
252	17.50	14.31	18.20	22.25	19.62	16.90	1.04	1.12	1.27	1.18
253	17.00	14.54	19.92	23.51	21.51	19.11	1.17	1.27	1.38	1.31
254	17.50	14.97	17.82	22.22	19.19	16.61	1.02	1.10	1.27	1.11
255	17.00	14.47	20.16	23.73	21.87	18.89	1.19	1.29	1.40	1.31
256	9.00	6.45	9.72	12.89	10.49	8.98	1.08	1.17	1.43	1.39
257	50.00	43.60	46.65	55.60	48.50	46.37	.93	.97	1.11	1.06
258	47.50	39.82	42.47	48.34	45.07	41.78	.89	.95	1.02	1.05
259	34.00	30.75	35.08	41.26	37.55	34.87	1.03	1.10	1.21	1.13
260	34.00	28.05	36.38	42.23	38.85	35.94	1.07	1.14	1.24	1.28
261	10.00	5.68	16.15	15.83	17.76	13.48	1.61	1.78	1.58	2.37
262	25.00	18.61	31.84	37.65	33.80	33.34	1.27	1.35	1.51	1.79
263	25.00	19.02	31.57	34.70	33.96	29.89	1.26	1.36	1.39	1.57
264	25.00	18.54	34.72	37.43	37.35	32.87	1.39	1.49	1.50	1.77
265	29.00	25.21	32.15	39.05	33.89	33.00	1.11	1.17	1.35	1.31
266	28.00	22.87	32.36	38.40	34.49	32.32	1.16	1.23	1.37	1.41
267	28.00	22.97	32.98	37.73	35.25	31.60	1.18	1.26	1.35	1.38
268	27.00	20.02	32.15	36.58	34.69	33.36	1.19	1.28	1.35	1.67
269	28.00	22.94	30.57	35.69	32.77	28.87	1.09	1.17	1.27	1.26
270	19.50	15.34	18.54	21.72	20.30	16.37	.95	1.04	1.11	1.07

Measured and predicted widths.

	Width (ft)						Ratio			
	(- - - Measured - - -)		(- - - - - - - - Predicted - - - - - - - - -)				Predicted / Measured			
No.	Top width	Bed width	Top width Lacey	Top width Yalin	Top width Chang	Bed Width Velikanov	Top Width Lacey	Top Width Chang	Top Width Yalin	Bed width Velikanov
271	20.00	15.42	20.01	22.78	21.96	17.07	1.00	1.10	1.14	1.11
272	109.50	99.13	136.67	137.59	140.70	130.96	1.25	1.28	1.26	1.32
273	110.00	97.45	142.51	132.15	148.77	127.12	1.30	1.35	1.20	1.30
274	109.50	99.02	142.88	145.37	148.64	157.44	1.30	1.36	1.33	1.59
275	17.50	12.85	18.93	24.14	20.12	19.42	1.08	1.15	1.38	1.51
276	50.00	44.36	56.09	63.26	59.38	55.54	1.12	1.19	1.27	1.25
277	48.00	39.98	48.17	52.82	51.52	44.78	1.00	1.07	1.10	1.12
278	19.10	15.30	24.88	27.32	27.01	24.42	1.30	1.41	1.43	1.60
279	22.00	17.05	28.59	31.18	31.17	28.73	1.30	1.42	1.42	1.69
280	22.00	17.12	32.62	35.99	34.98	30.96	1.48	1.59	1.64	1.81
281	24.00	16.79	23.56	28.16	25.09	22.72	.98	1.05	1.17	1.35
282	33.00	25.95	30.72	37.84	32.36	33.38	.93	.98	1.15	1.29
283	18.00	14.98	21.75	28.60	22.72	23.76	1.21	1.26	1.59	1.59
284	14.00	9.65	18.43	22.33	19.78	18.03	1.32	1.41	1.60	1.87
285	27.00	24.60	23.78	27.43	25.61	19.23	.88	.95	1.02	.78
286	25.53	23.99	26.90	30.57	28.81	20.57	1.05	1.13	1.20	.86
287	25.50	22.89	24.90	31.57	26.06	21.48	.98	1.02	1.24	.94
288	27.00	25.60	24.84	28.86	26.52	18.96	.92	.98	1.07	.74
289	26.37	23.09	25.20	28.86	27.29	22.47	.96	1.04	1.09	.97
290	25.33	23.30	25.25	29.67	27.28	23.65	1.00	1.08	1.17	1.01
291	18.00	15.54	21.47	27.03	22.40	19.27	1.19	1.24	1.50	1.24
292	17.00	15.68	21.73	24.37	23.04	16.64	1.28	1.36	1.43	1.06
Average							1.05	1.12	1.18	1.14
Standard Daviation							.17	.18	.20	.29

Measured and predicted widths.

Systems	Number of Measurements	Ratios predicted/measured velocities					
		Lacey	EH	AW	KK	VR	HDC
Depalpur	115	0.93	1.06	1.15	0.93	1.07	1.00
Mailsi	52	0.91	1.11	1.15	0.92	1.06	1.01
Lower Gugera	12	0.93	1.01	1.05	0.94	1.02	1.00
Upper Gugera (disties)	38	0.94	1.02	1.24	0.91	1.15	1.01
Upper Gugera (branch)	19	0.96	1.09	0.94	0.96	0.96	0.98
Sind	48	0.85	1.06	1.16	0.84	1.07	1.00
All Systems	248	0.92	1.06	1.15	0.91	1.07	1.00

AW = Ackers and White
EH = Englund and Hansen
KK = Karim and Kenndy
VR = Van Rijn
HDC = Hydraulic Design Criteria

Systems	Number of Measurements	Standard deviation Ratios predicted/measured velocities					
		Lacey	EH	AW	KK	VR	HDC
Depalpur	115	0.09	0.13	0.11	0.10	0.09	0.08
Mailsi	52	0.10	0.14	0.13	0.08	0.11	0.08
Lower Gugera	12	0.07	0.11	0.13	0.08	0.10	0.07
Upper Gugera (disties)	38	0.09	0.13	0.15	0.09	0.13	0.10
Upper Gugera (branch)	19	0.08	0.18	0.06	0.12	0.06	0.06
Sind	48	0.09	0.11	0.11	0.10	0.10	0.09
All Systems	248	0.10	0.13	0.13	0.10	0.11	0.08

Table 4.1 Velocity predicted, ratios and standard deviations

Systems	0.667 < R < 1.50					
	AW	EH	KK	VR	Y	HDC
Depalpur	31	41	19	17	22	31
U-G Branch	32	53	32	58	21	37
U-G Distries	19	21	31	19	46	25
Sind	28	26	9	11	19	23

Systems	0.50 < R < 2.00					
	AW	EH	KK	VR	Y	HDC
Depalpur	53	58	37	29	33	55
U-G Branch	63	68	53	79	32	58
U-G Distries	53	31	56	44	65	44
Sind	48	47	28	23	28	45

Systems	0.33 < r < 3.33					
	AW	EH	KK	VR	Y	HDC
Depalpur	73	78	62	50	54	81
U-G Branch	84	89	84	95	53	89
U-G Distries	78	65	81	63	84	75
Sind	63	84	47	42	49	67

AW = Ackers and White
EH = Engelund and Hansen
KK = Karim and Kenndy
VR = Van Rijn
Y = Yang
HDC= Hydraulic Design Criteria

Table 6.1 Precentage of obervations with ratio of calculated over measured concentration between 0.667 and 1.5, between 0.5 and 2.0 and between 0.33 and 3.0

GENERAL CANAL DESIGN PROCEDURES

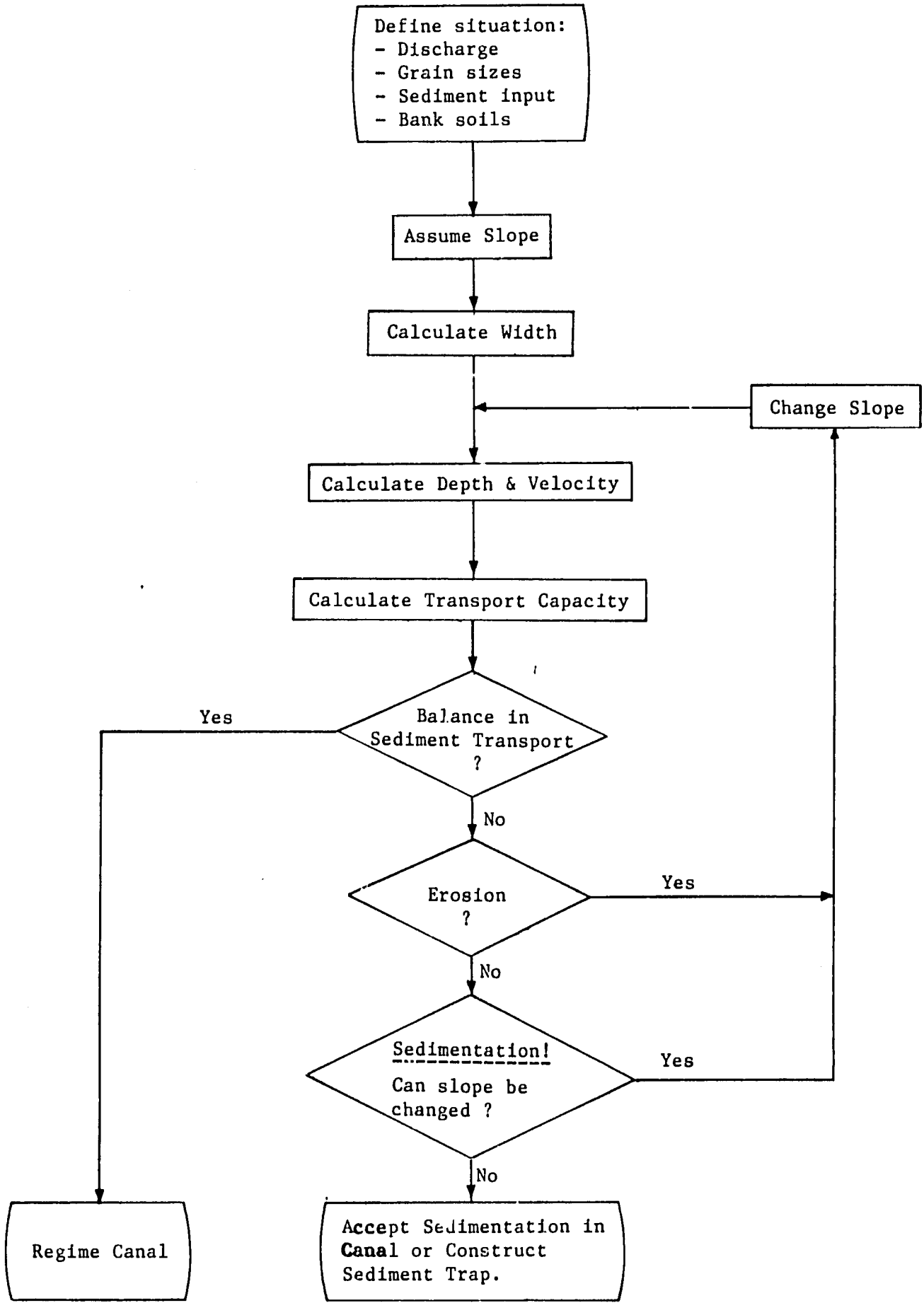
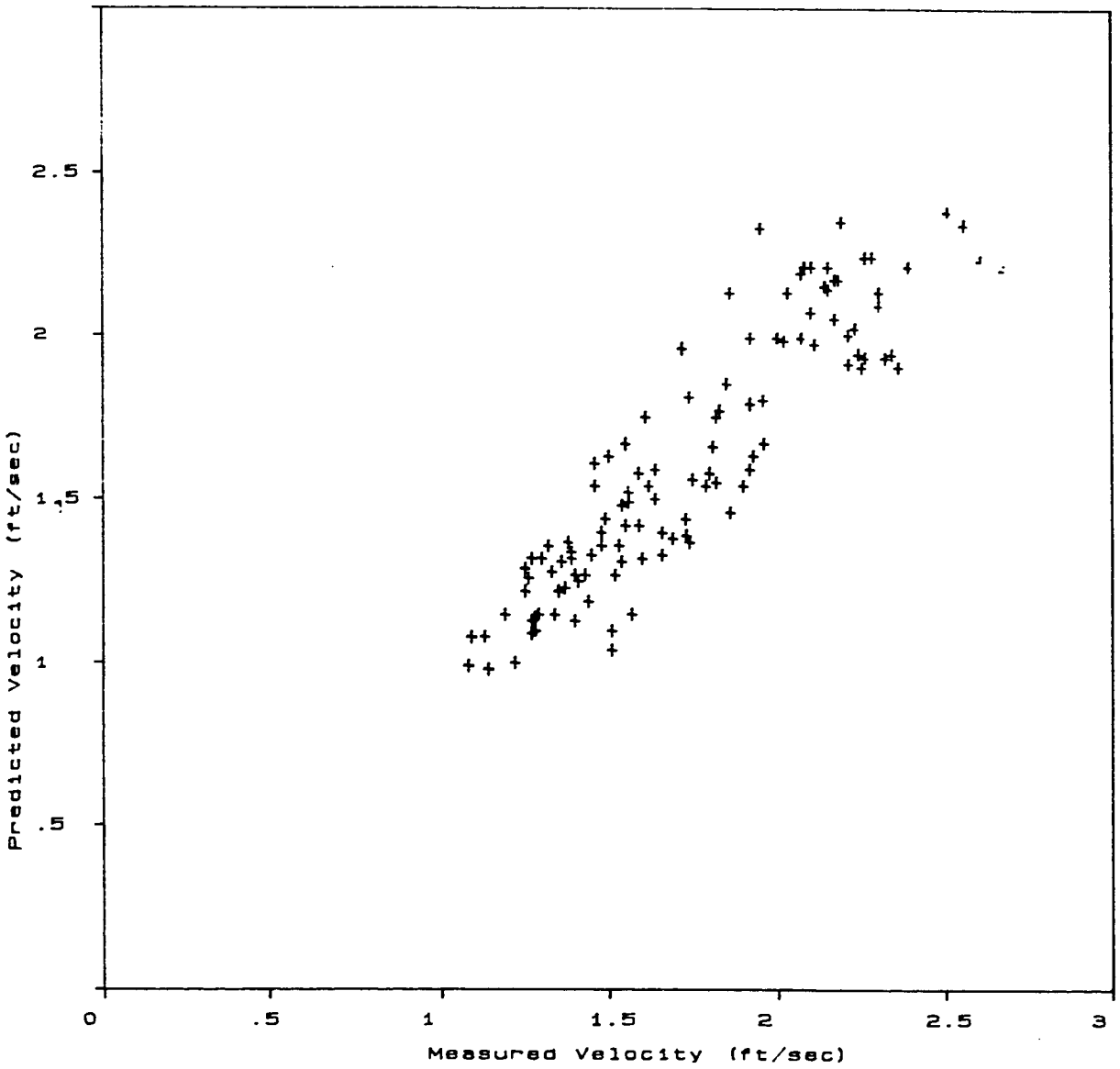
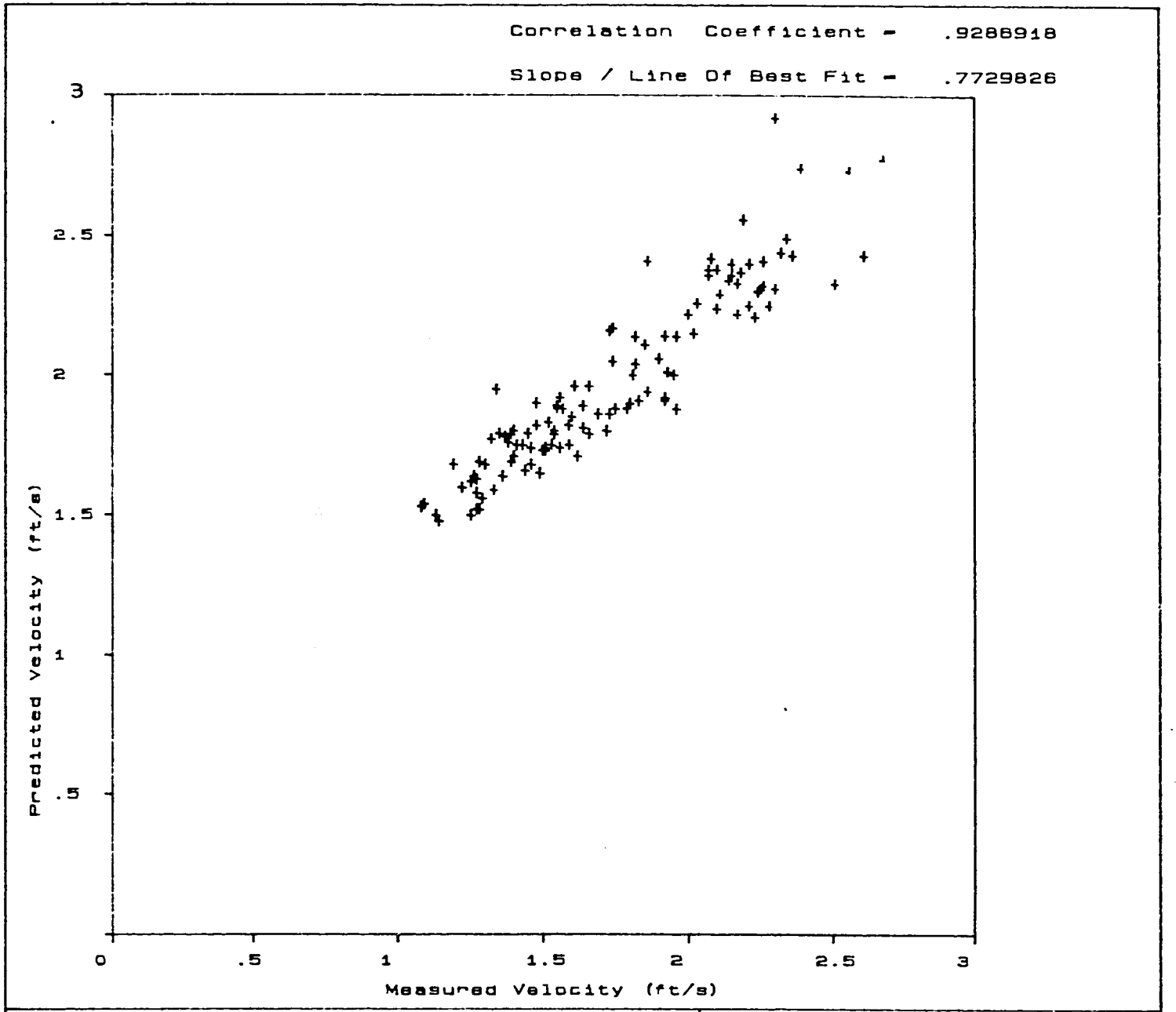


FIGURE 2.1

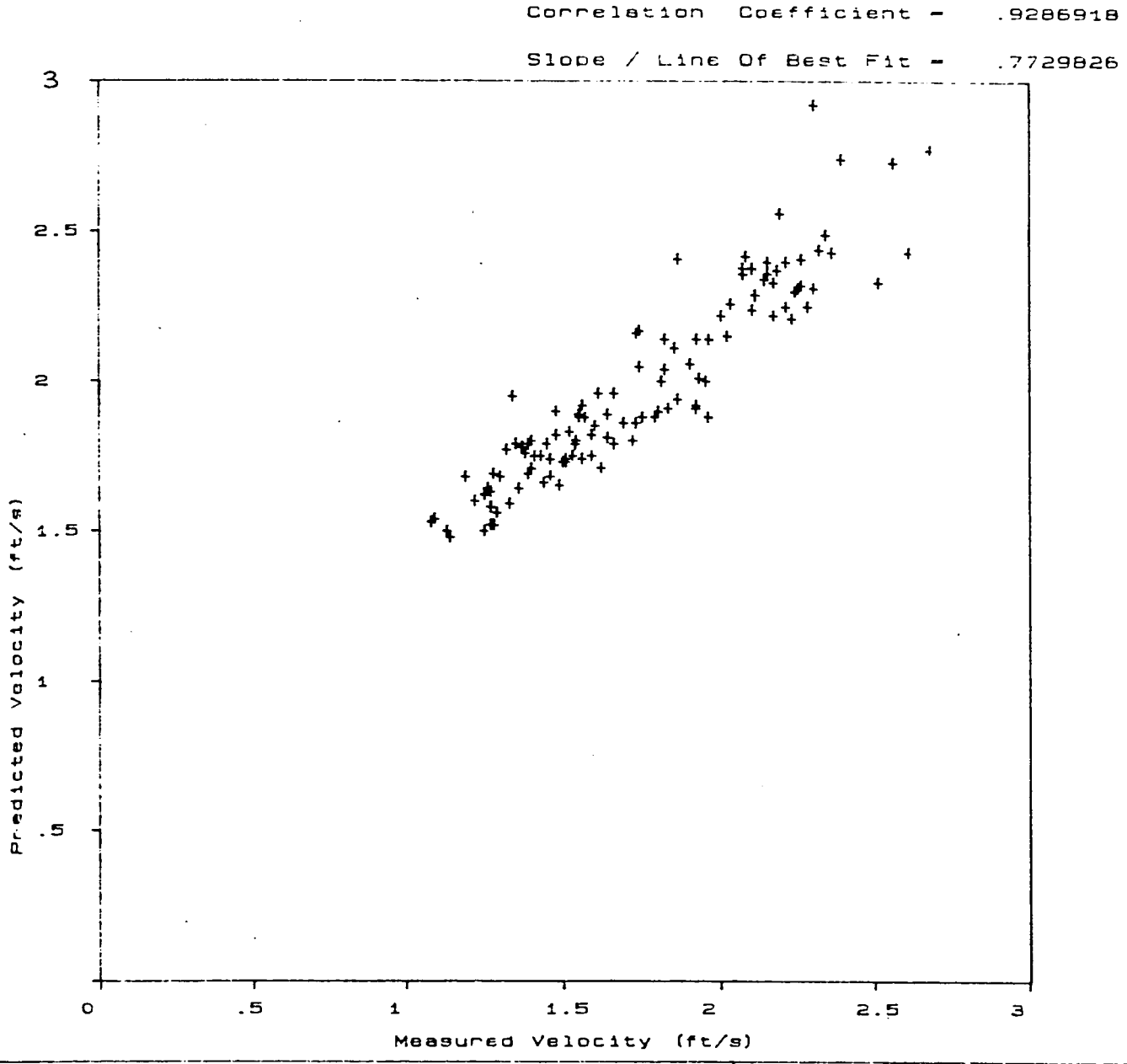


Lacey Measured Versus Predicted Velocity	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·1

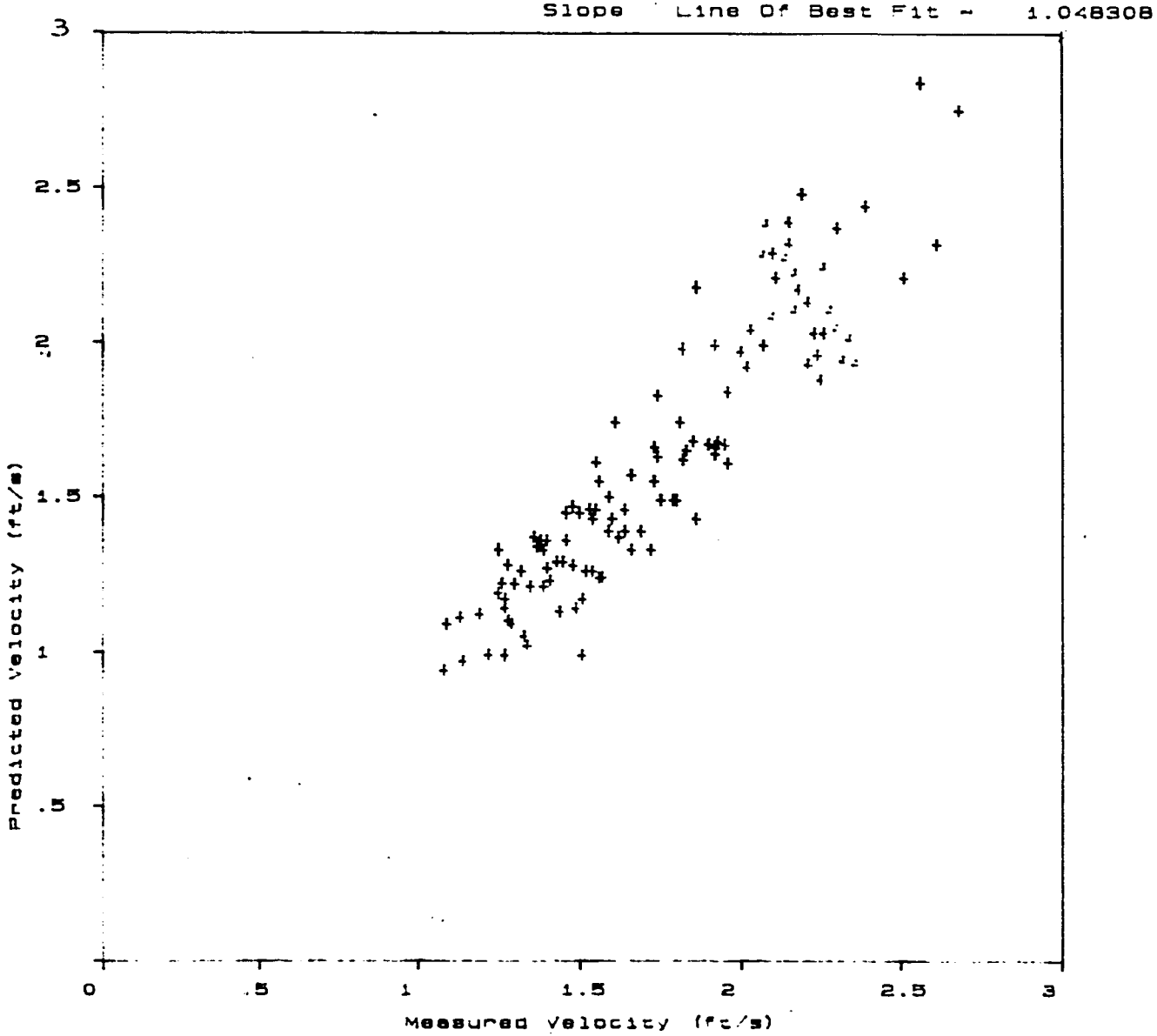


ENGELUND AND HANSEN Measured versus Predicted Velocity	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·2

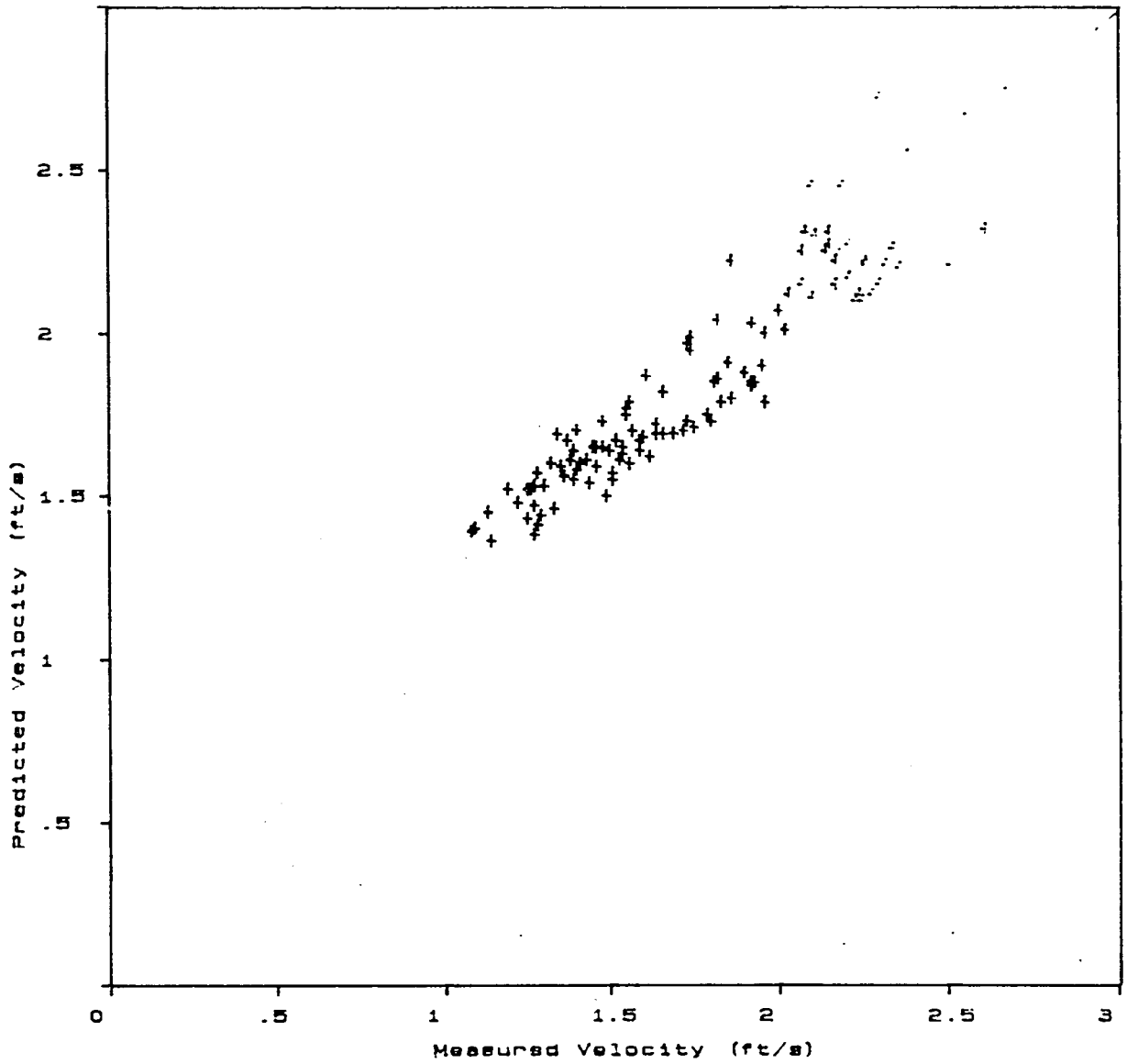
125



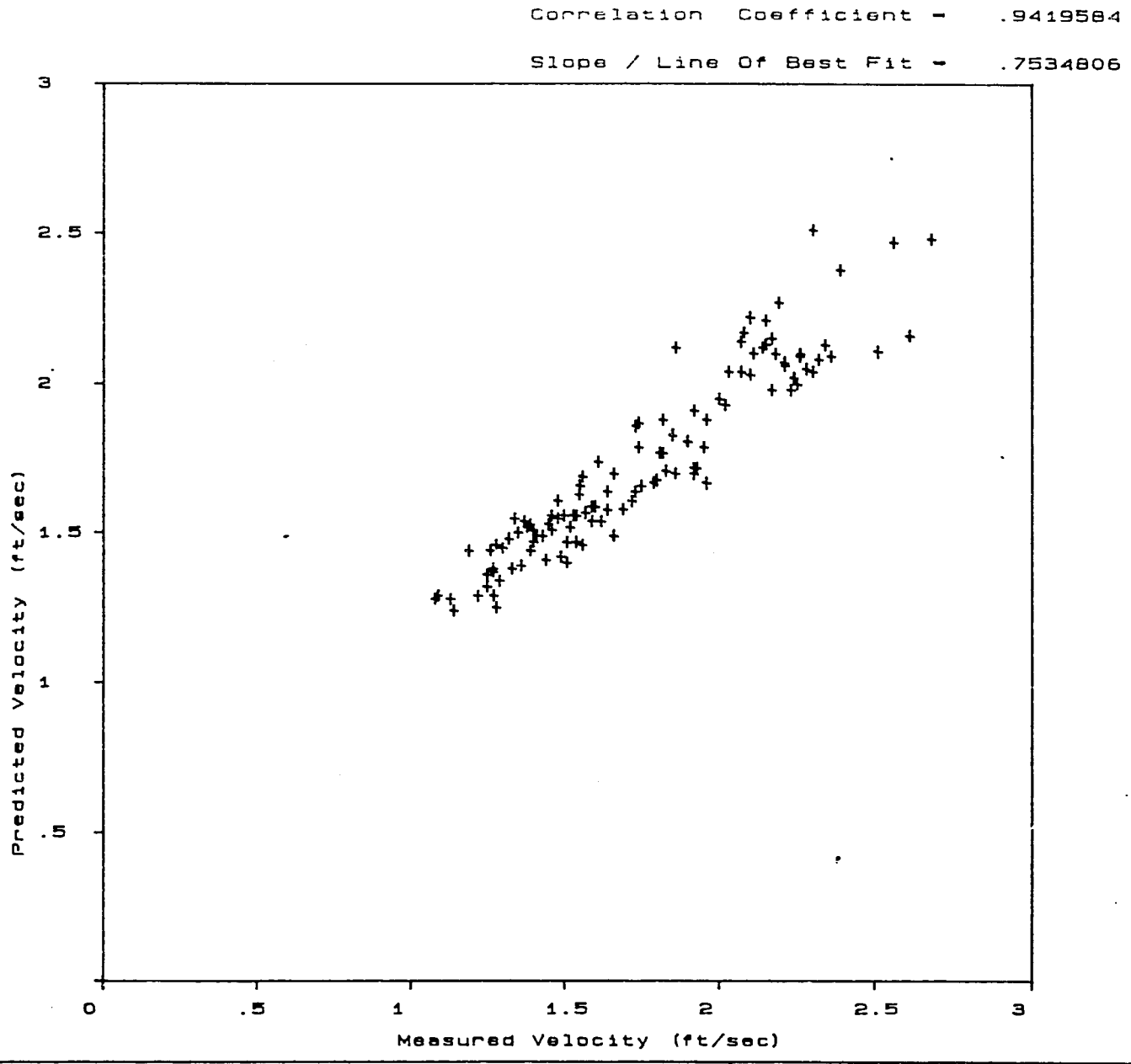
ACKERS AND WHITE	Depalpur Canal System
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRG/CHECCHI	FIG. 4·3



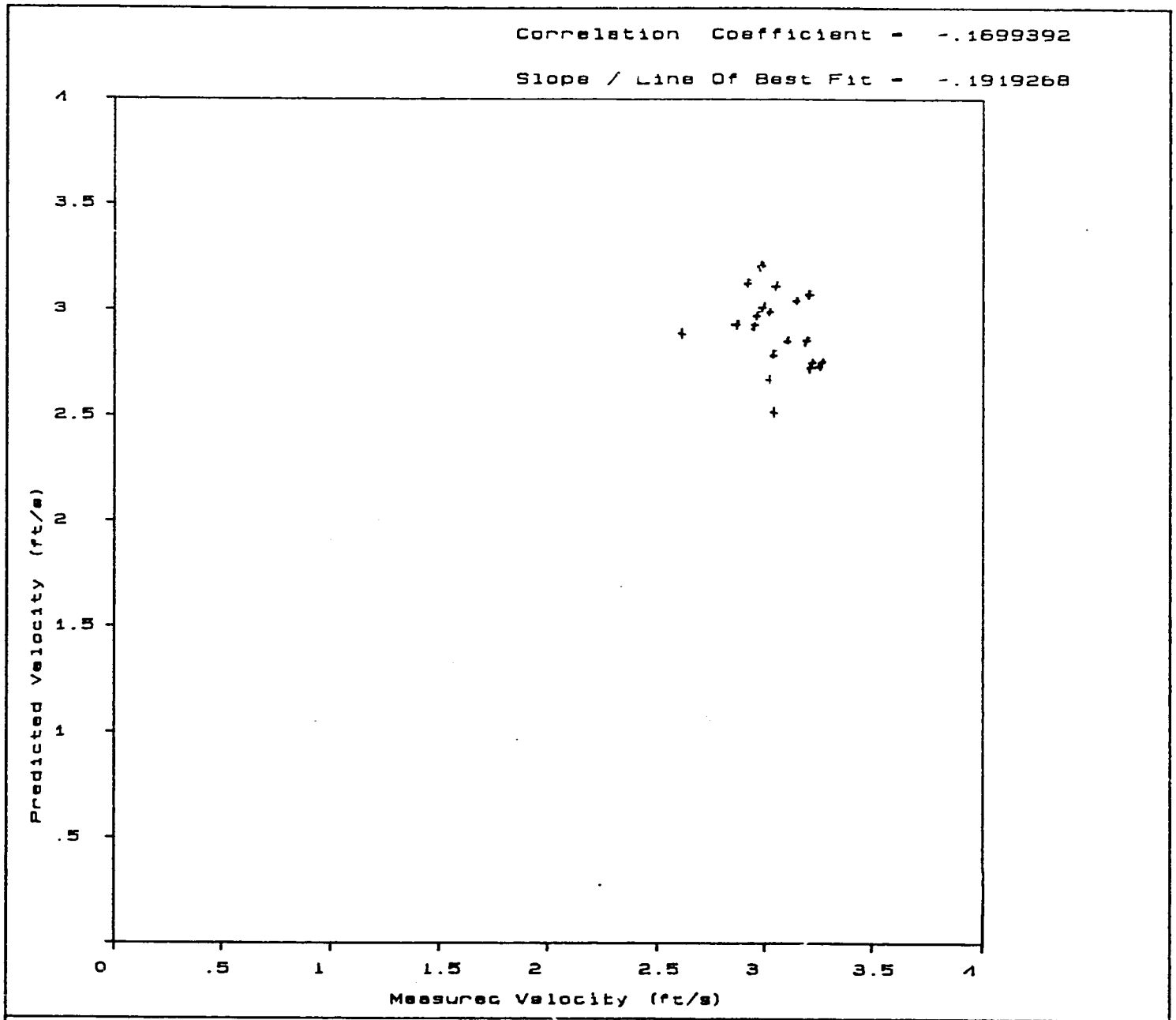
KARIM AND KENNEDY	Depalpur Canal System
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4-4



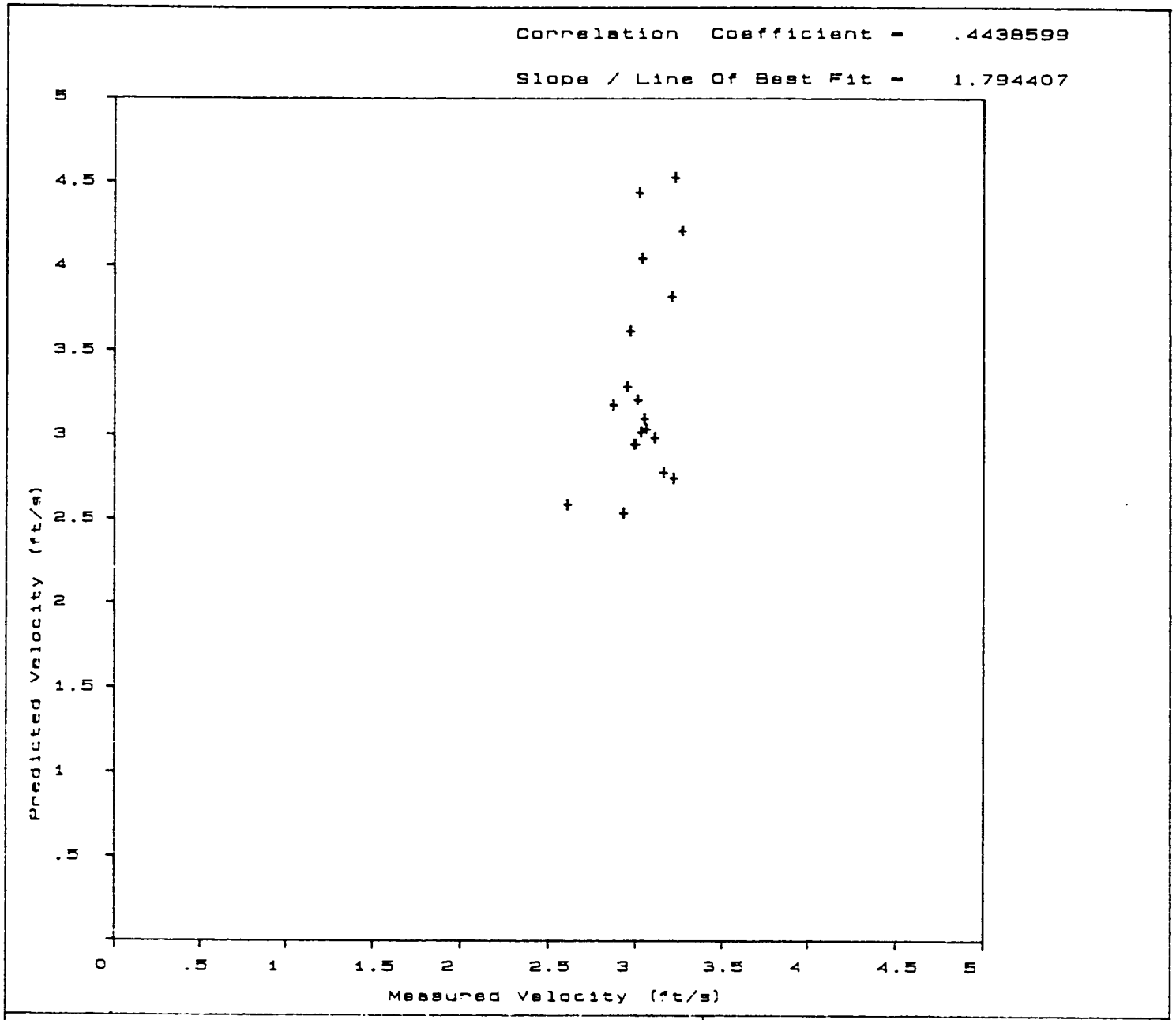
VAN RIJN Measured versus Predicted Velocity	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·5



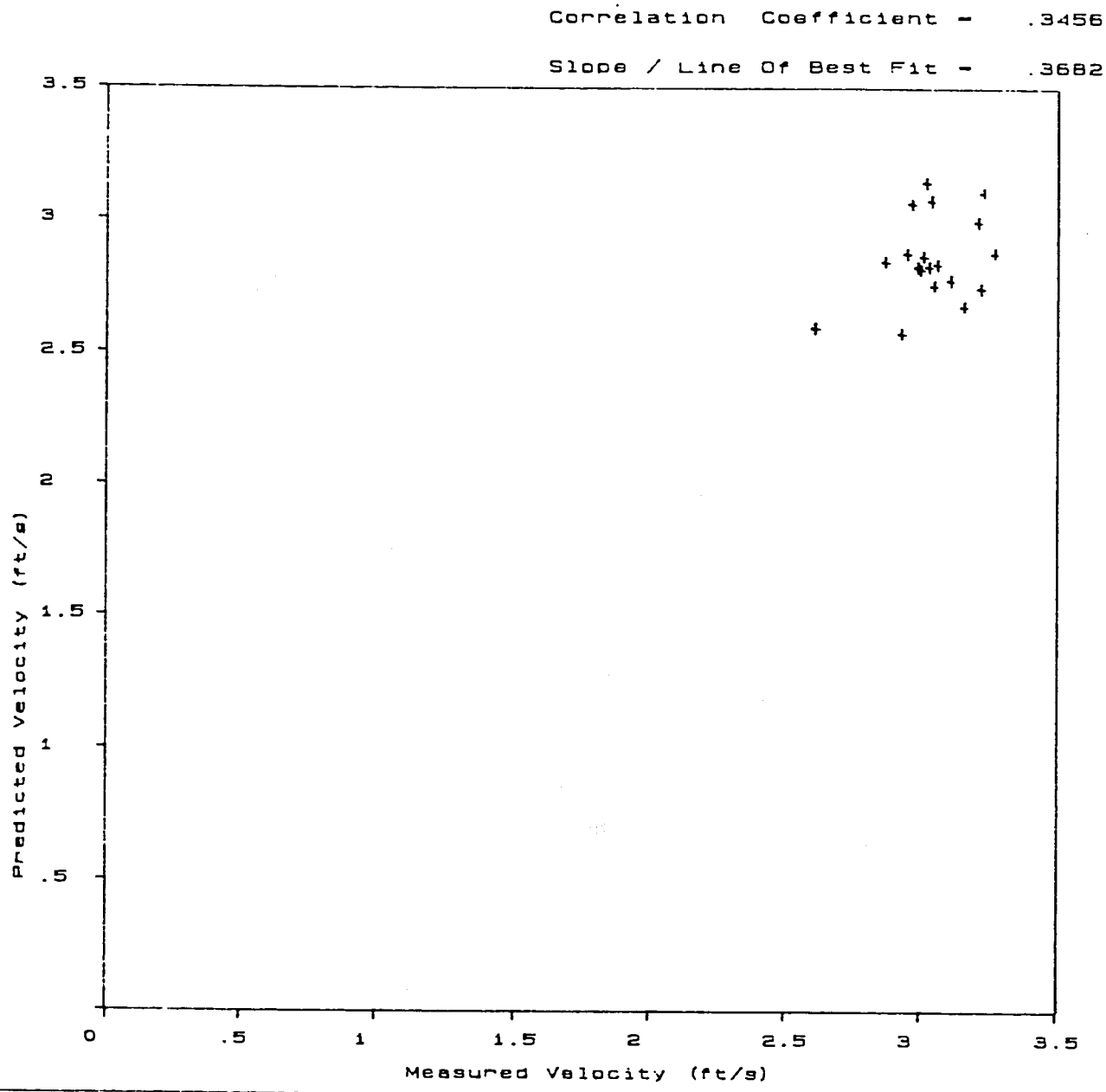
Hydraulic Design Criteria	Depalpur Canal System
Measured Versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·6



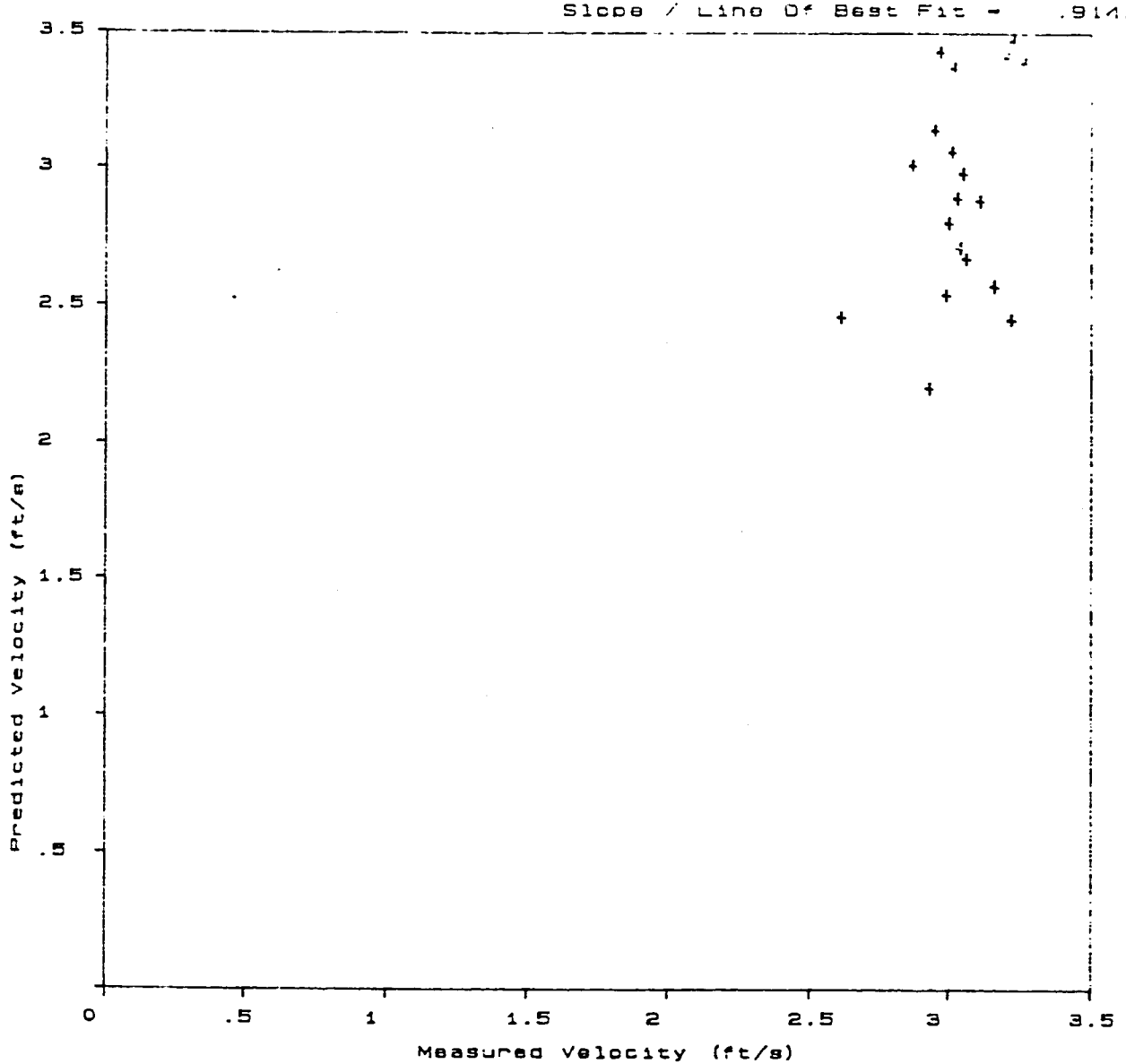
LACEY Measured versus Predicted Velocity	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·7



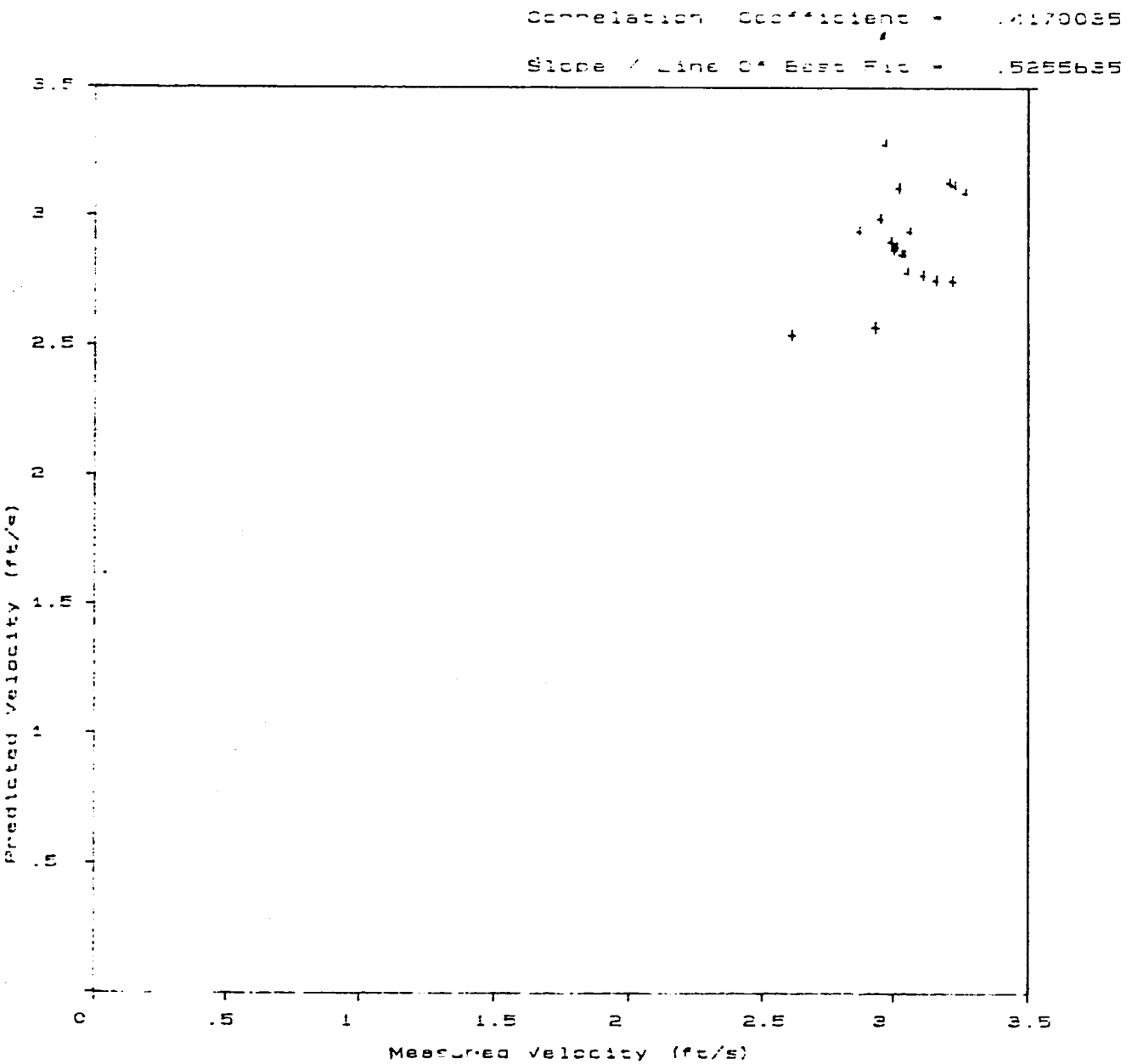
ENGELUND AND HANSEN Measured versus Predicted Velocity	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRO/CHECCHI	FIG. 4·8



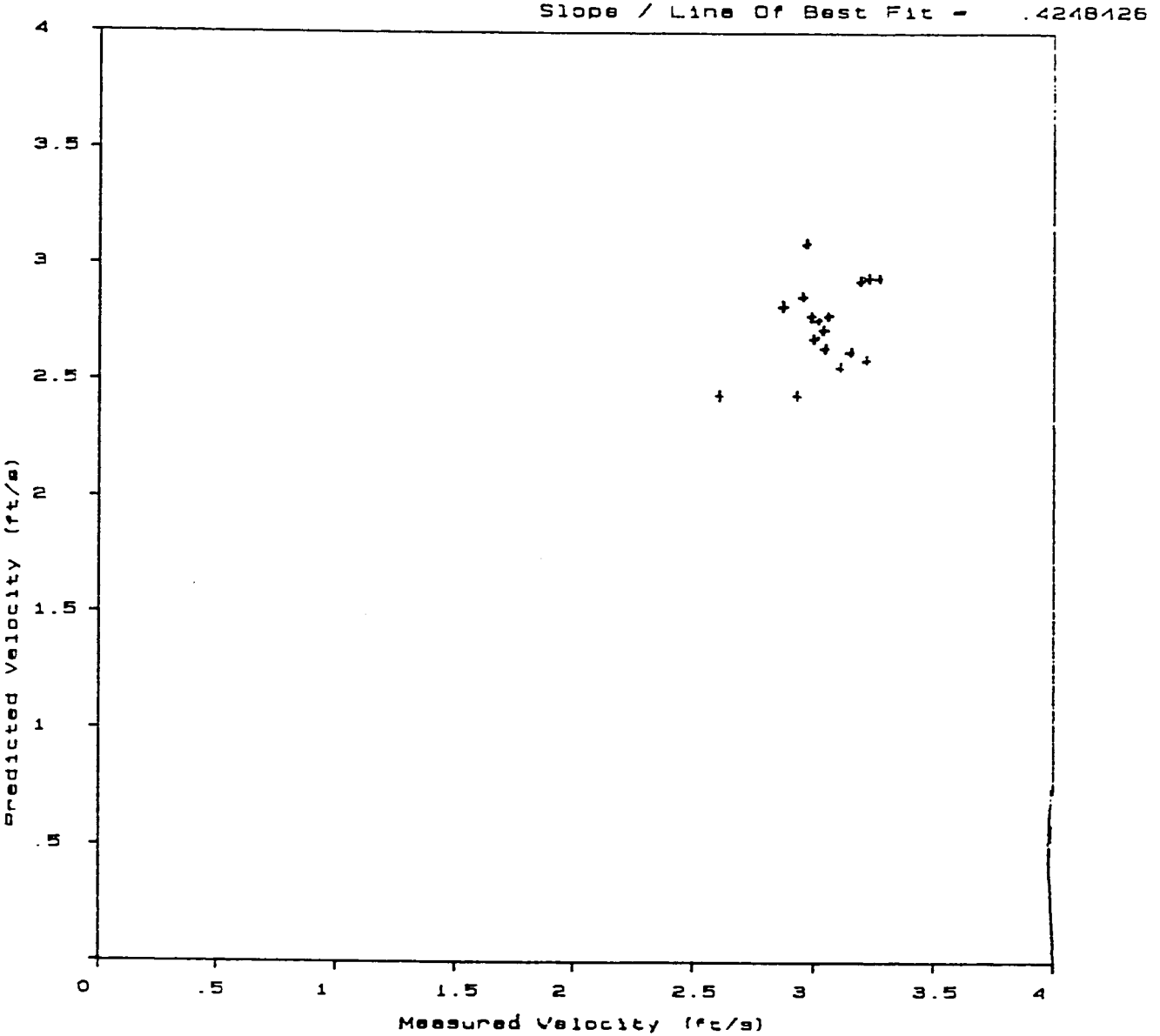
ACKERS AND WHITE Measured versus Predicted Velocity	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·9



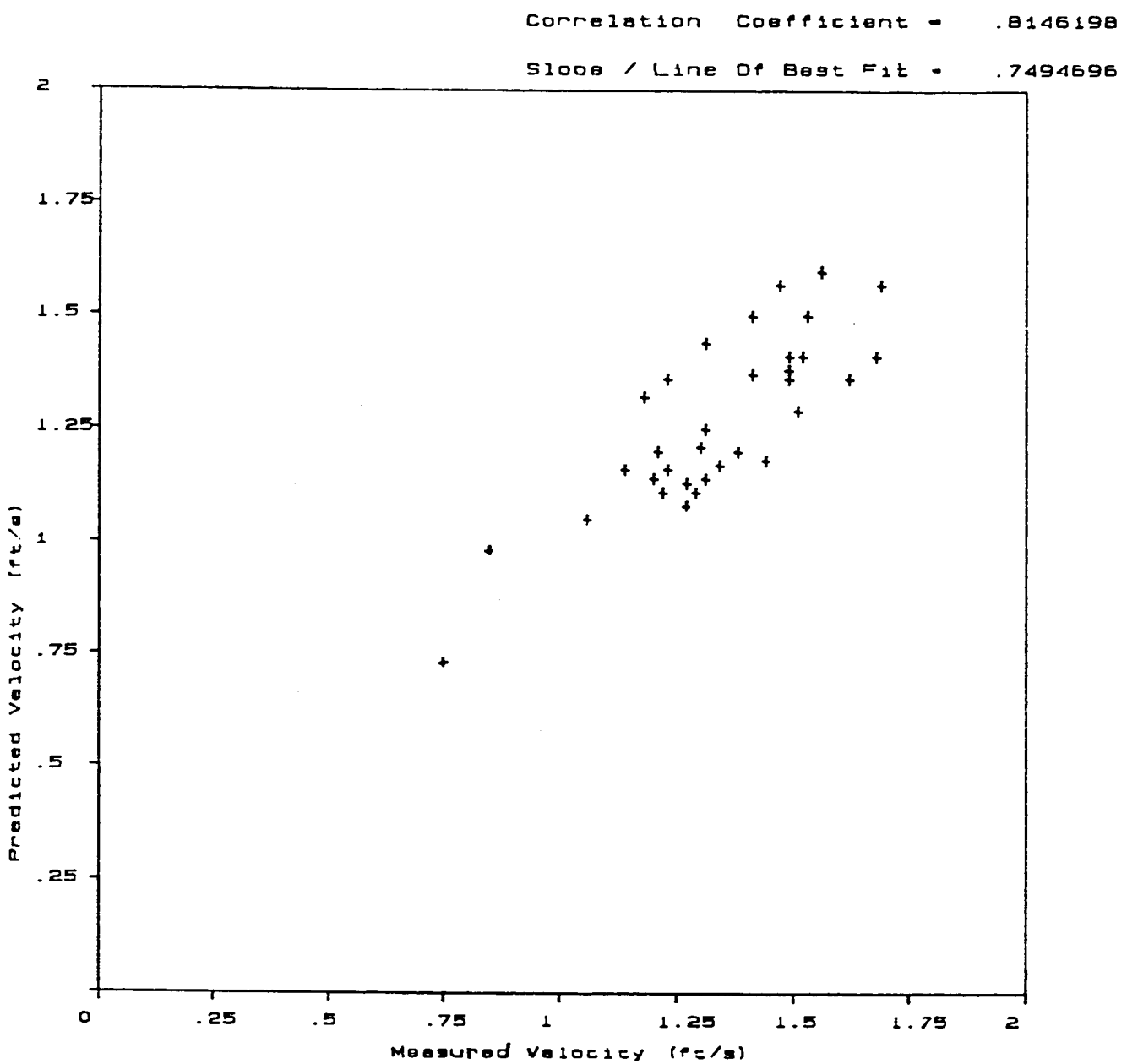
KARIM AND KENNEDY	Upper Gugera Branch
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·10



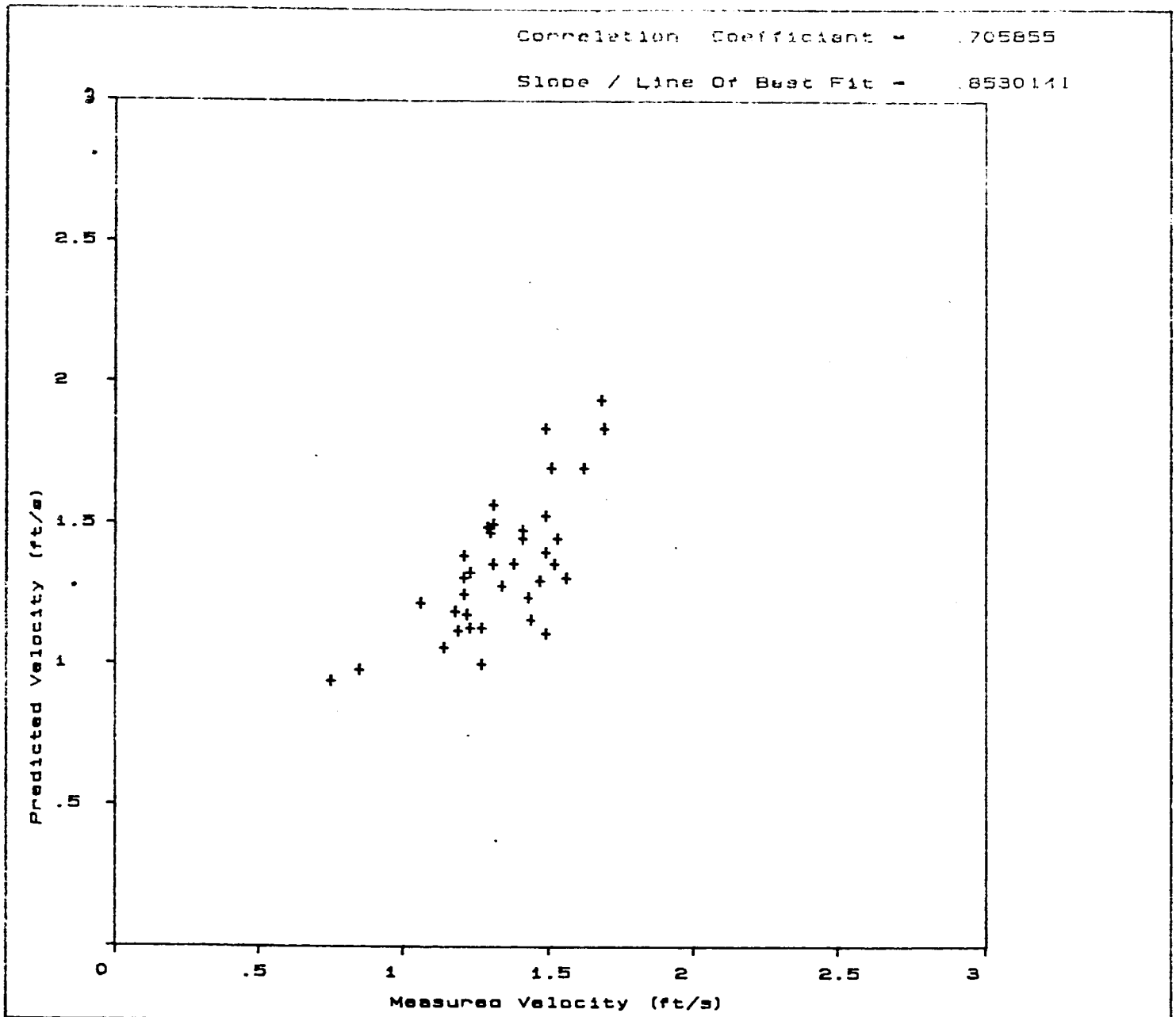
VAN RIJN Measured versus Predicted Velocity	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·11



HYDRAULIC DESIGN CRITERIA	Upper Gugera Branch
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·12

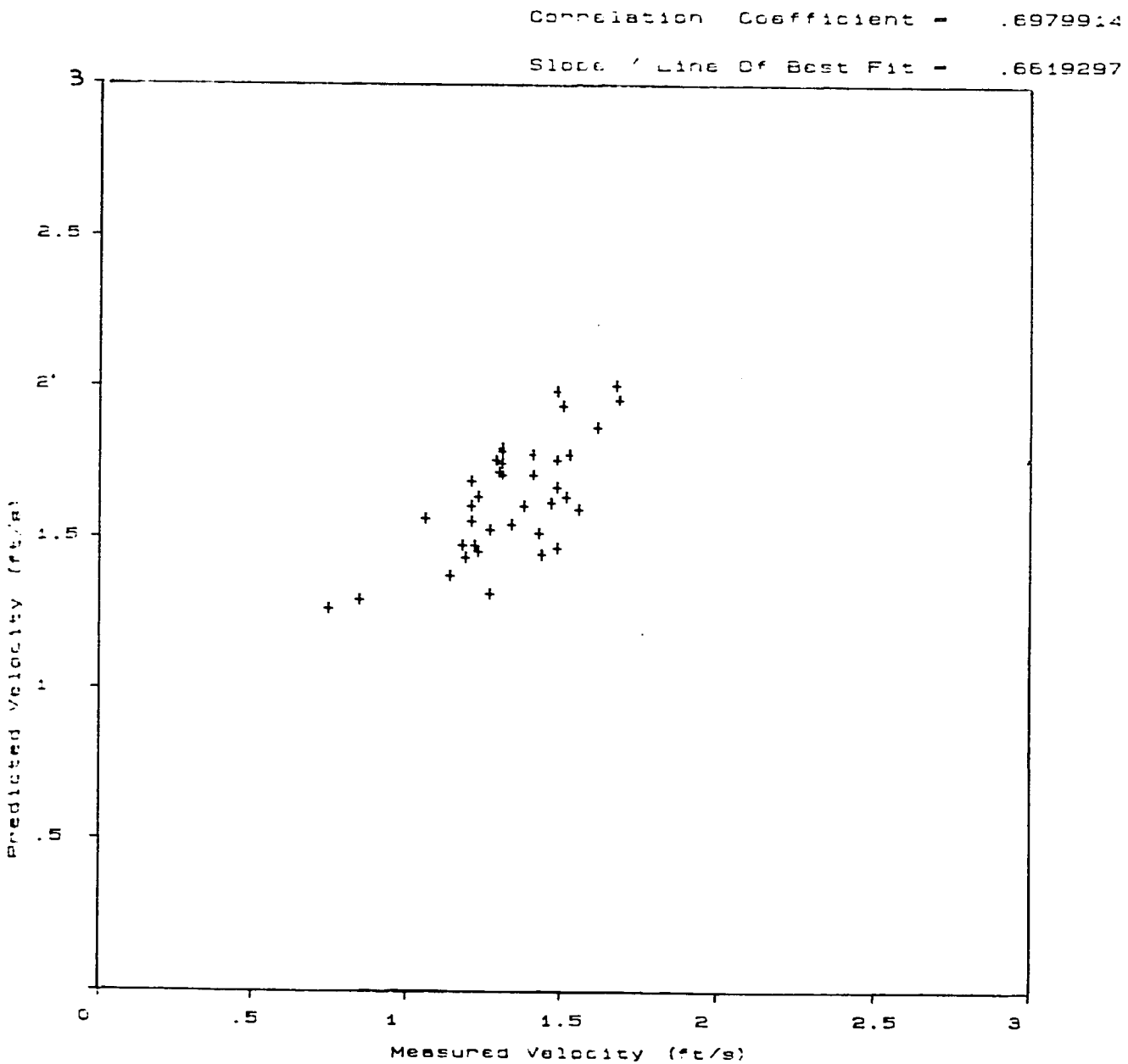


LACEY Measured versus Predicted Velocity	Upper Gugera Distics Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·13

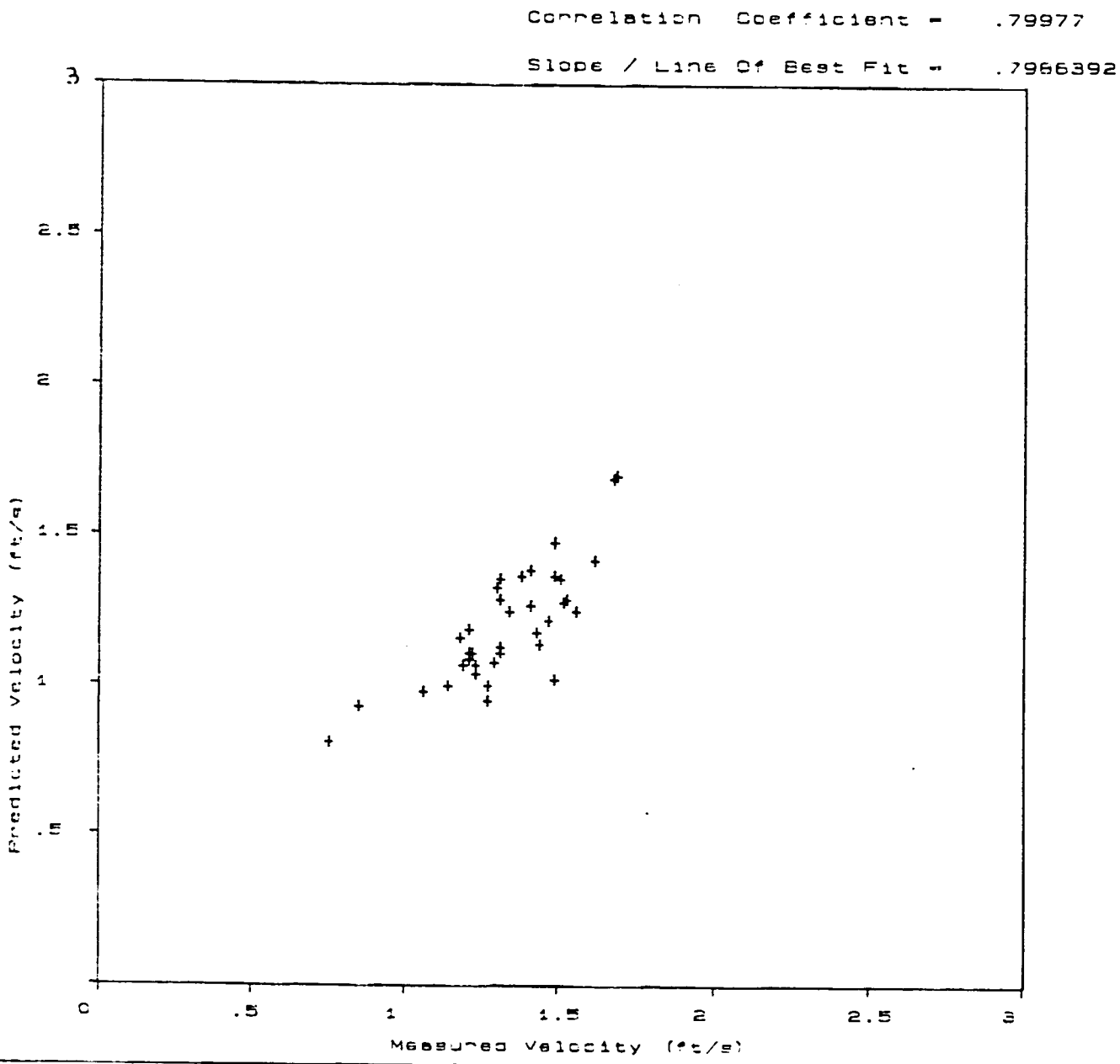


ENGELUND AND HANSEN Measured versus Predicted Velocity	Upper Gugera Disties Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRG/CHECCHI	FIG. 4·14

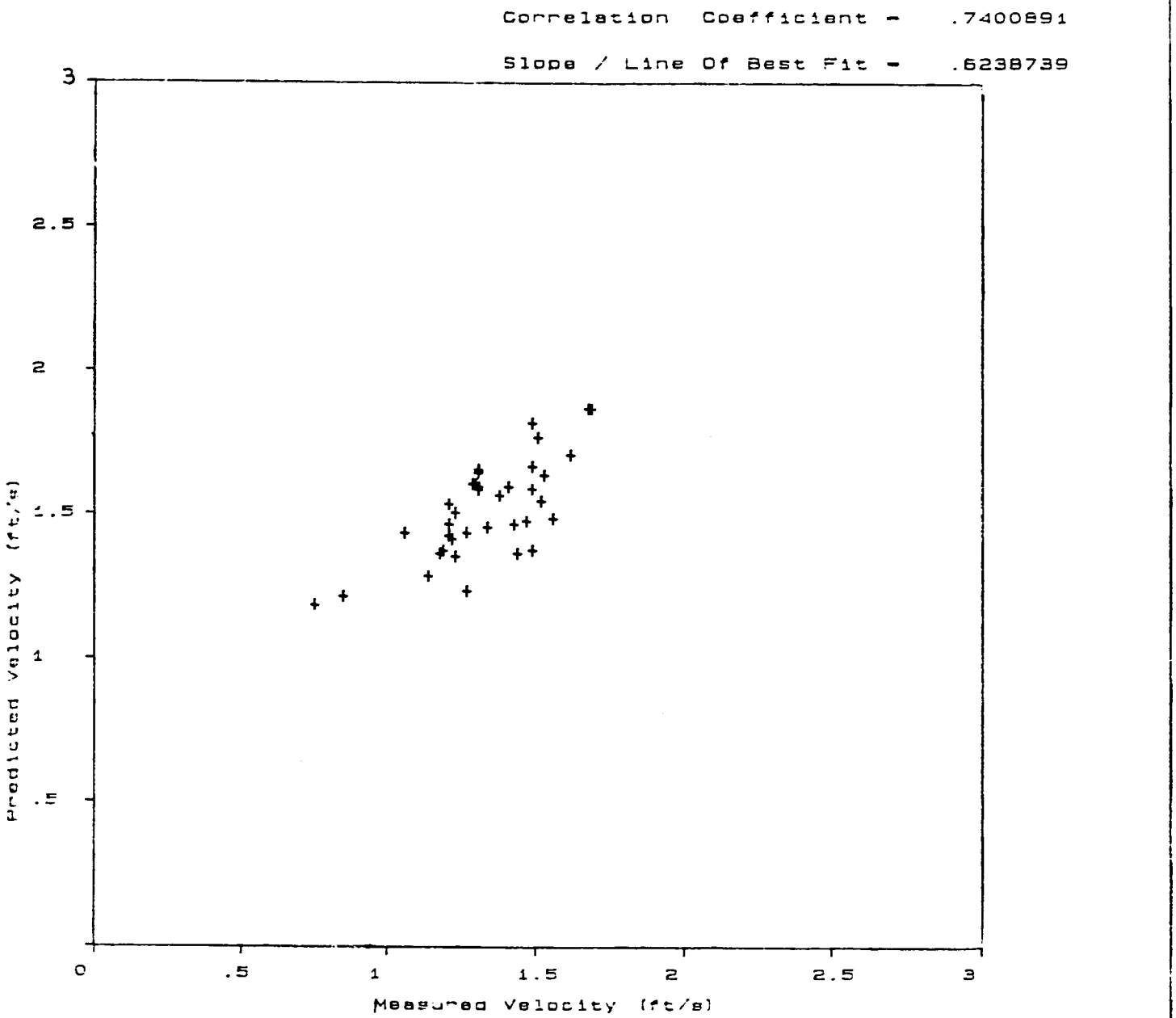
137



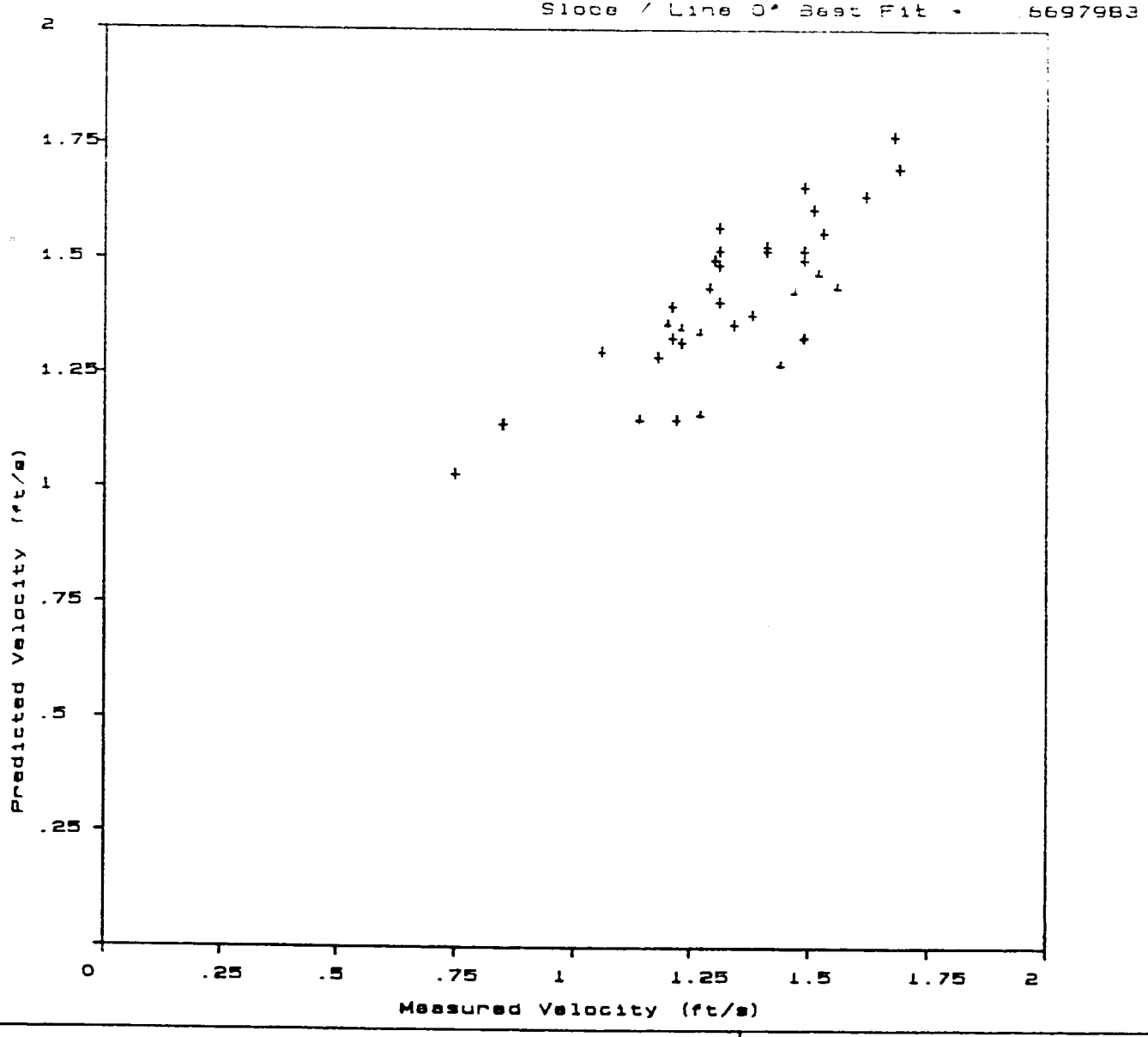
ACKERS AND WHITE Measured versus Predicted Velocity	Upper Gugera Disties Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·15



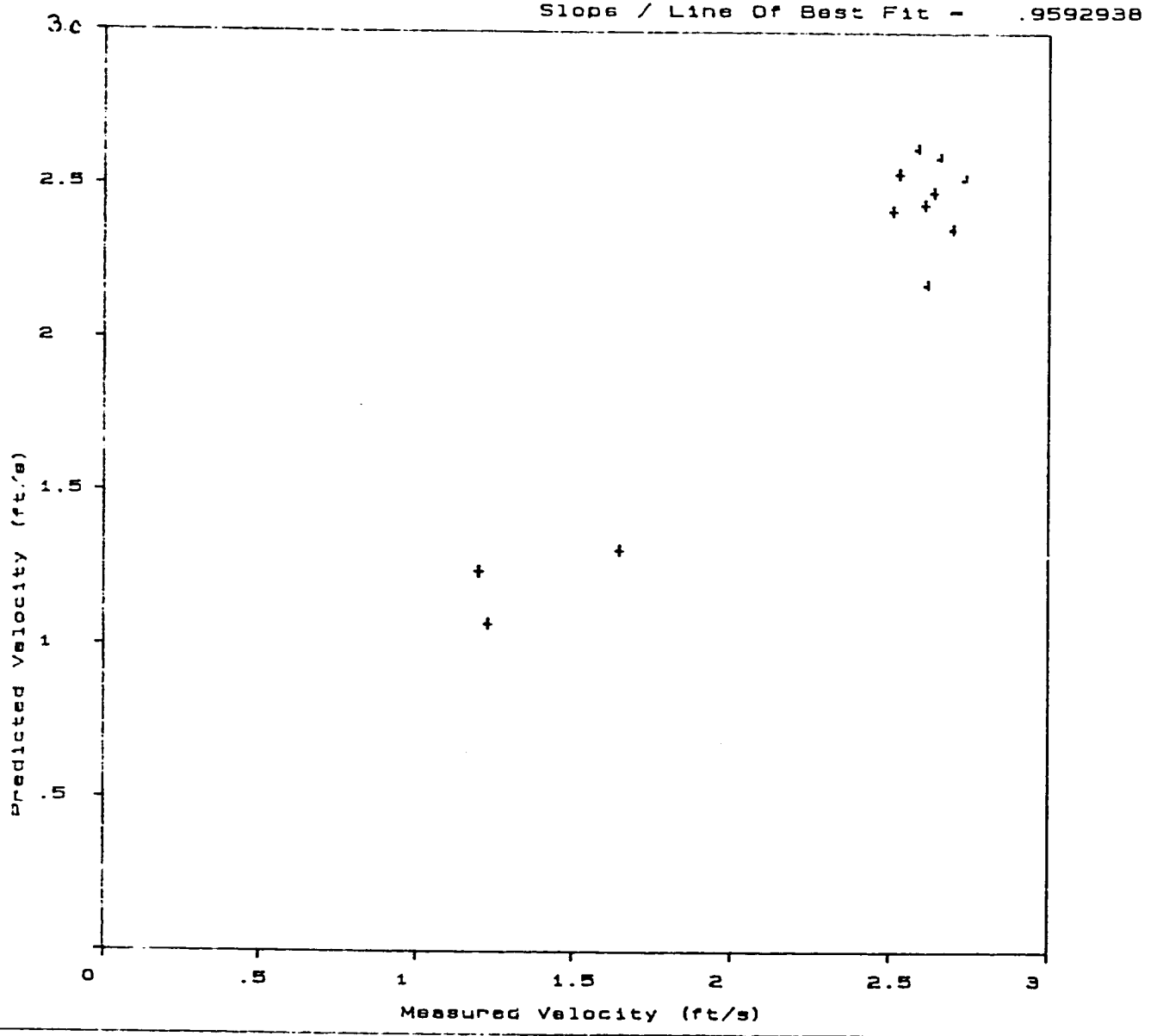
KARIM AND KENNEDY Measured versus Predicted Velocity	Upper Gugera Distles Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRO/CHECCHI	FIG. 4-16



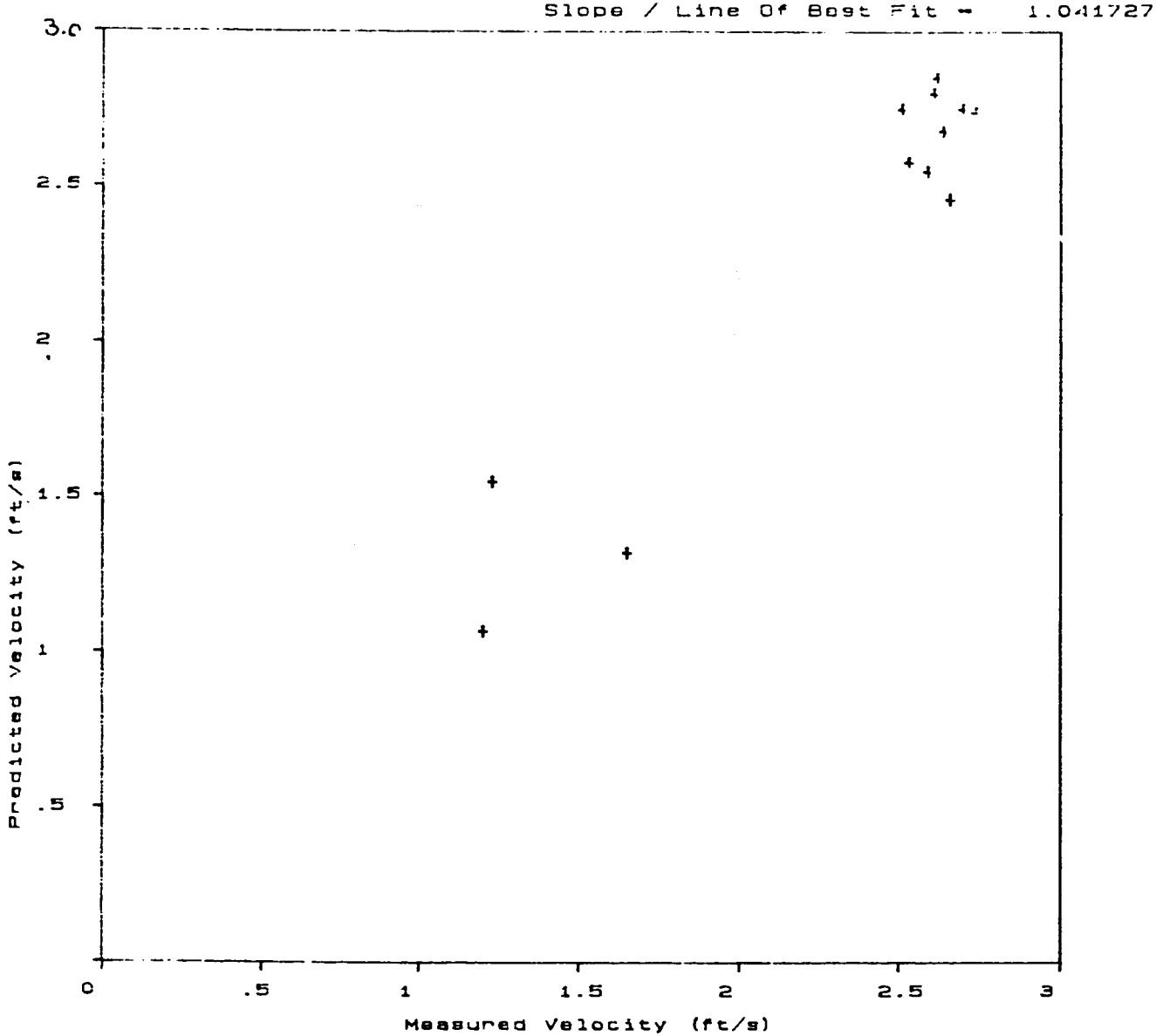
VAN RIJN Measured versus Predicted Velocity	Upper Gugera Distics Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PROJECHECCHI	FIG. 4·17



HYDRAULIC DESIGN CRITERA	Upper Gugera Distles
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·18

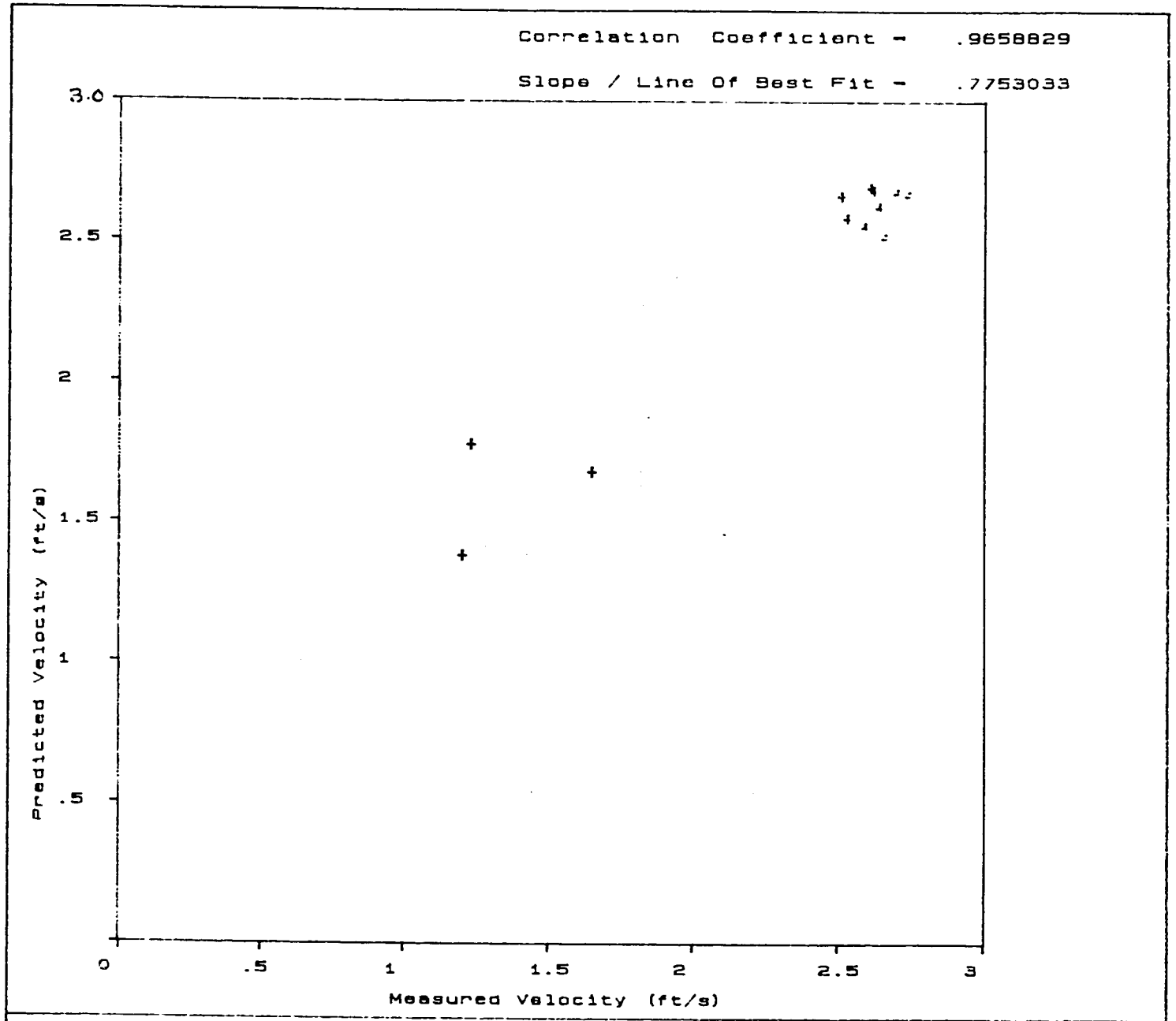


LACEY Measured versus Predicted Velocity	Lower Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·19

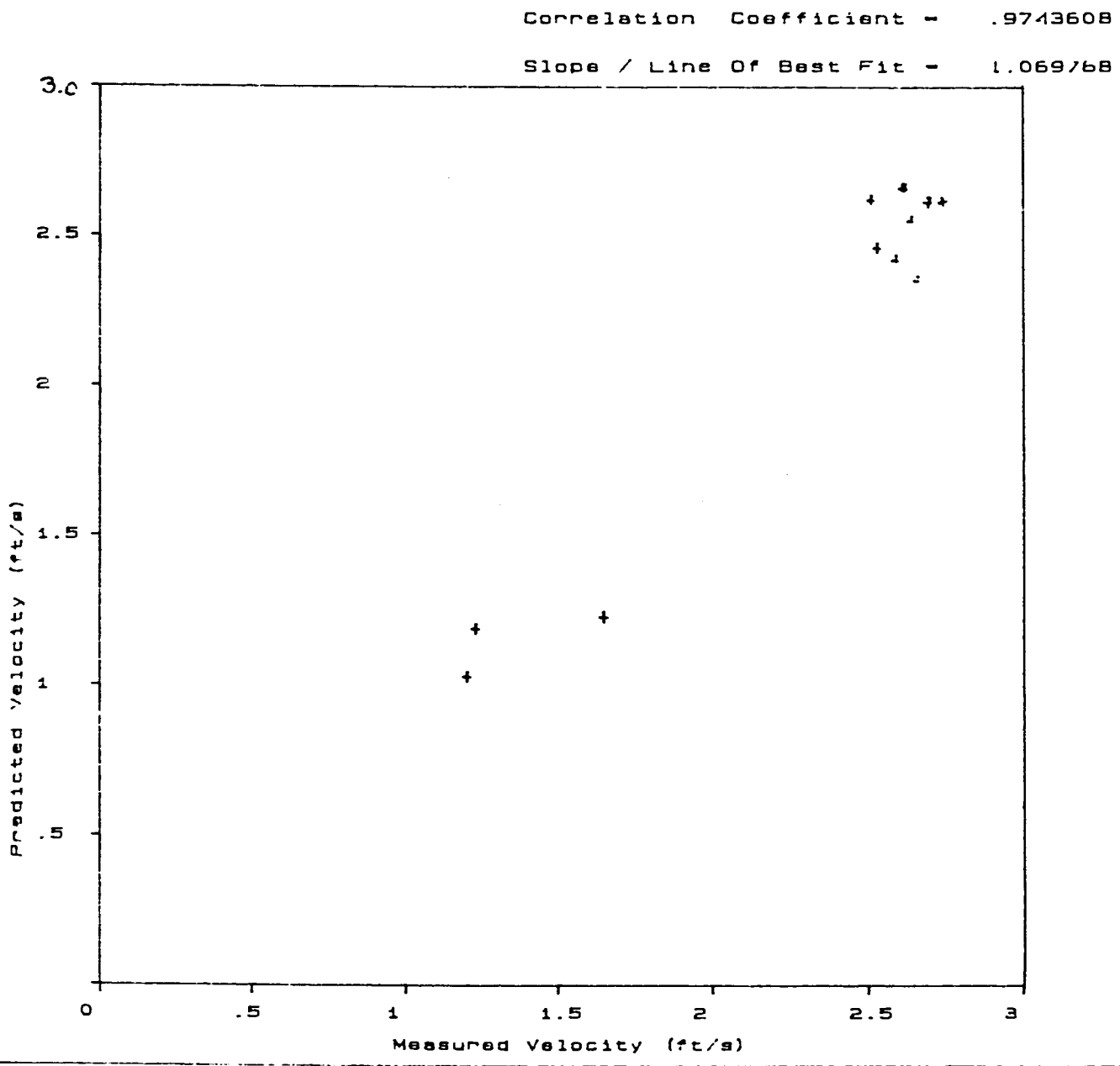


ENGELUND AND HANSEN	Lower Gugera Branch
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·20

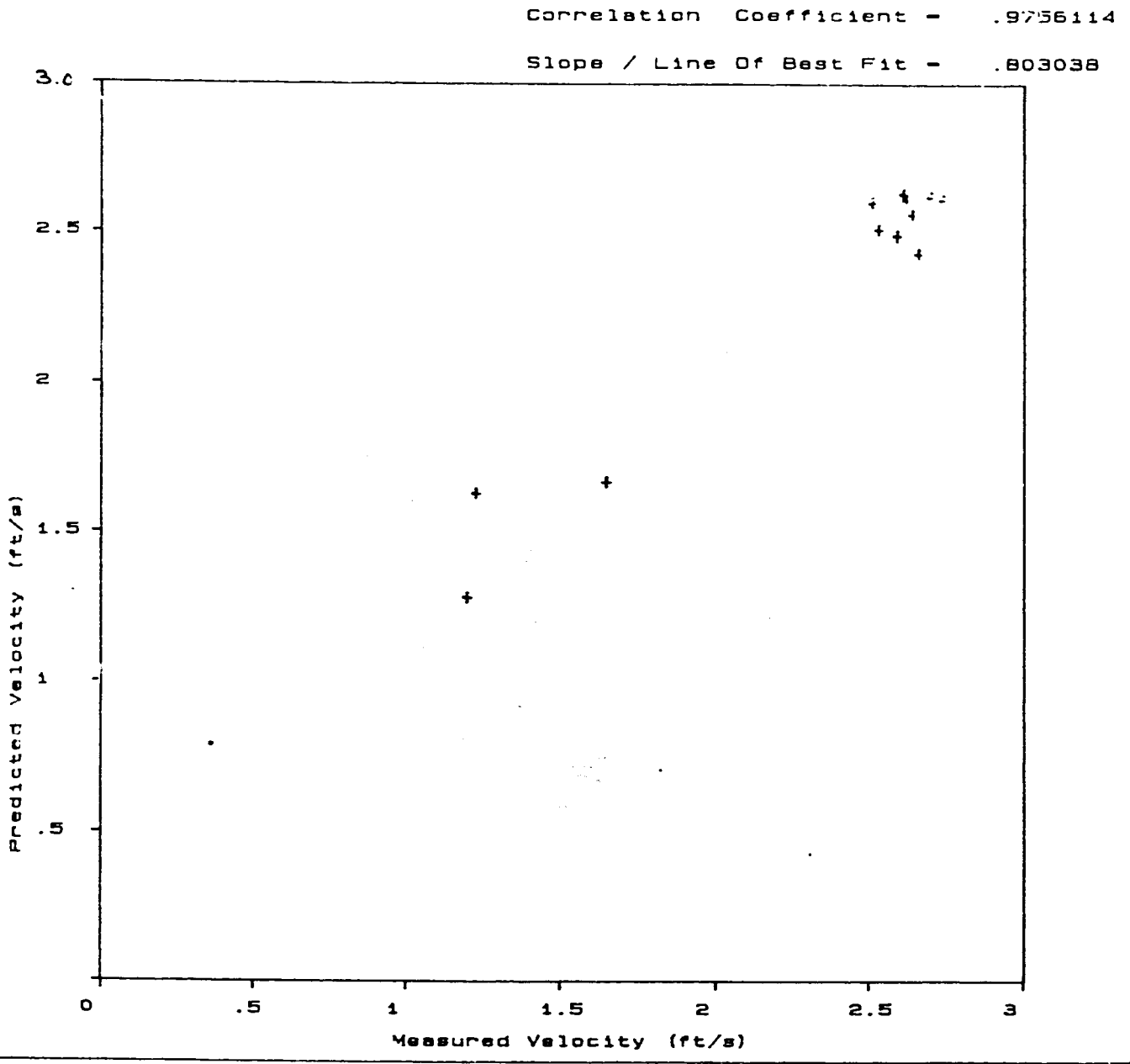
147



ACKERS AND WHITE Measured versus Predicted Velocity	Lower Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·21

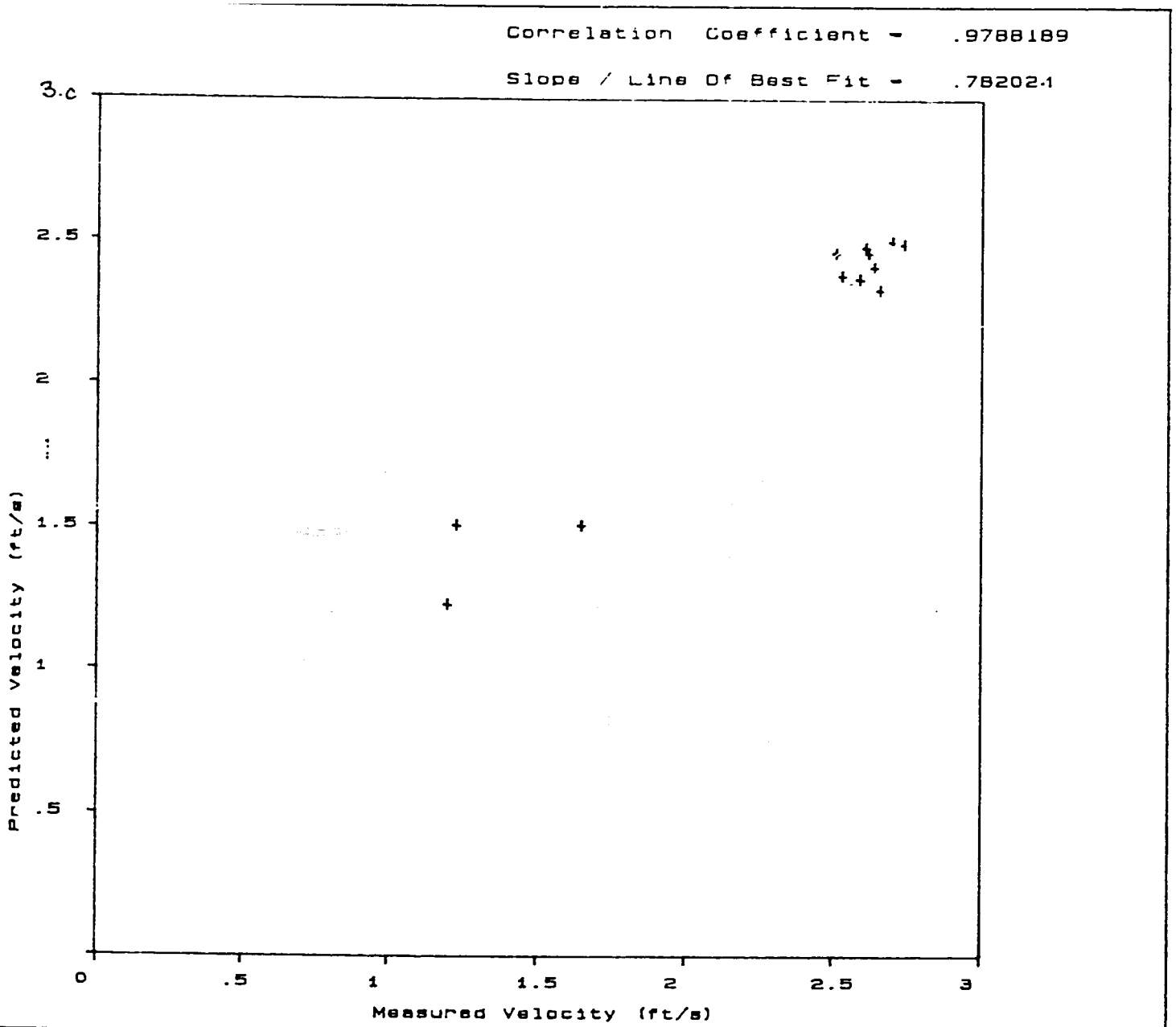


KARIM AND KENNEDY	Lower Gugera Branch
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·22



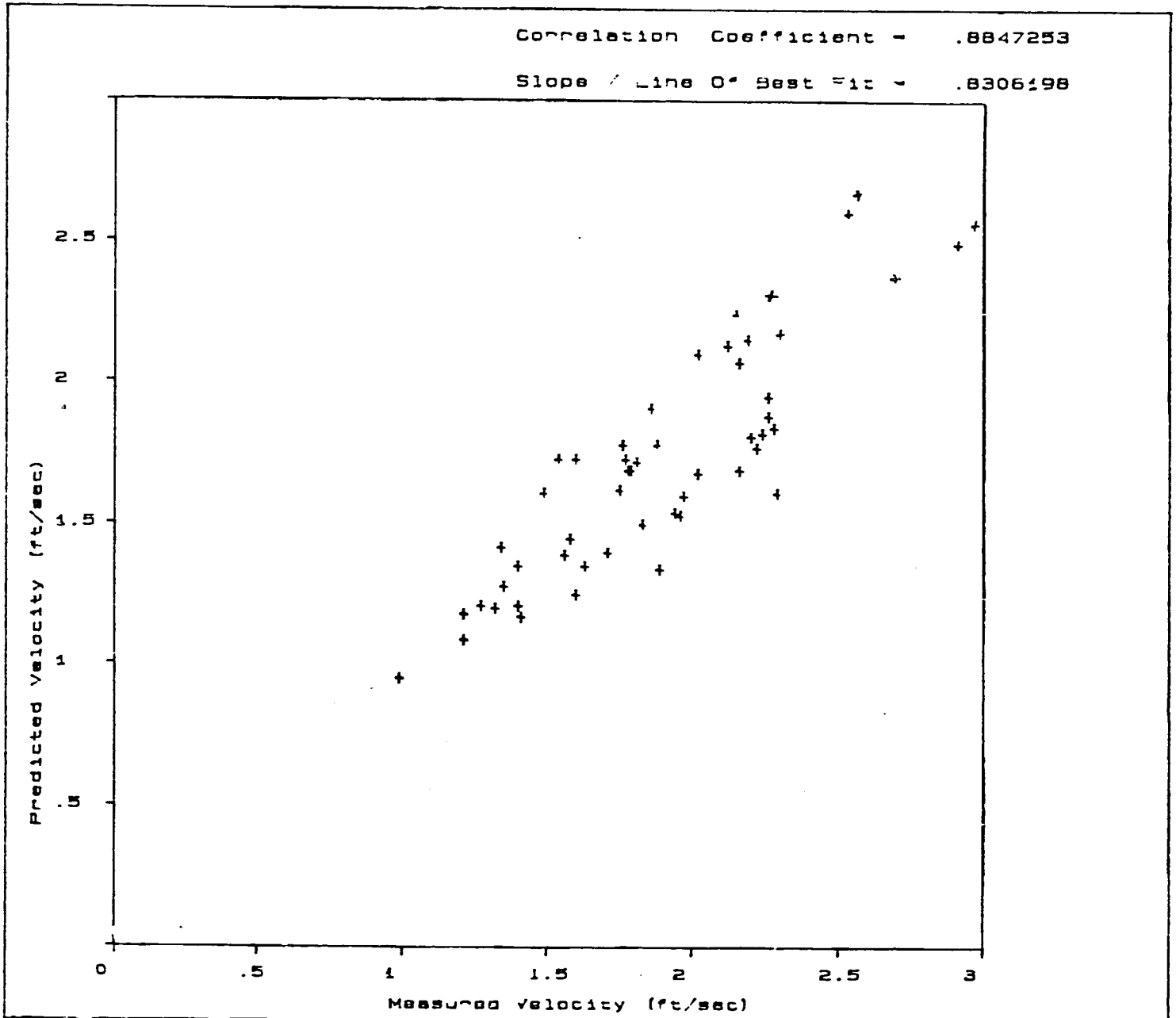
VAN RIJN Measured versus Predicted Velocity	Lower Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·23

146

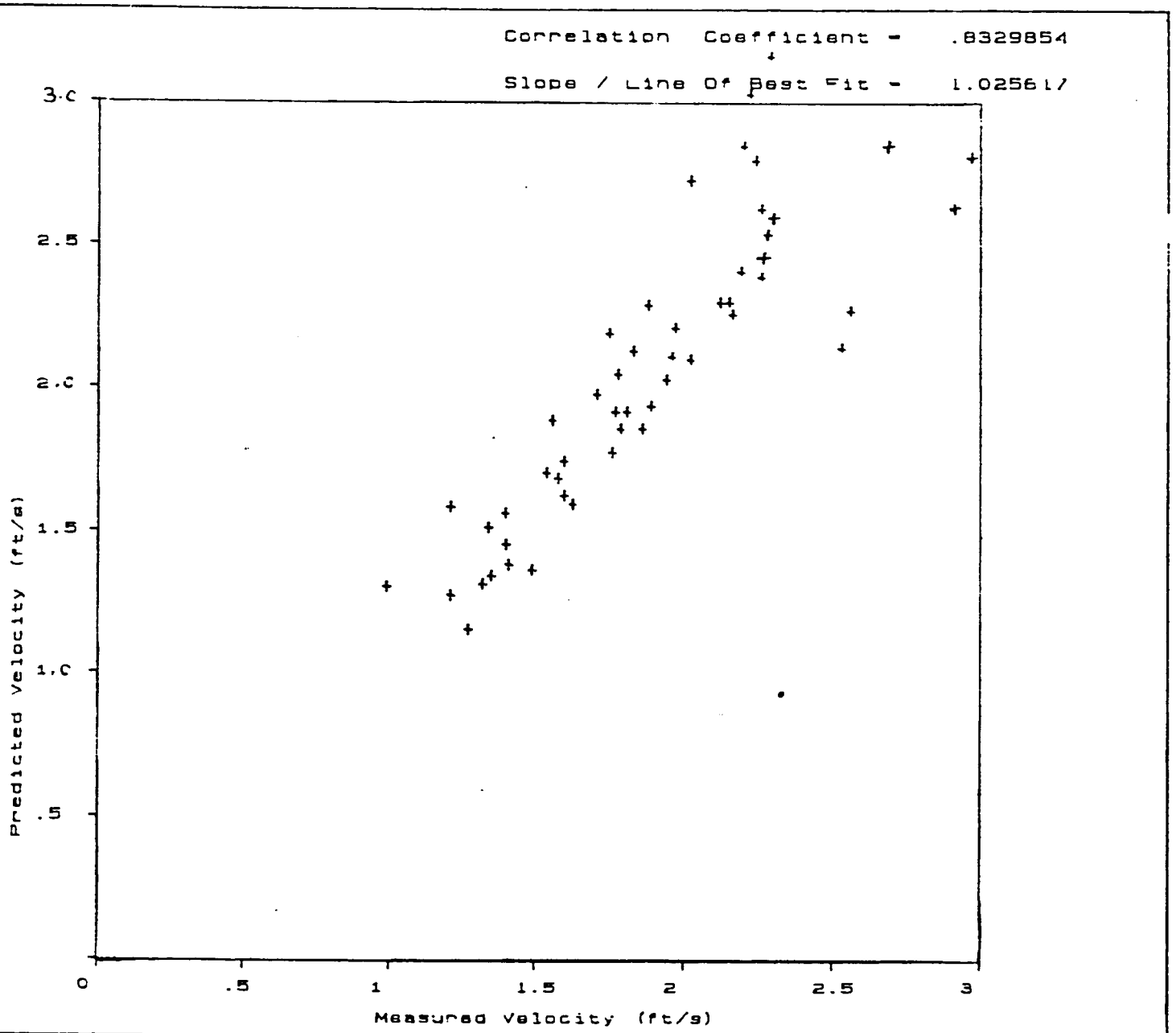


HYDRAULIC DESIGN CRITERIA	Lower Gugera Branch
Measured versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·24

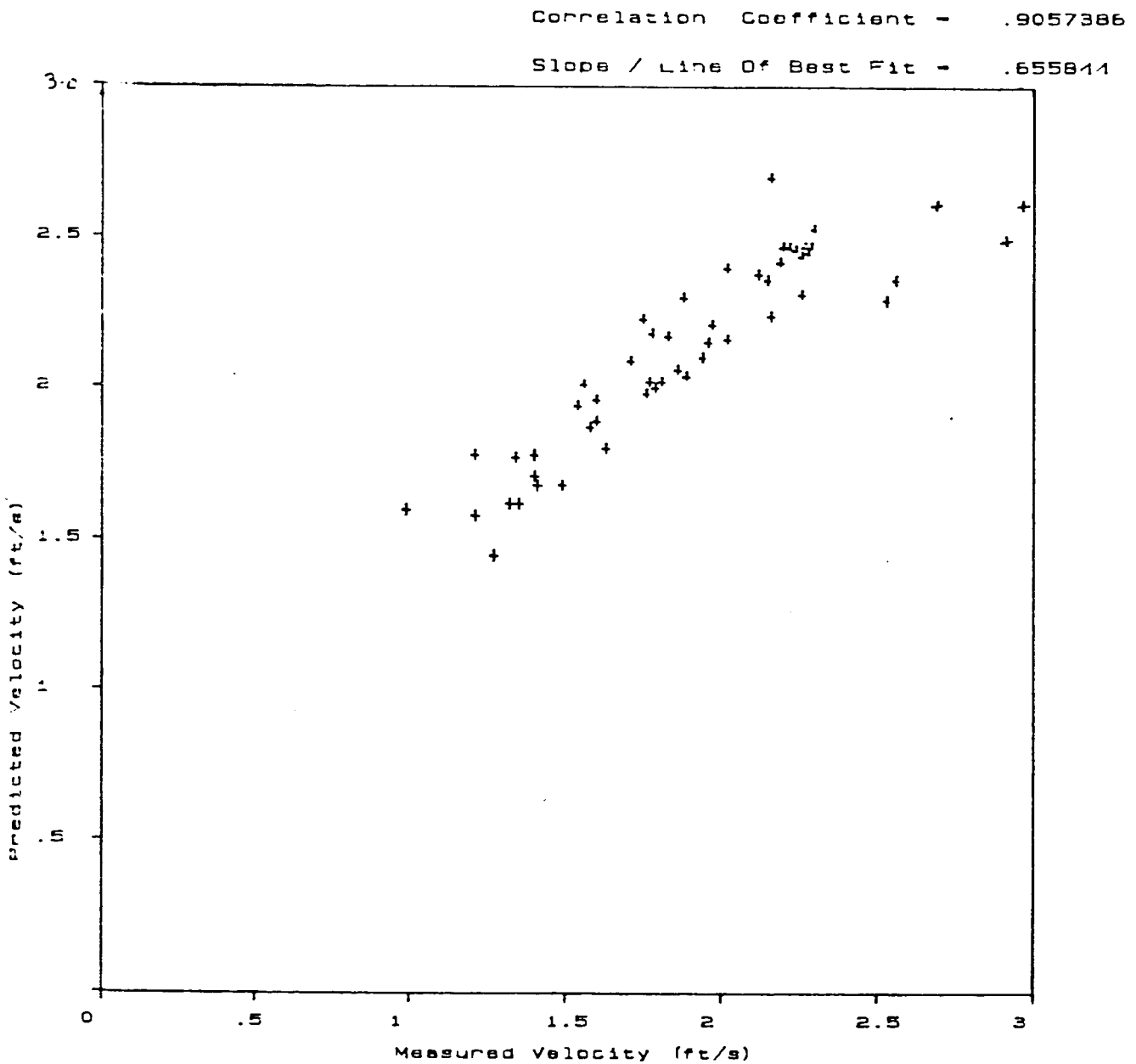
147



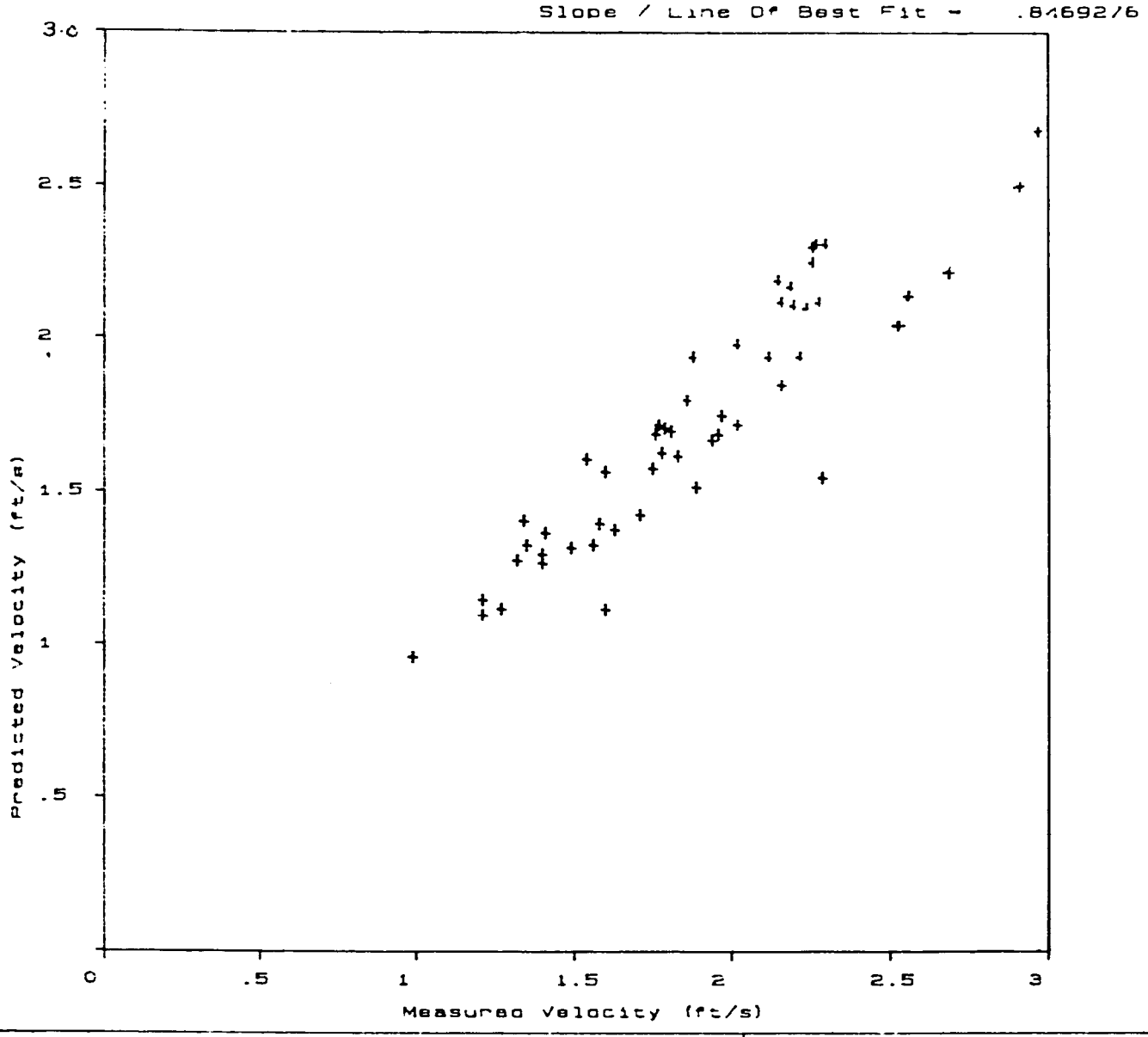
LACEY Measured Versus Predicted Velocity	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PROJ/CHECCHI	FIG. 4·25



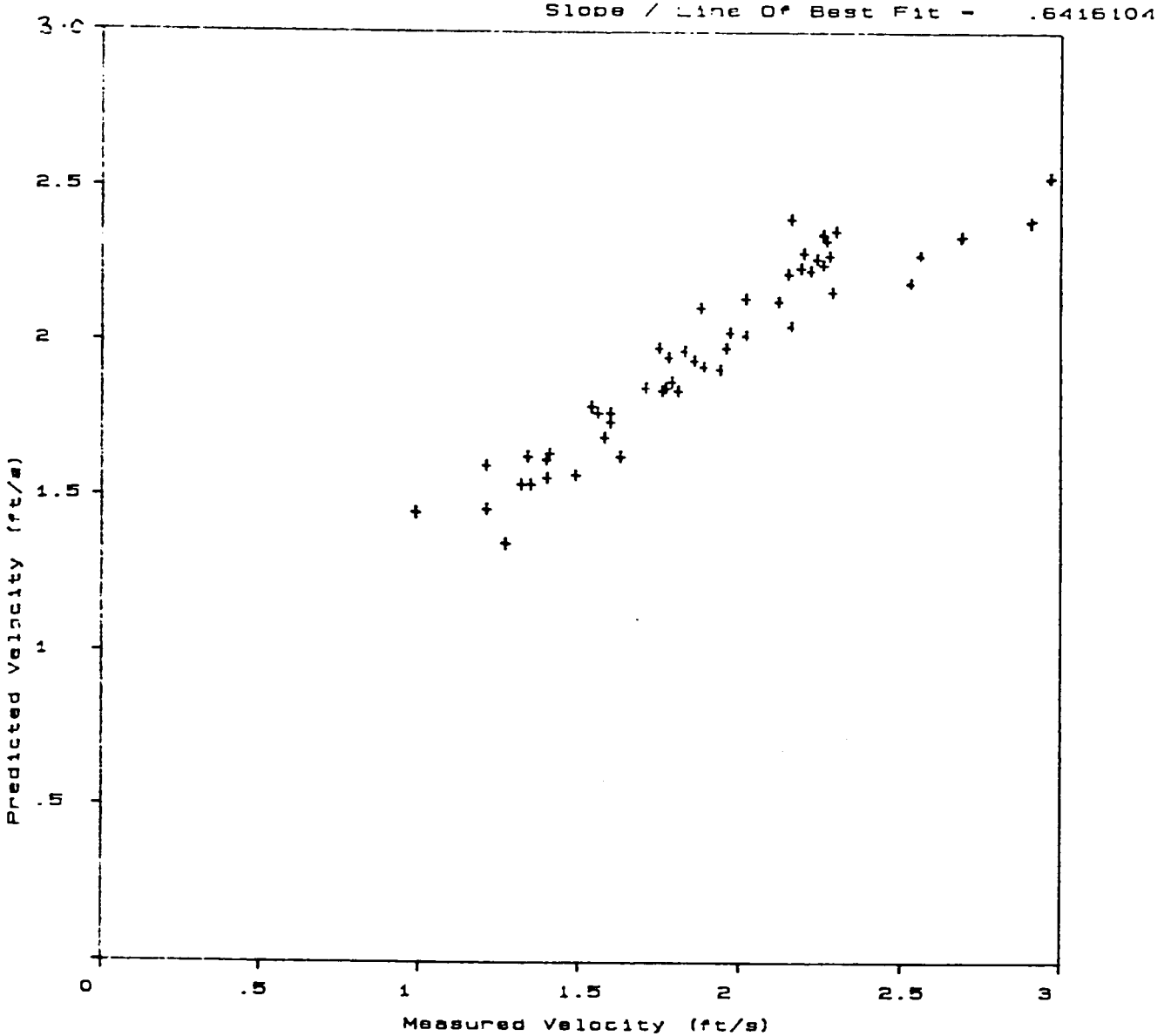
ENGELUND AND HANSEN Measured versus Predicted Velocity	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·26



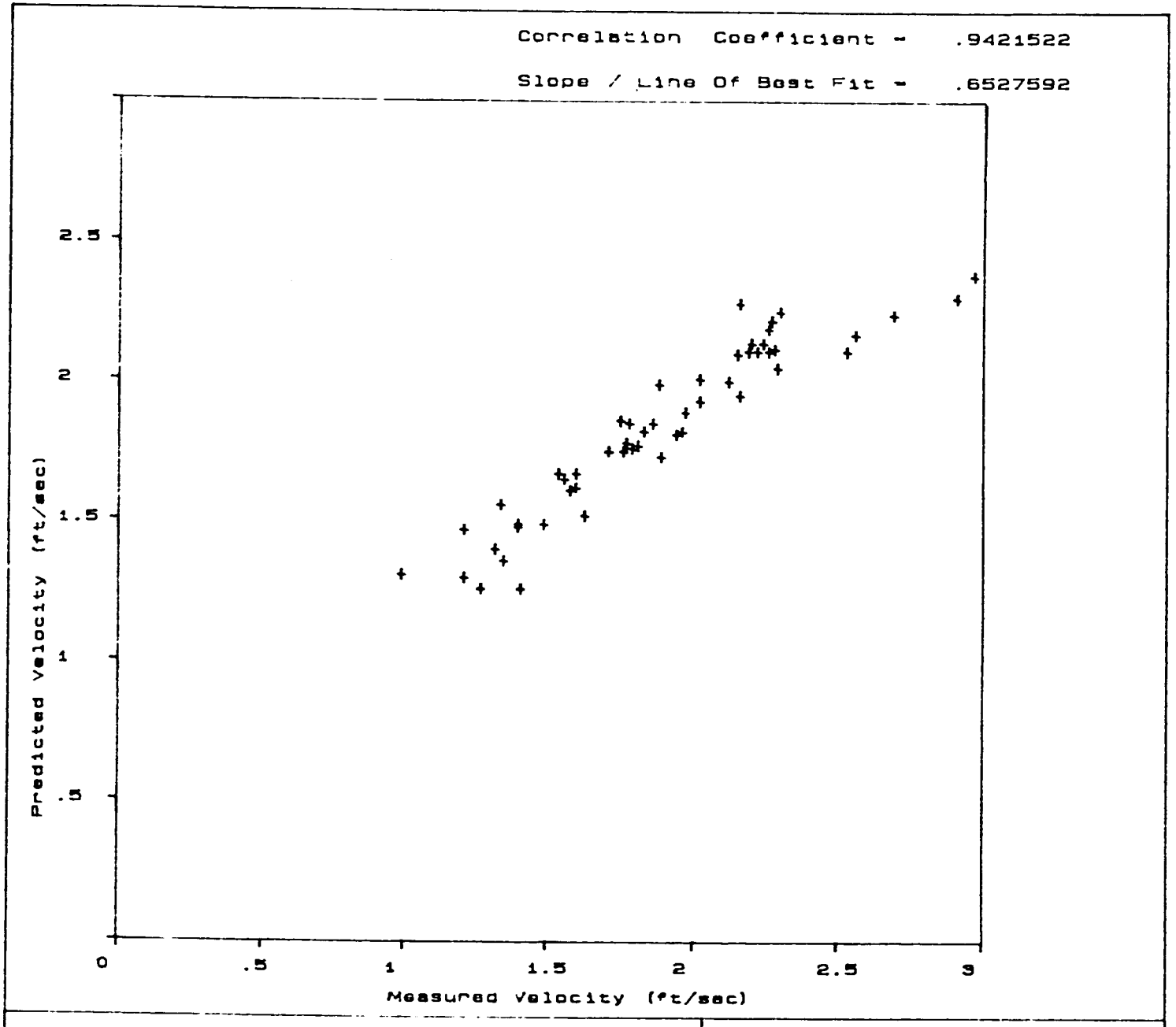
ACKERS AND WHITE Measured versus Predicted Velocity	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·27



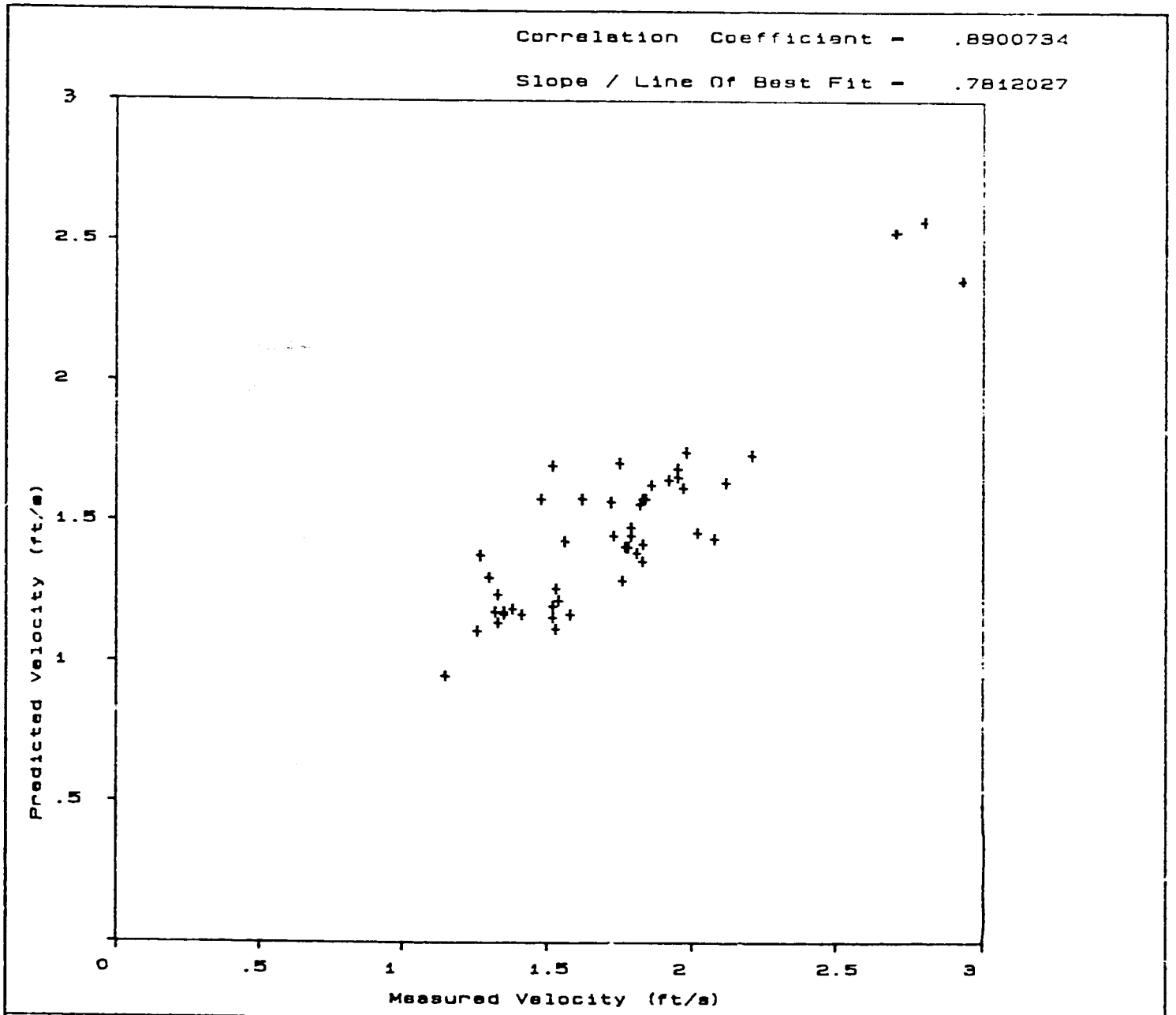
KARIM AND KENNEDY Measured versus Predicted Velocity	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·28



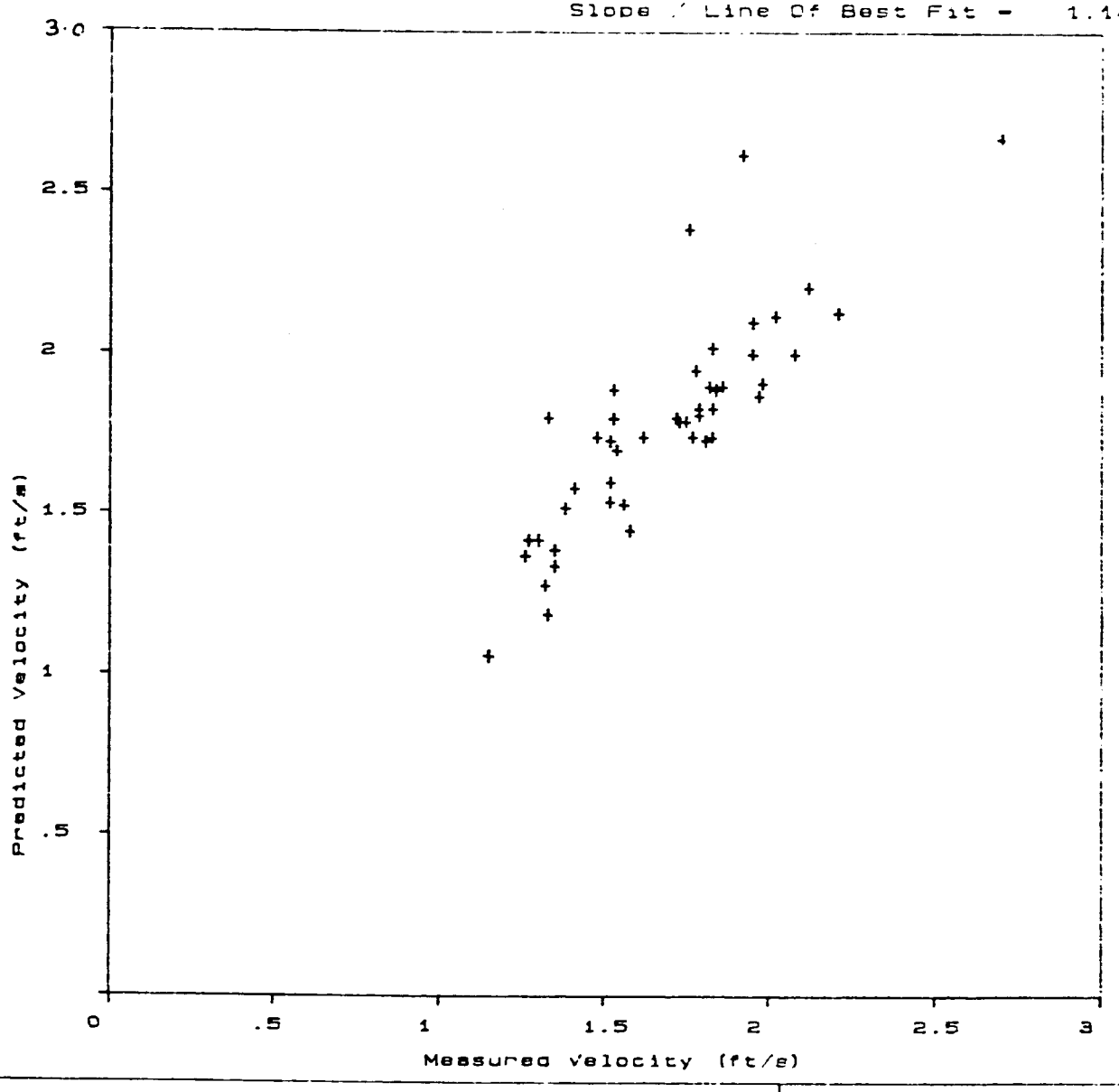
VAN RIJN Measured versus Predicted Velocity	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·29



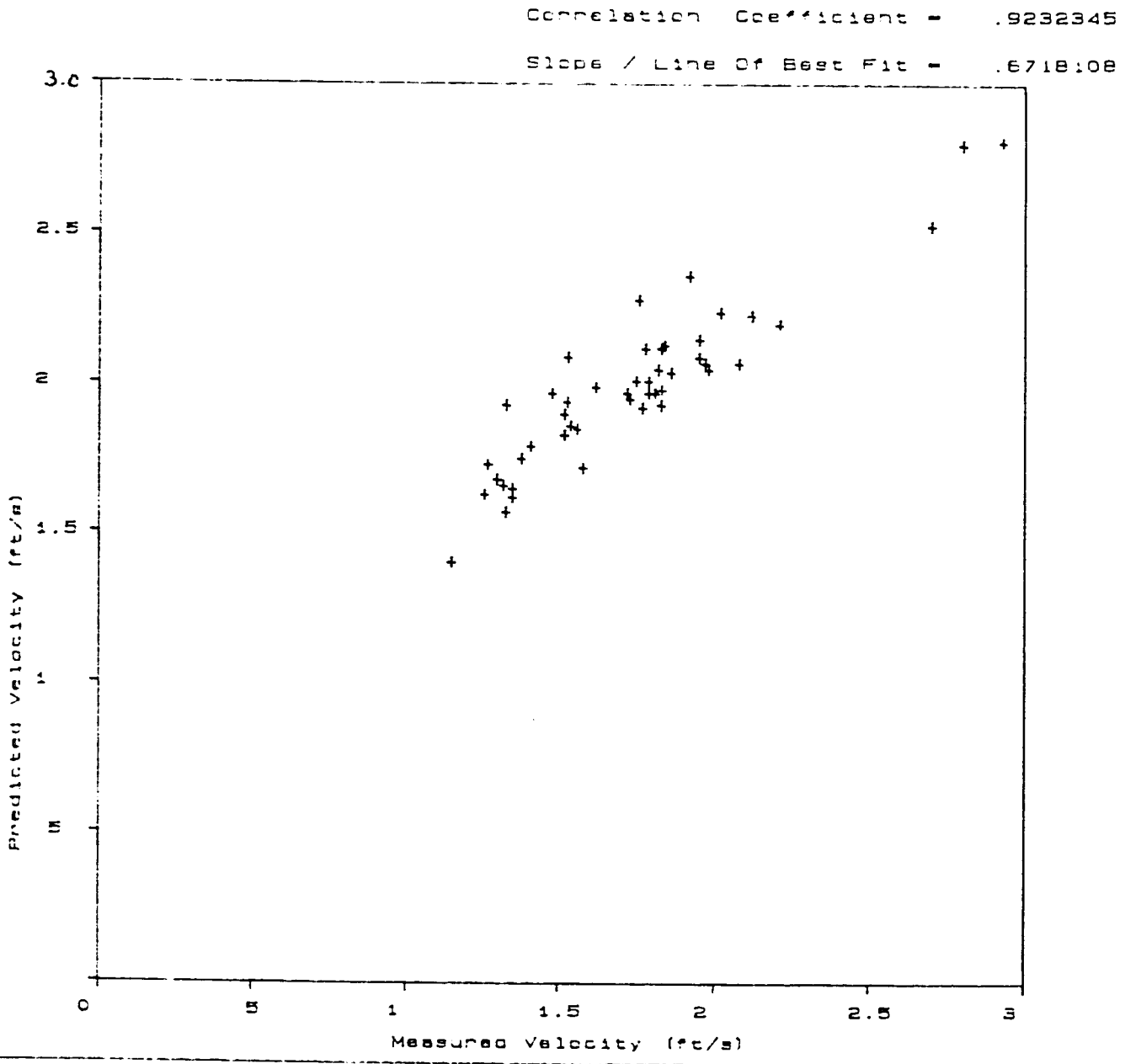
HYDRAULIC DESIGN CRITERIA	Mailsi Canal System
Measured Versus Predicted Velocity	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·30



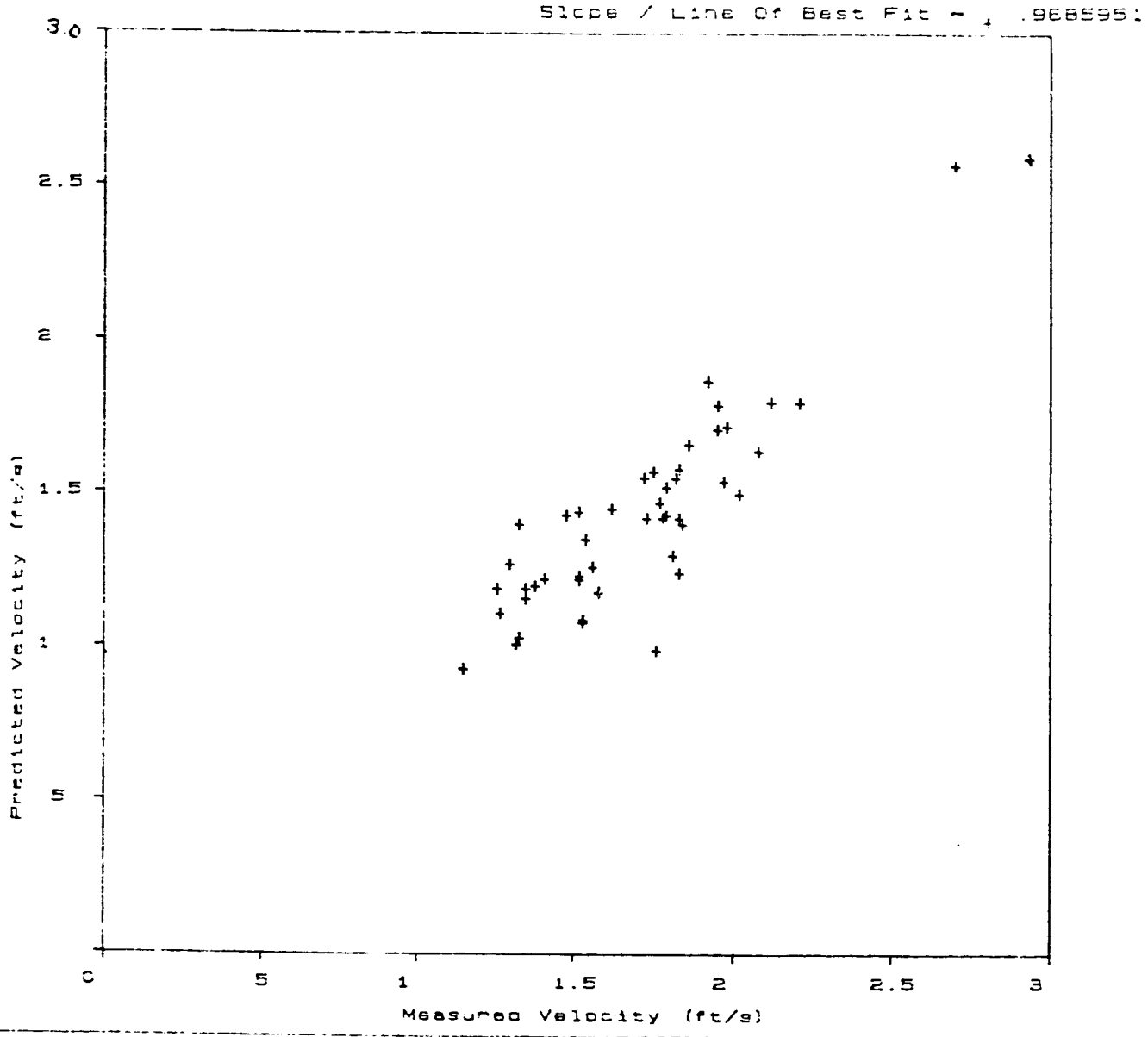
LACEY Measured versus Predicted Velocity	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·31



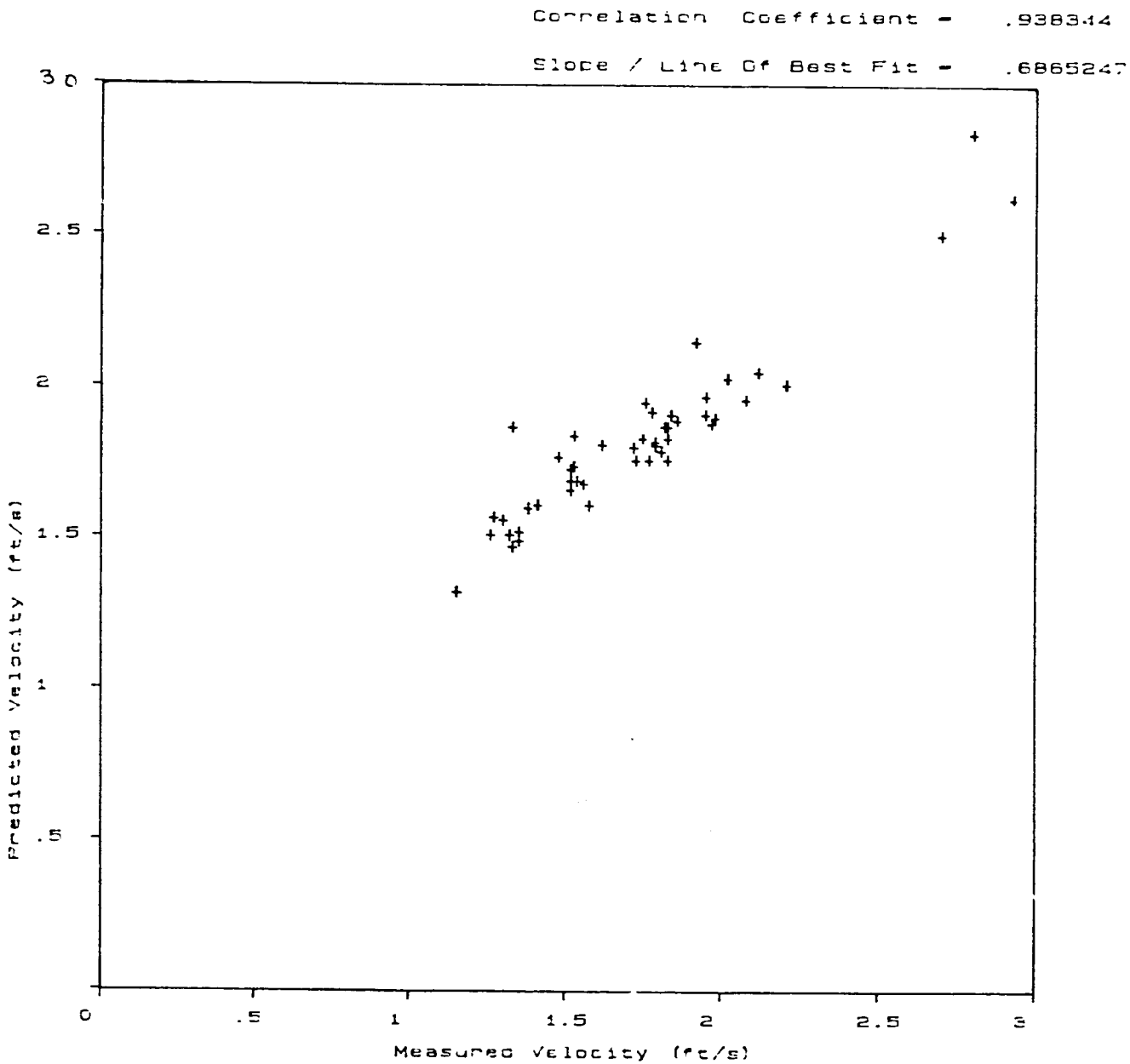
ENGELUND AND HANSEN	Sind Canal Systems
Measured versus Predicted Velocity	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·32



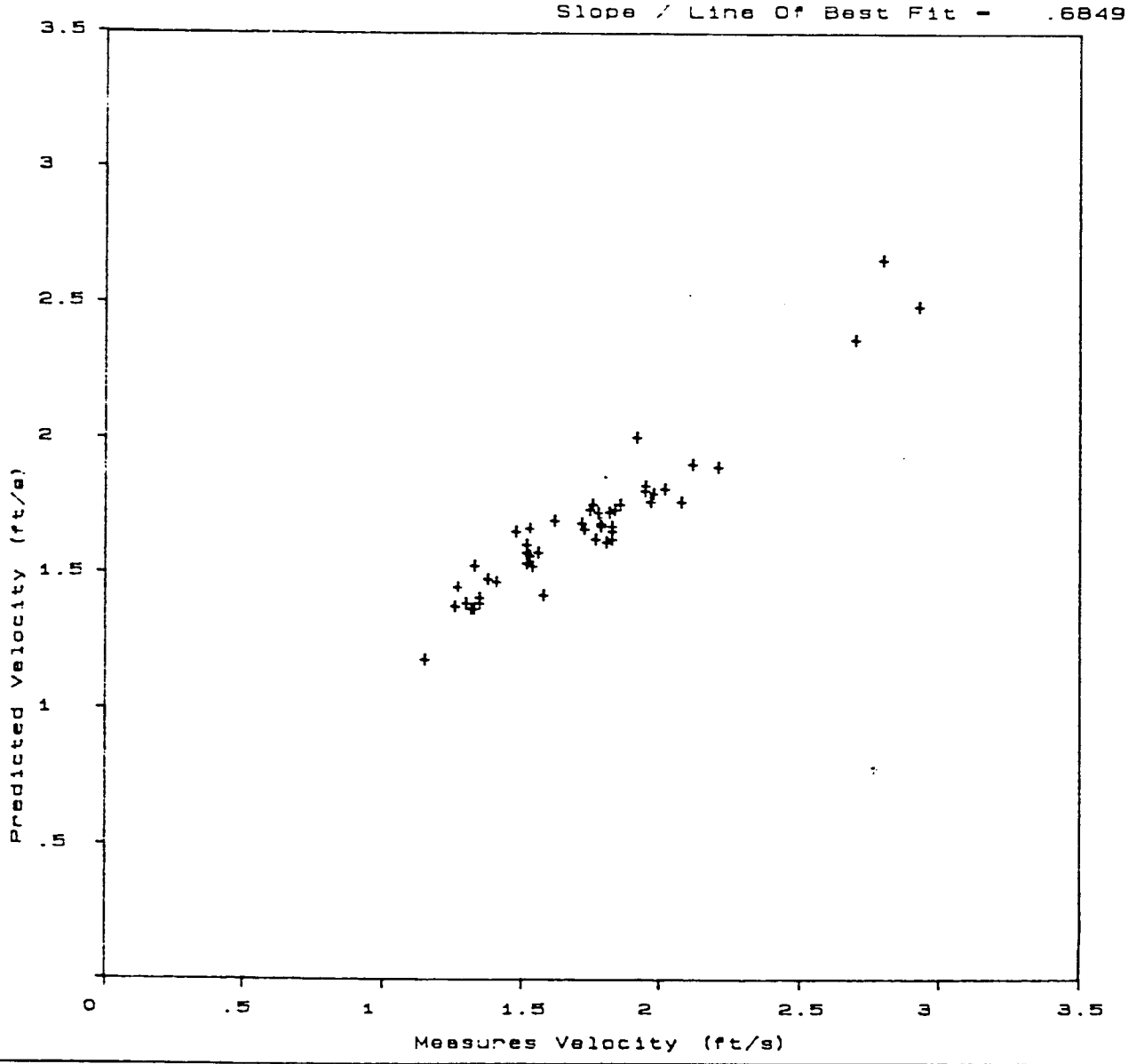
ACKERS AND WHITE Measured versus Predicted Velocity	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·33



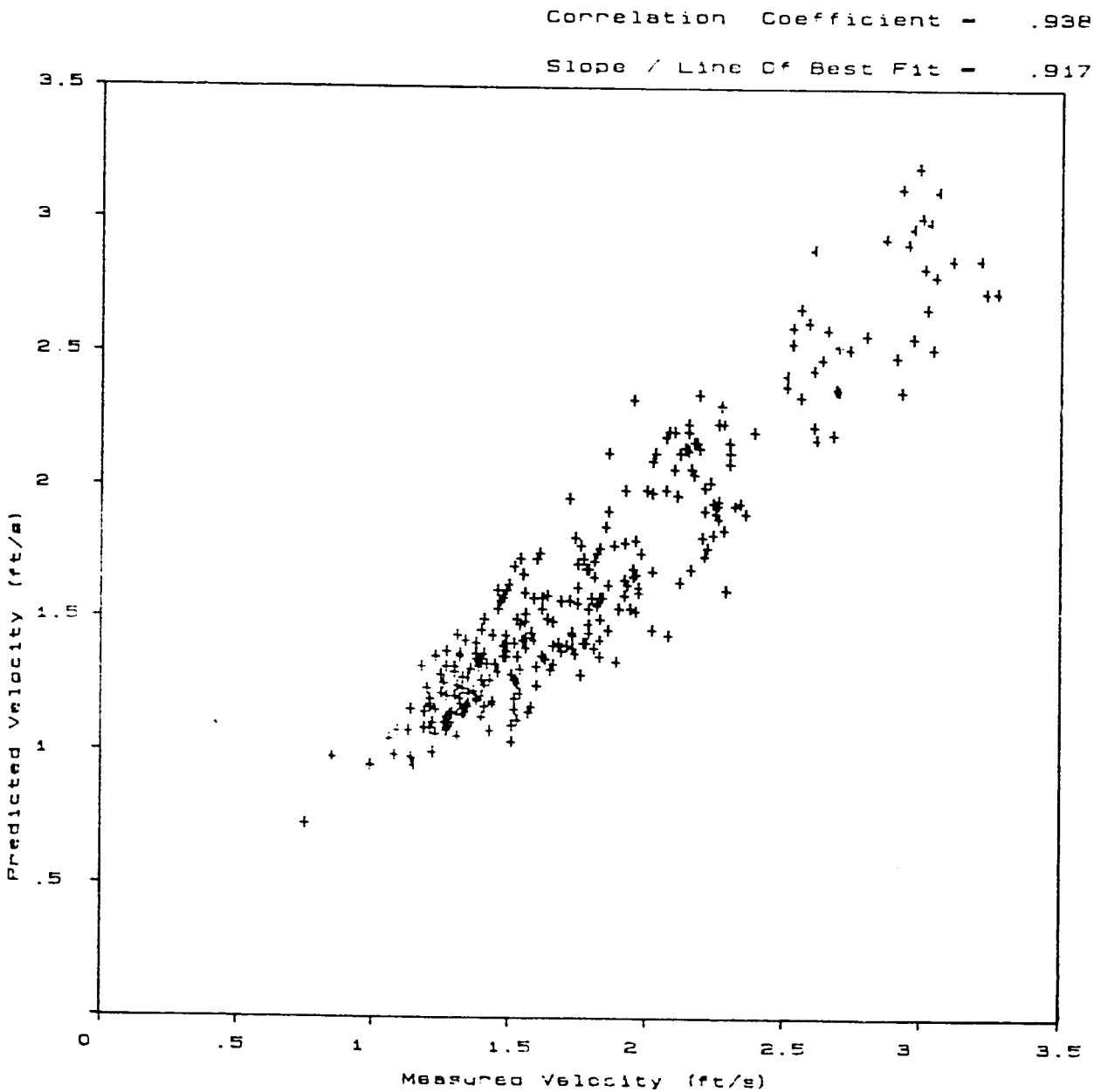
KARIM AND KENNEDY Measured versus Predicted Velocity	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·34



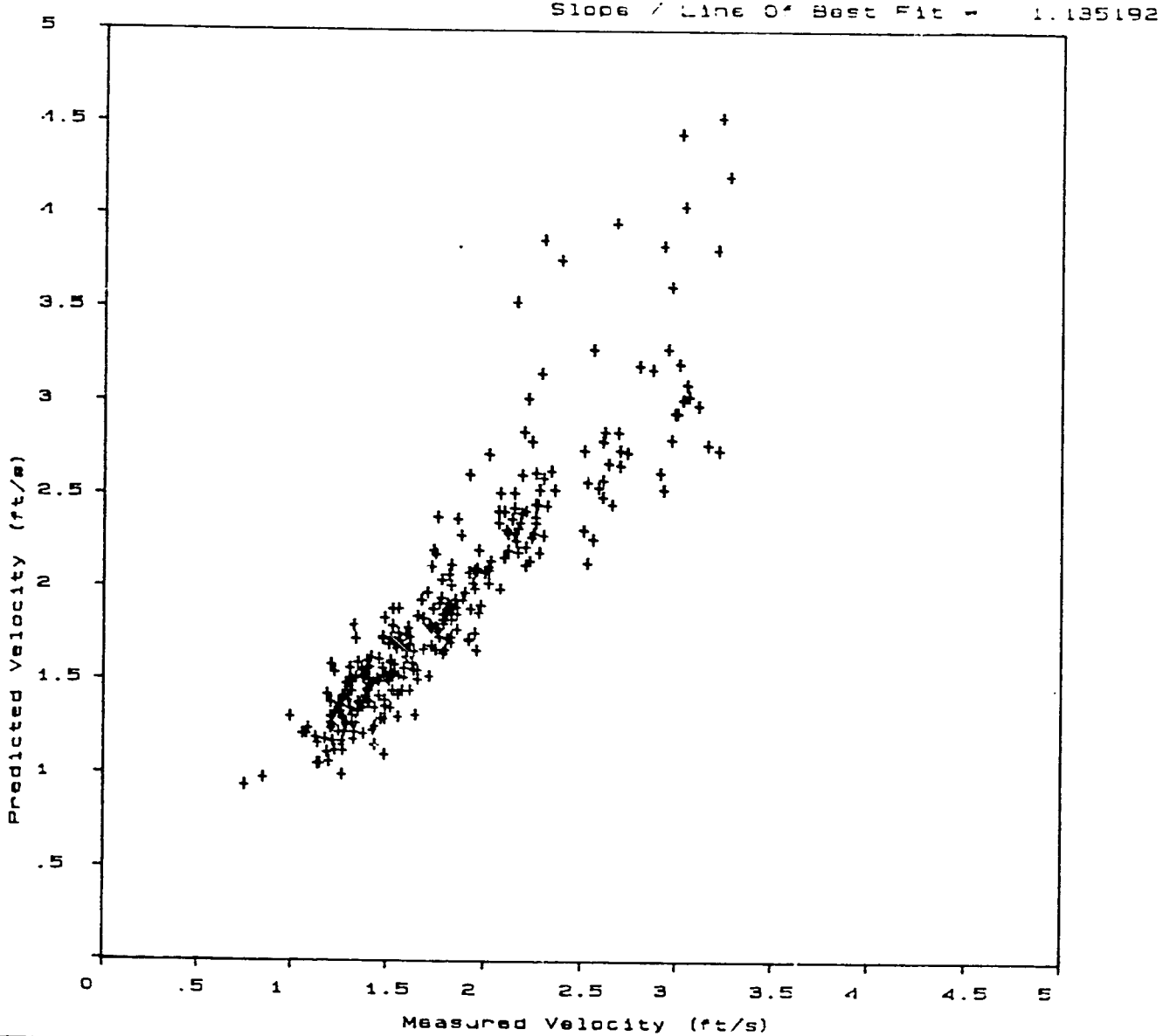
VAN RIJN Measured versus Predicted Velocity	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHPCCHI	FIG. 4·35



HYDRAULIC DESIGN CRITERIA	Sind Canal Systems
Measured verses Predicted Velocity	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·36

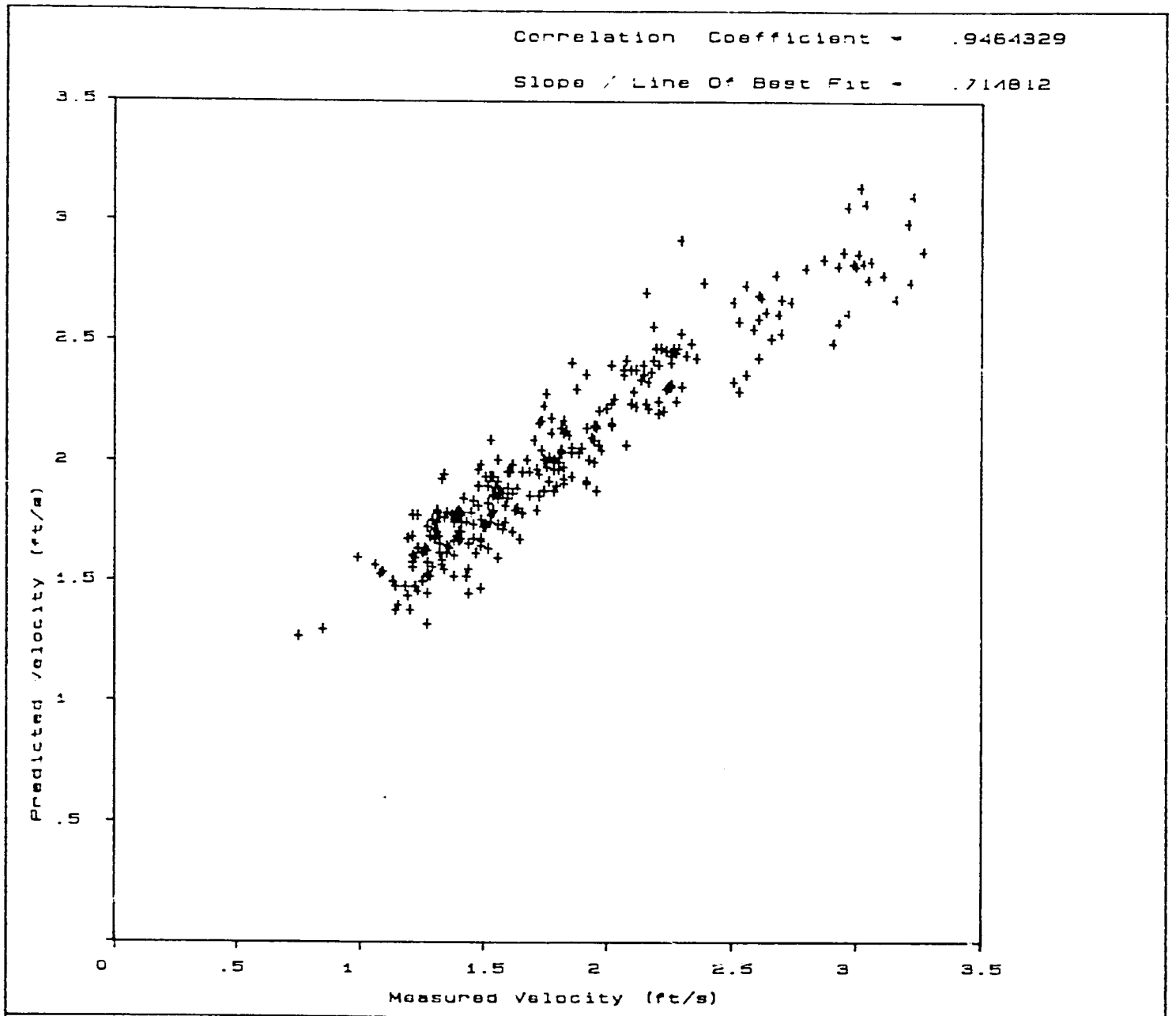


LACEY Measured versus Predicted Velocity	Canal Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·37

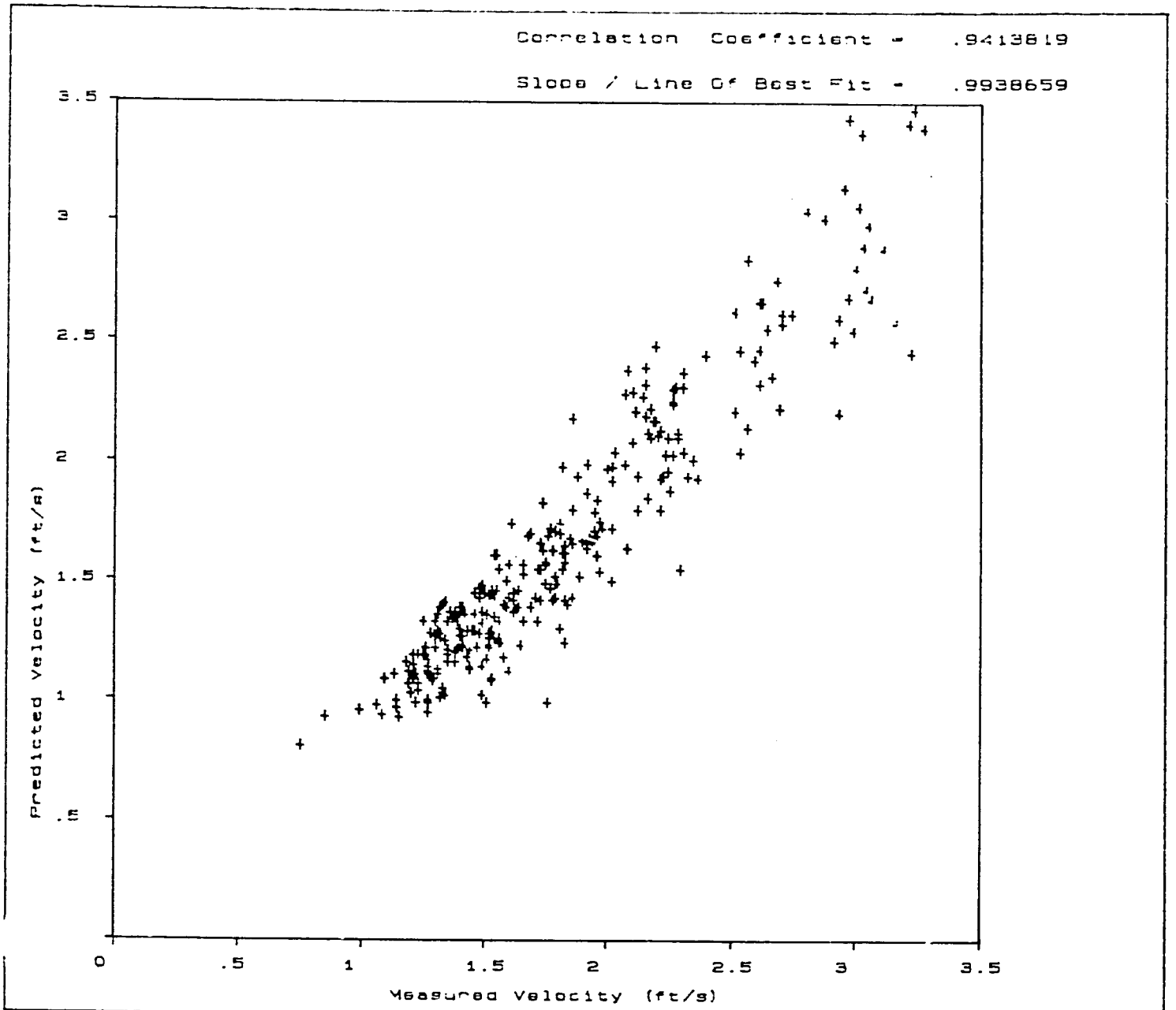


ENGELUND AND HANSEN Measured versus Predicted Velocity	Canal Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·38

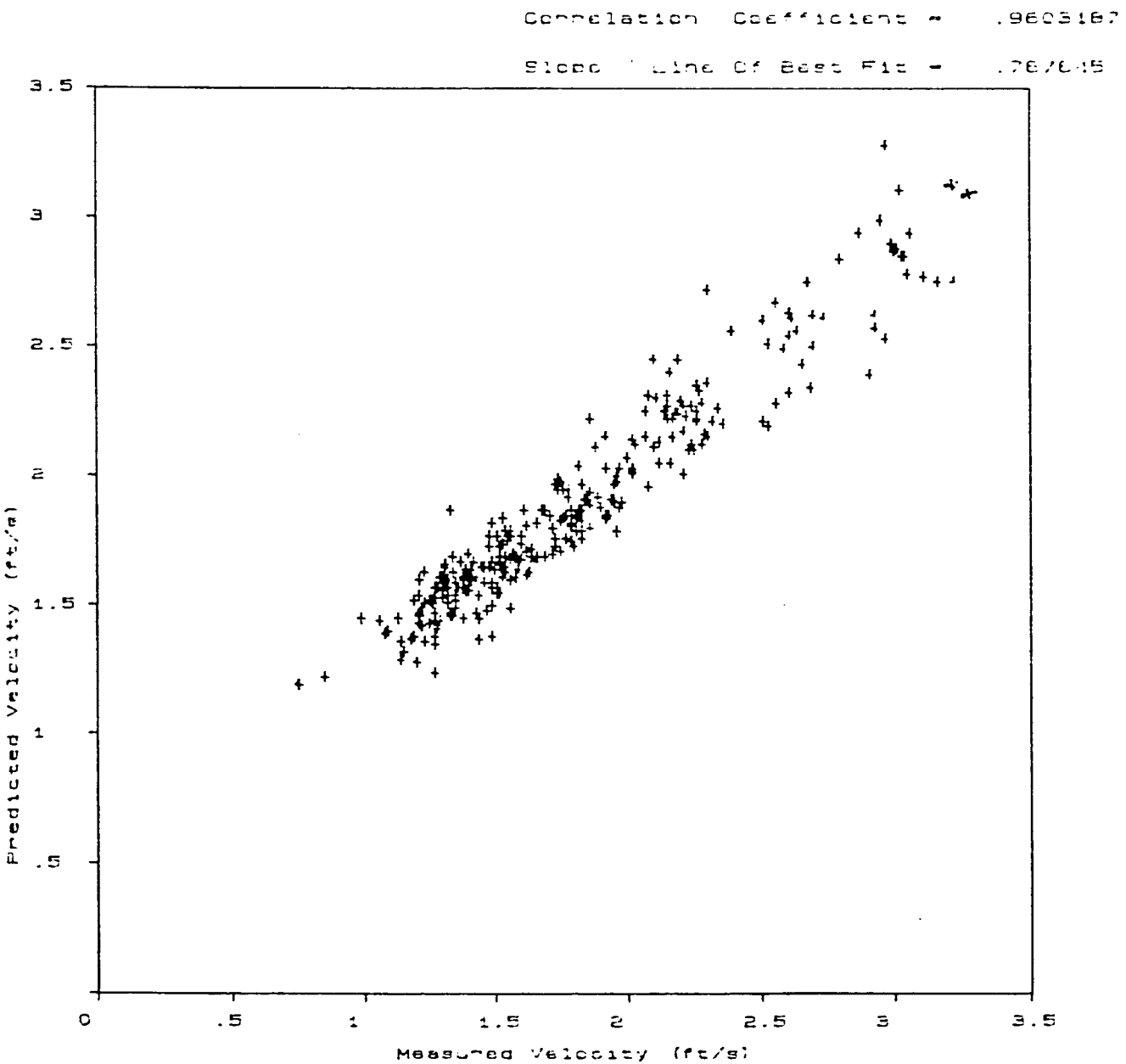
/6/



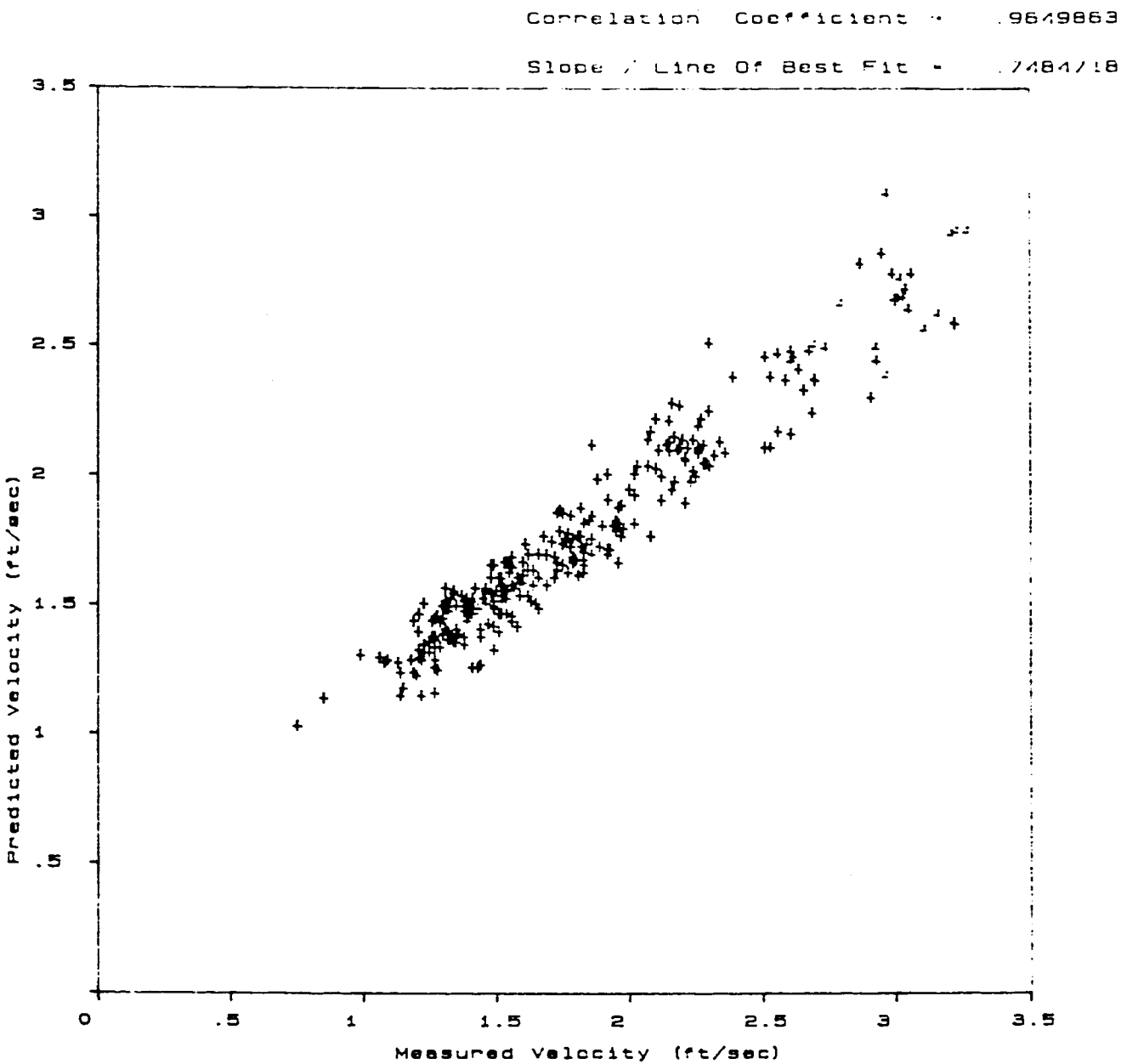
ACKERS AND WHITE	Canal Systems
Measured versus Predicted Velocity	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·39



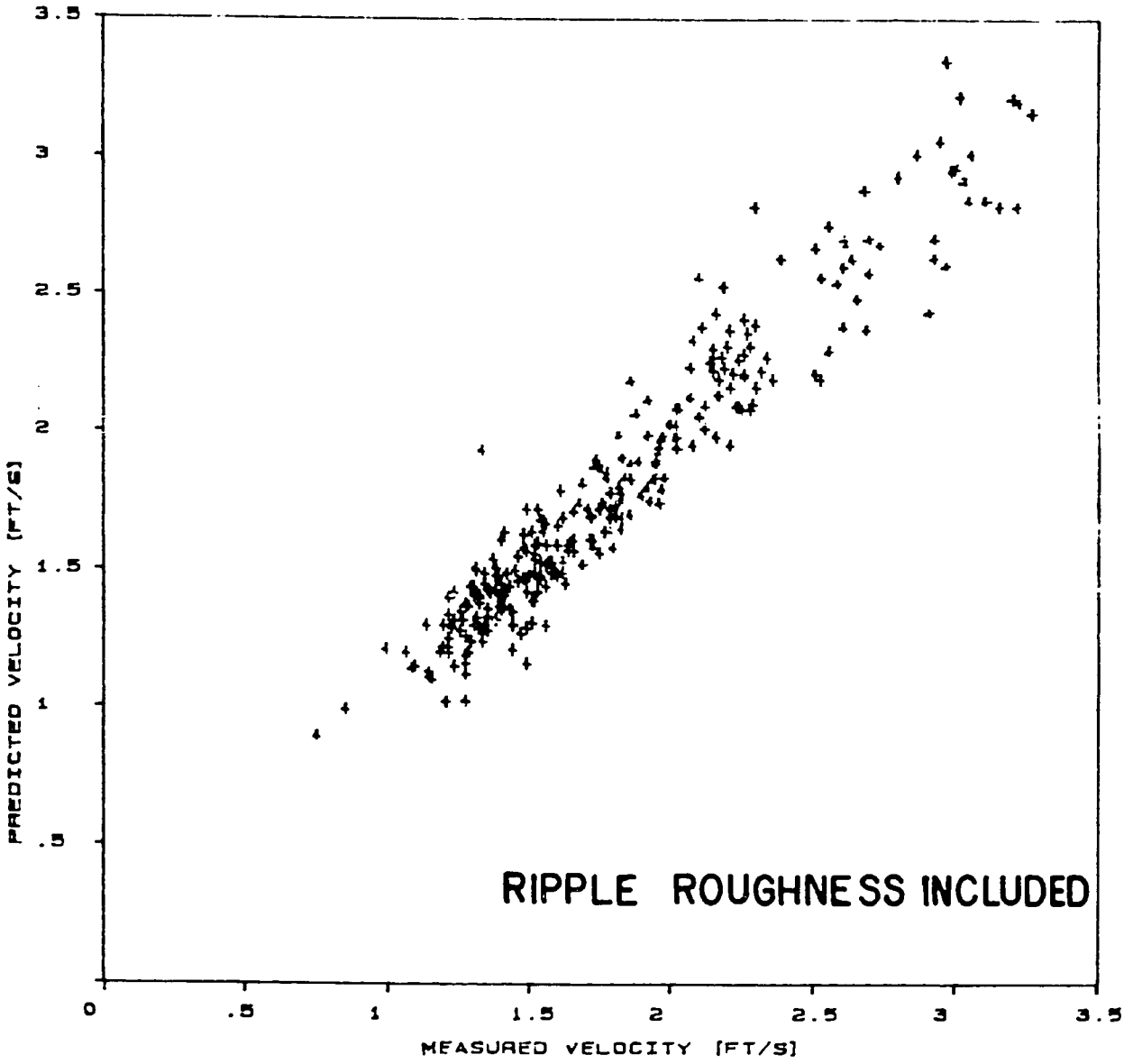
KARIM AND KENNEDY Measured versus Predicted Velocity	Canal Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·40



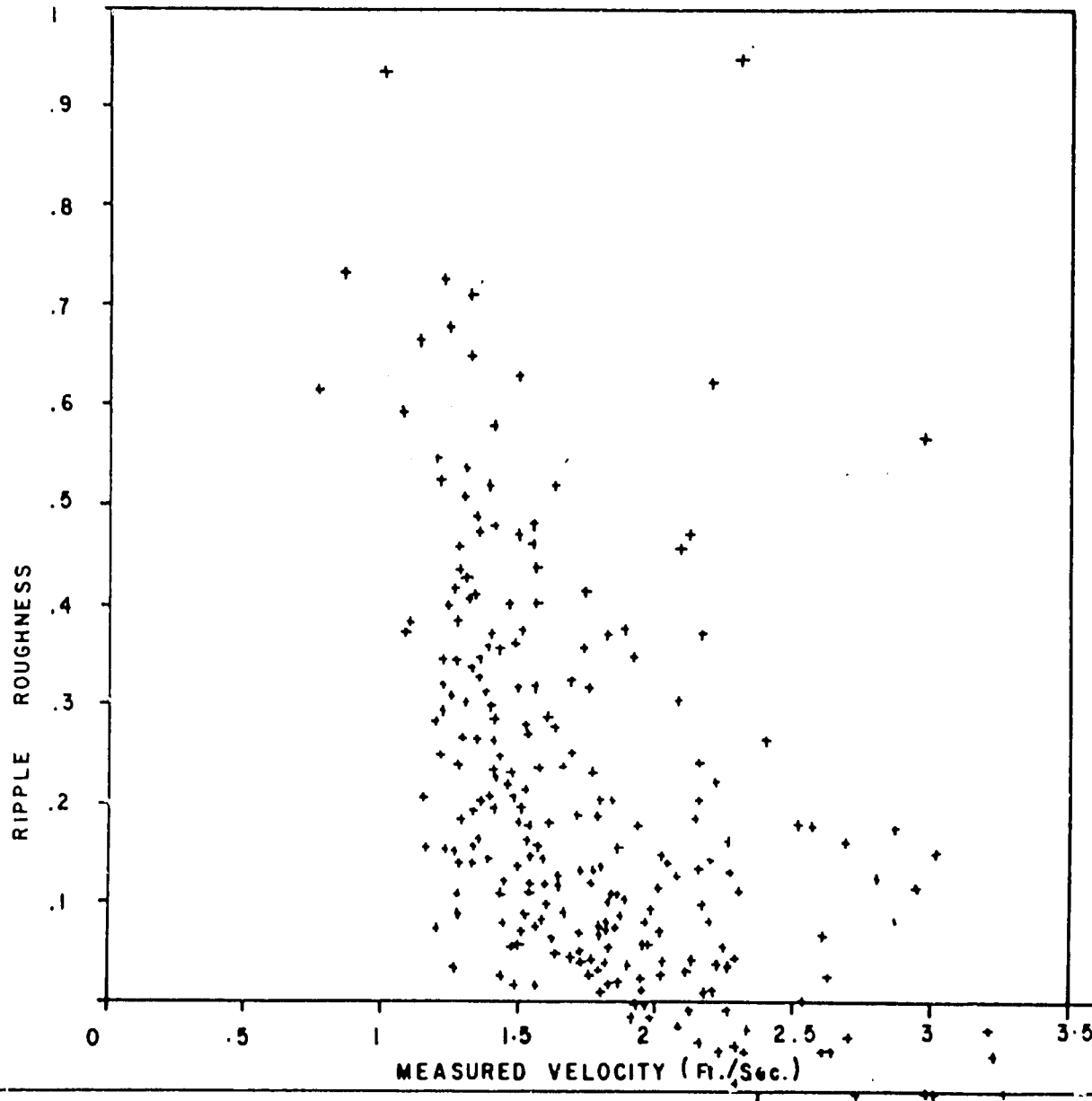
VAN RIJN Measured versus Predicted Velocity	Canal Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRO/CHECCHI	FIG. 4·41



HYDRAULIC DESIGN CRITERIA	Canal Systems
Measured Vs Predicted Velocity	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 4·42



HYDRAULIC DESIGN CRITERIA	CANAL SYSTEMS
MEASURED VERSUS PREDICTED VELOCITY	PUNJAB & SIND PROVINCES
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 4.43



Kripple Measured Velocity VS Kripple	CANAL SYSTEMS PUNJAB & SIND PROVINCES
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG.4.44

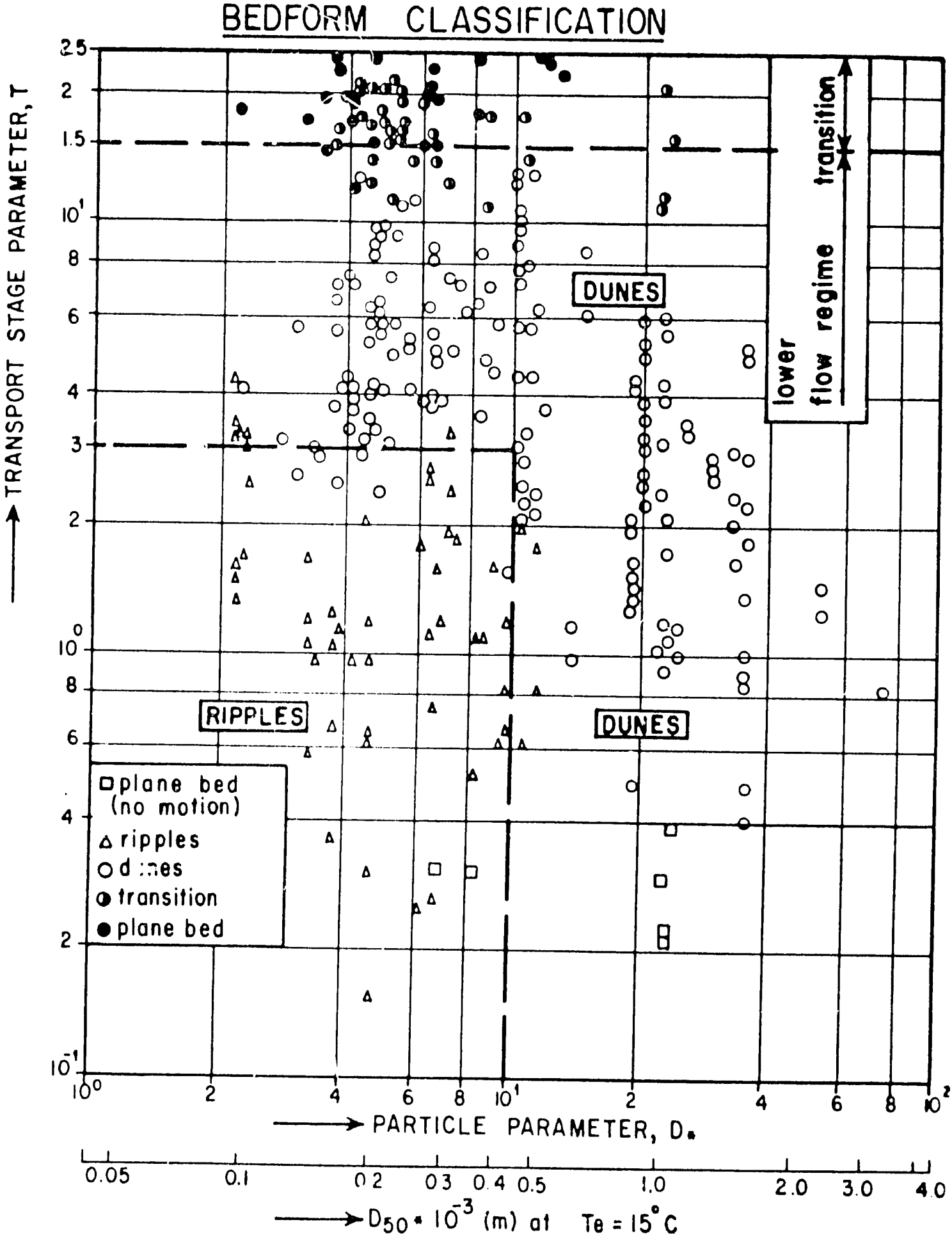

BEDFORM CLASSIFICATION
TRANSPORT STAGE PARAMETER, T
PARTICLE PARAMETER, D*
$D_{50} \cdot 10^{-3}$ (m) at Te = 15°C
DUNES
RIPPLES
DUNES
lower flow regime transition
plane bed (no motion)
ripples
dunes
transition
plane bed

FIGURE 4.45

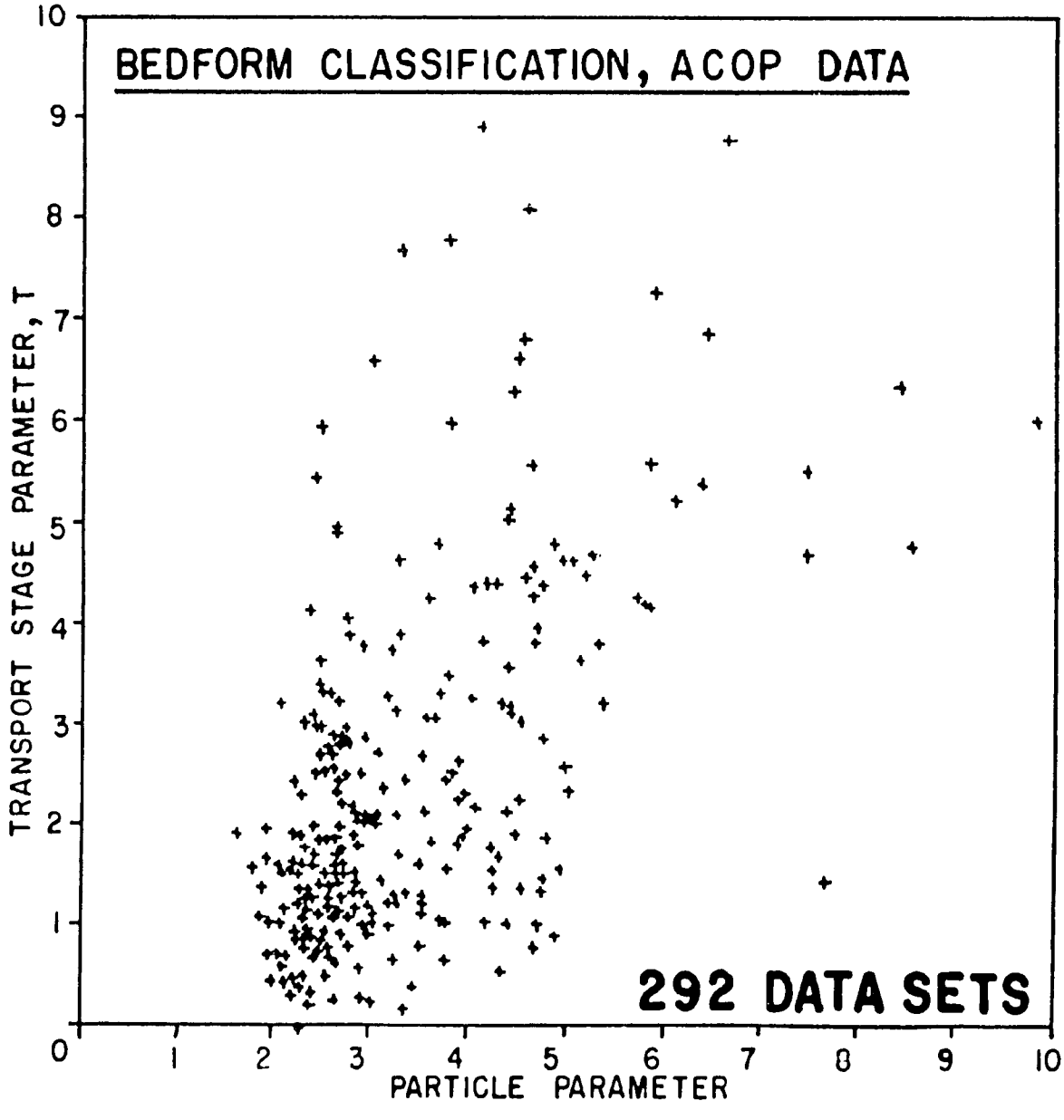
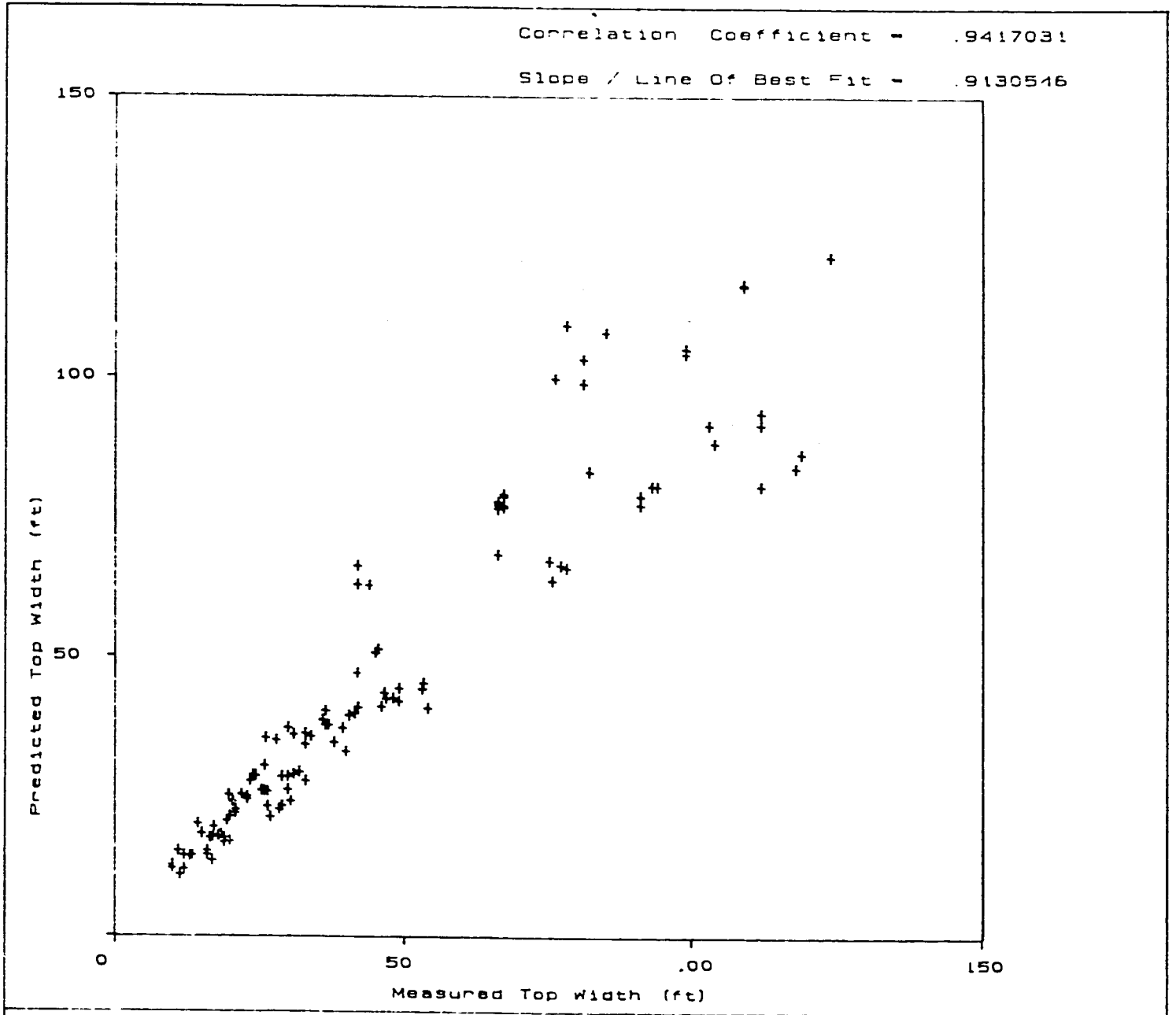
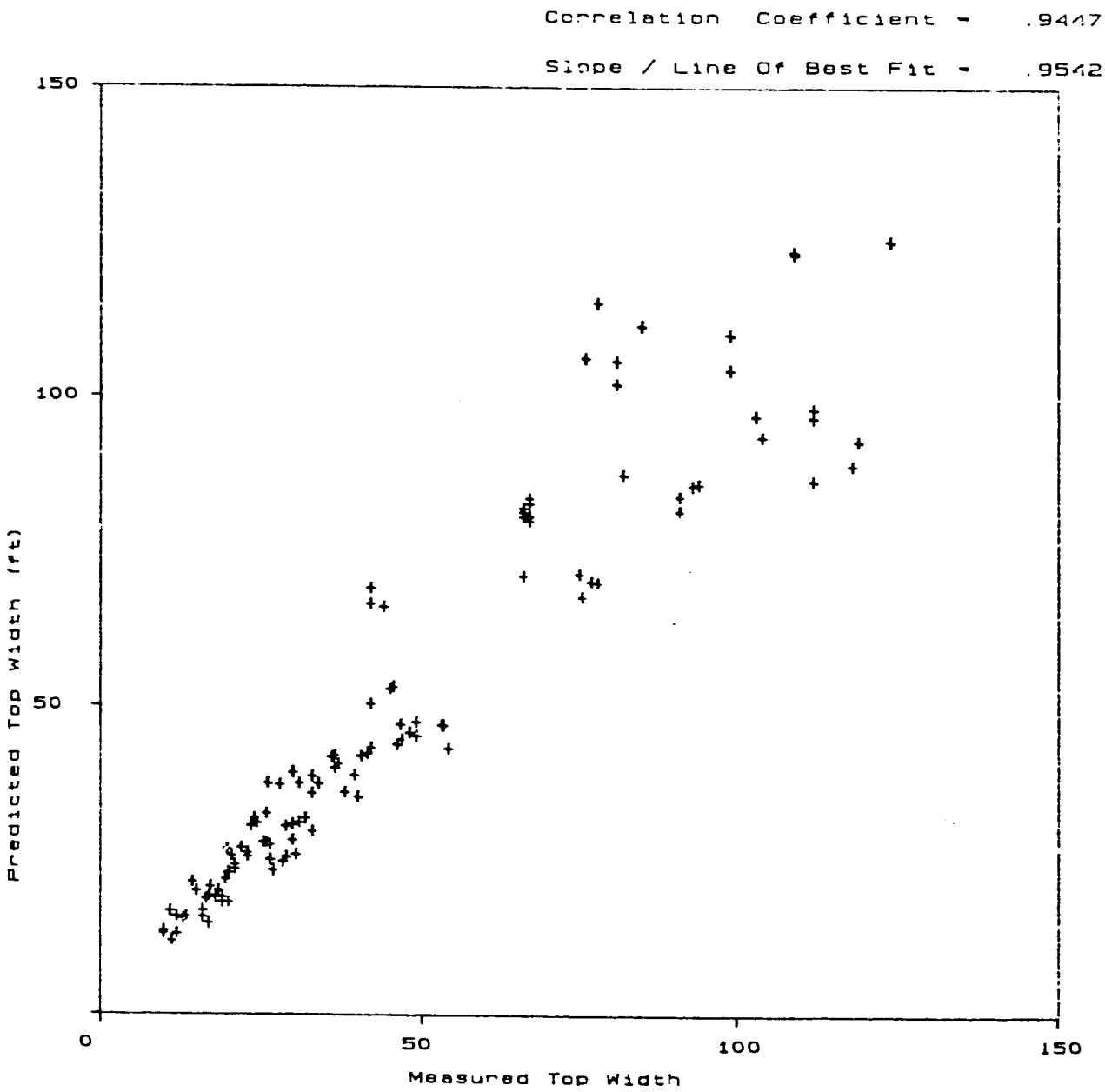

BEDFORM CLASSIFICATION, ACOP DATA
292 DATA SETS
TRANSPORT STAGE PARAMETER, T
PARTICLE PARAMETER
0
1
2
3
4
5
6
7
8
9
10

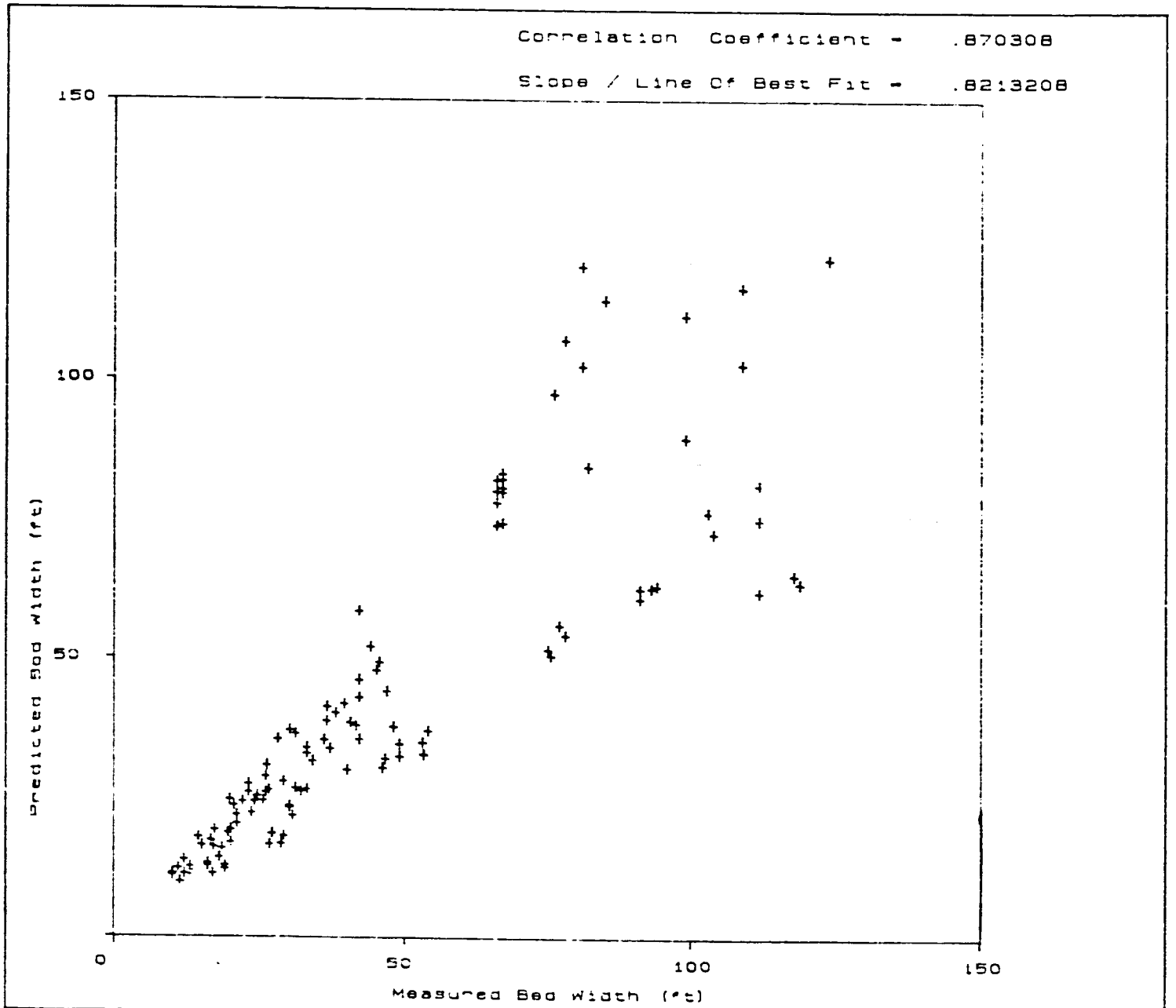
FIGURE 4.46



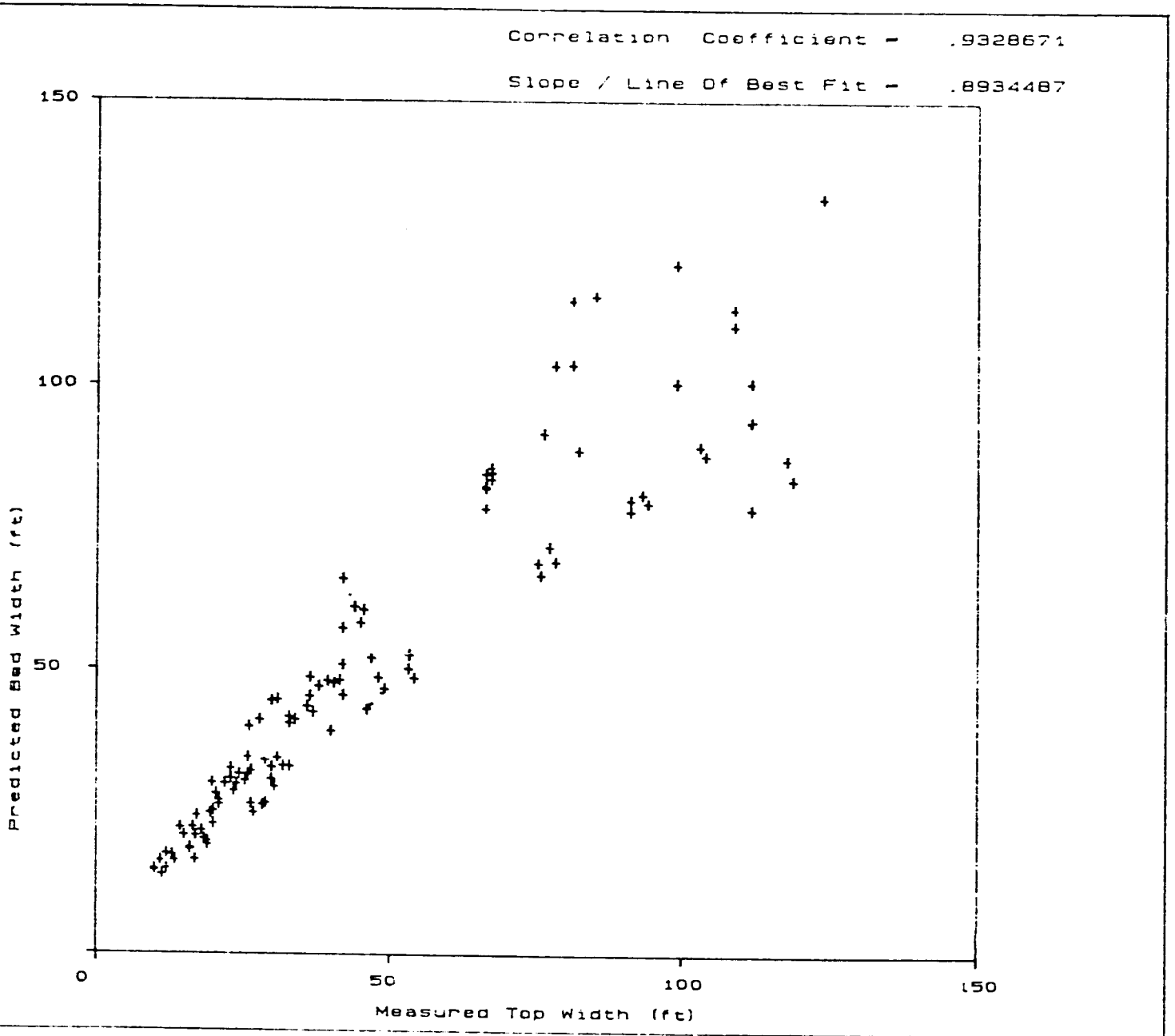
Lacey Measured Versus Predicted Top Width	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·1



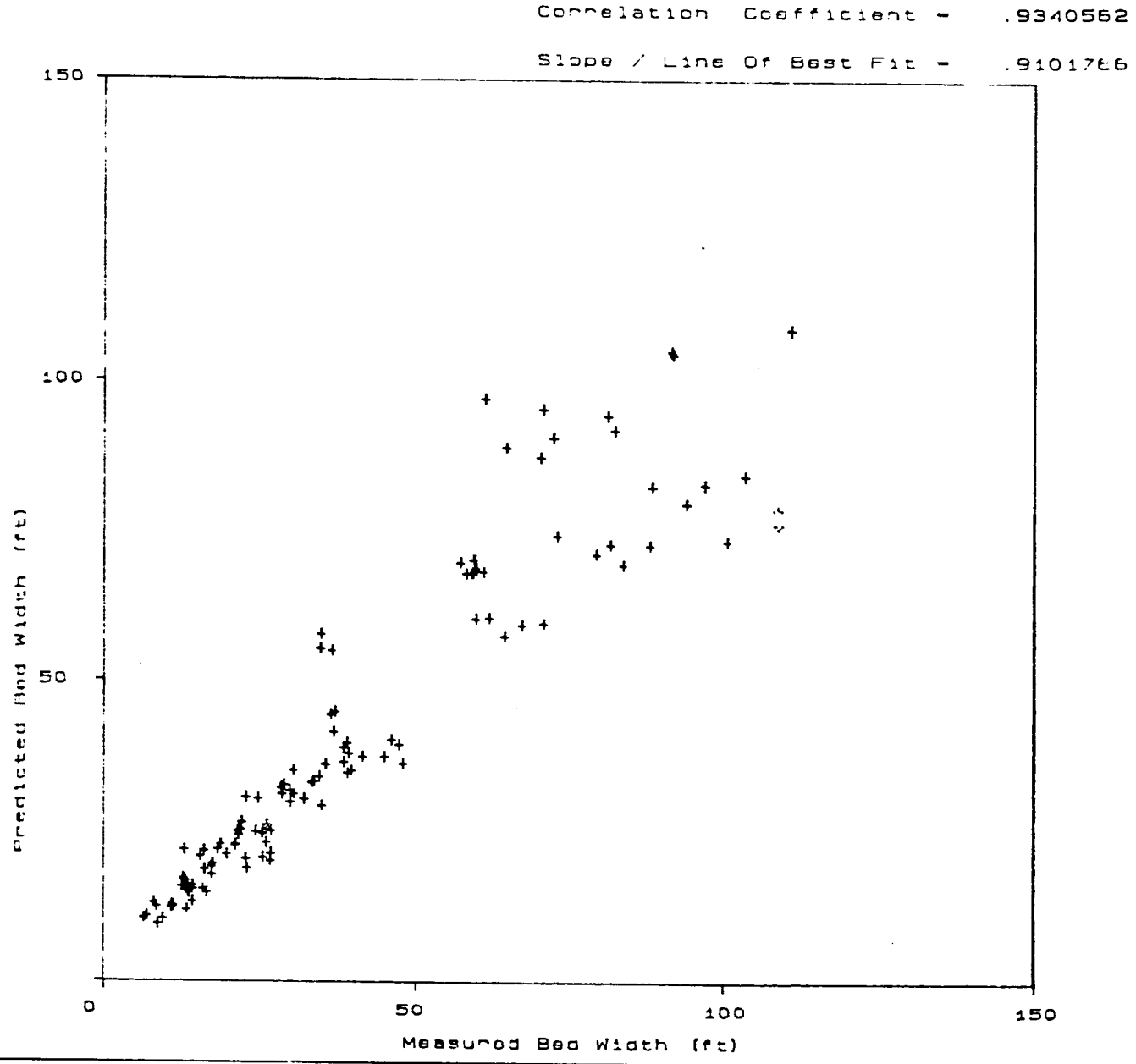
Chang Measured Versus Predicted Top Width	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·2



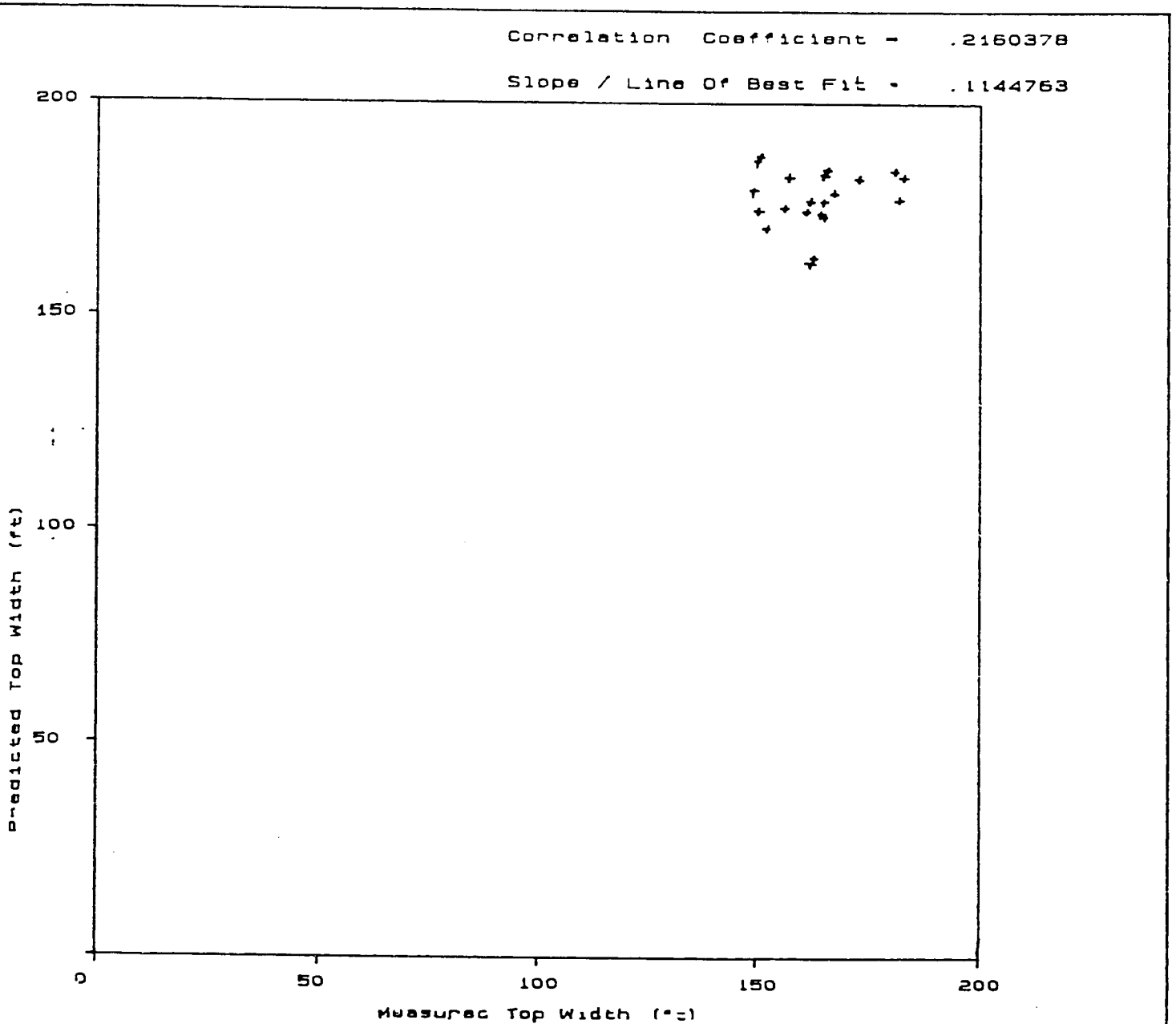
VELIKANOV Measured Versus Predicted Bed Width	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5-3



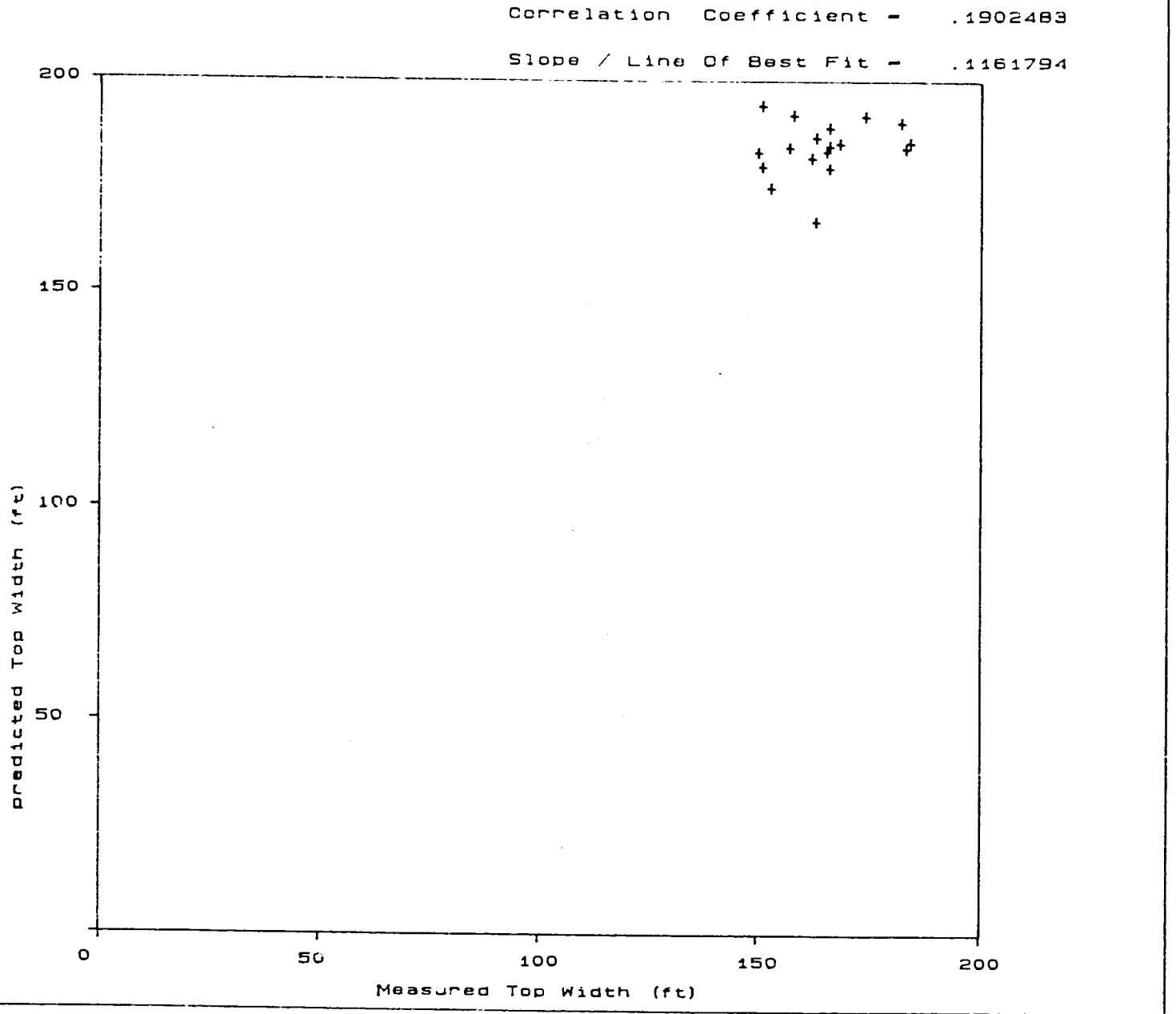
YALIN Measured Versus Predicted Top Width	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·4



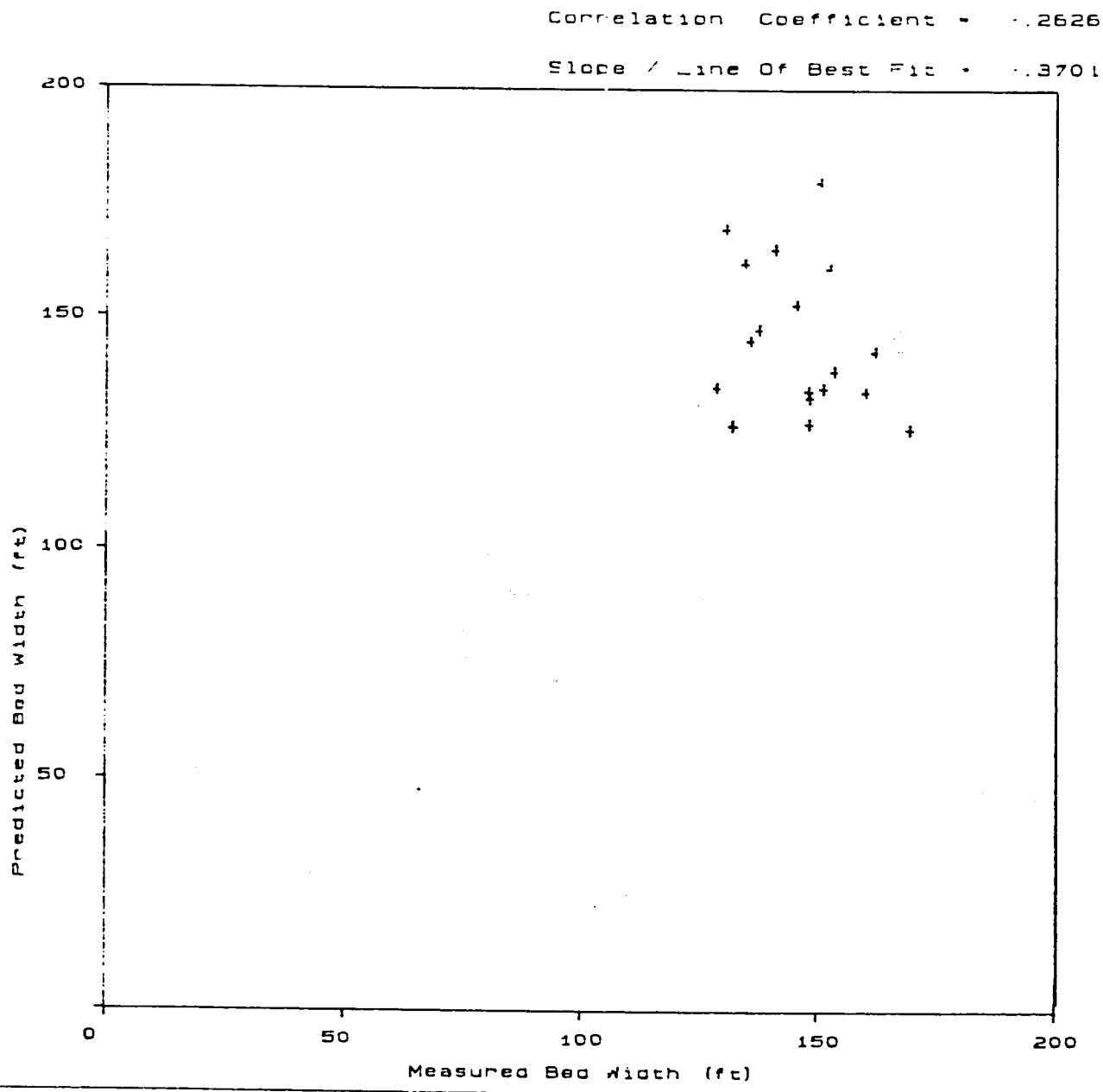
Hydraulic Design Criteria	Depalpur Canal System
Measured Versus Predicted Bed Width	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·5



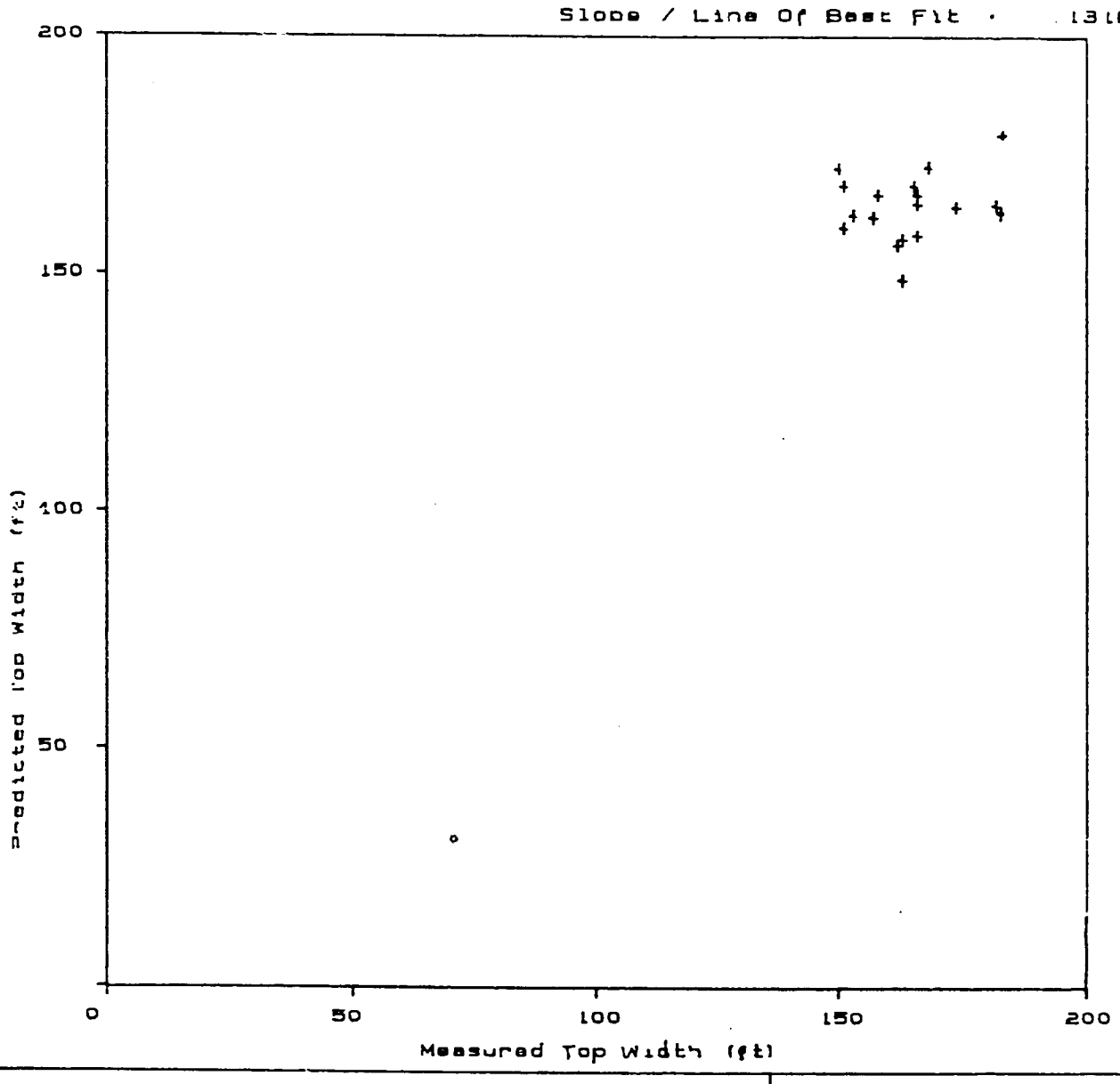
LACEY Measured versus Predicted Top Width	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·6



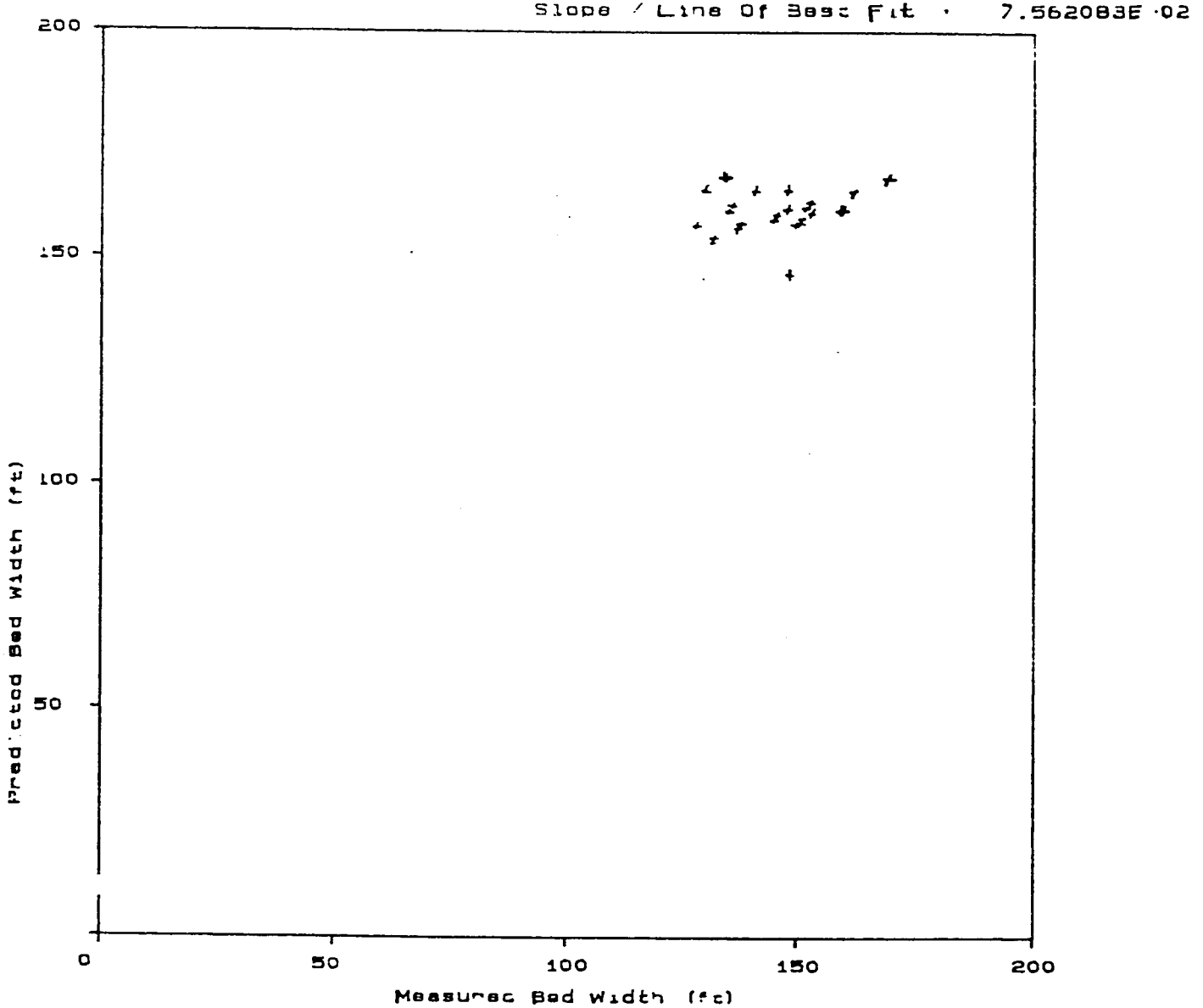
CHANG Measured versus Predicted Top Width	Uppera Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·7



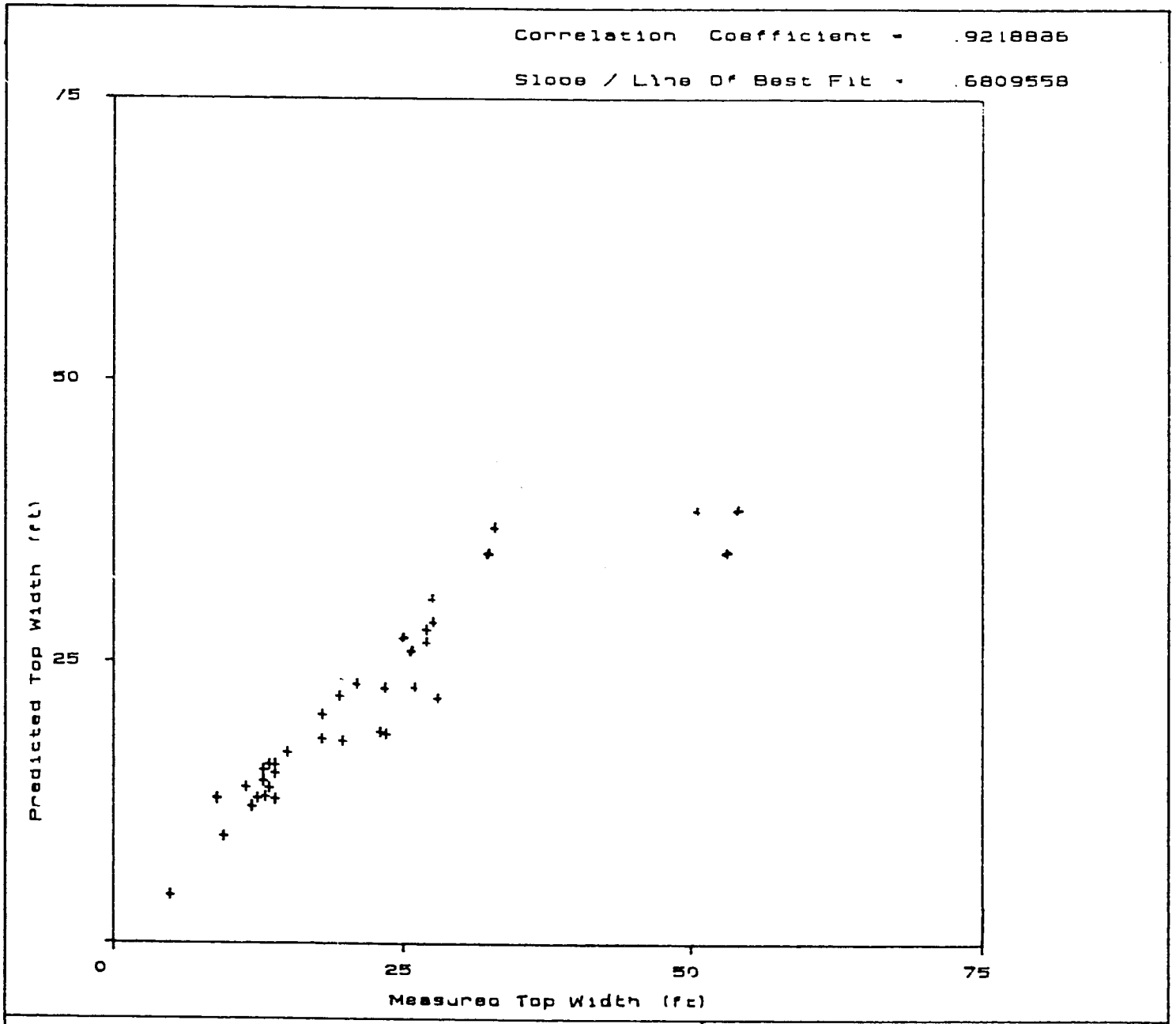
VELIKANOV Measured vesus Predicted Bed Width	Uppera Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·8



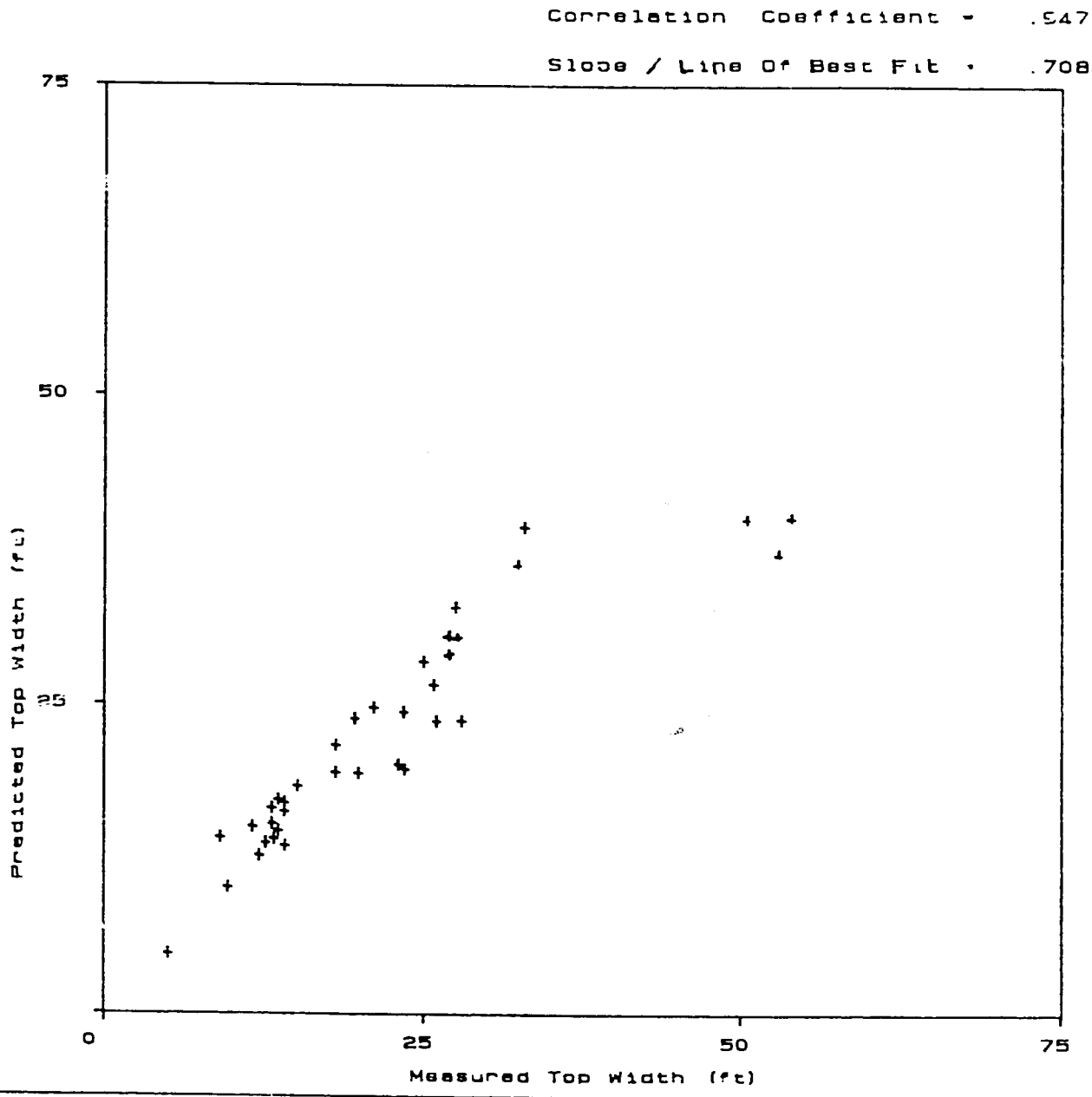
YALIN Measured versus Predicted Top Width	Uppera Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·9



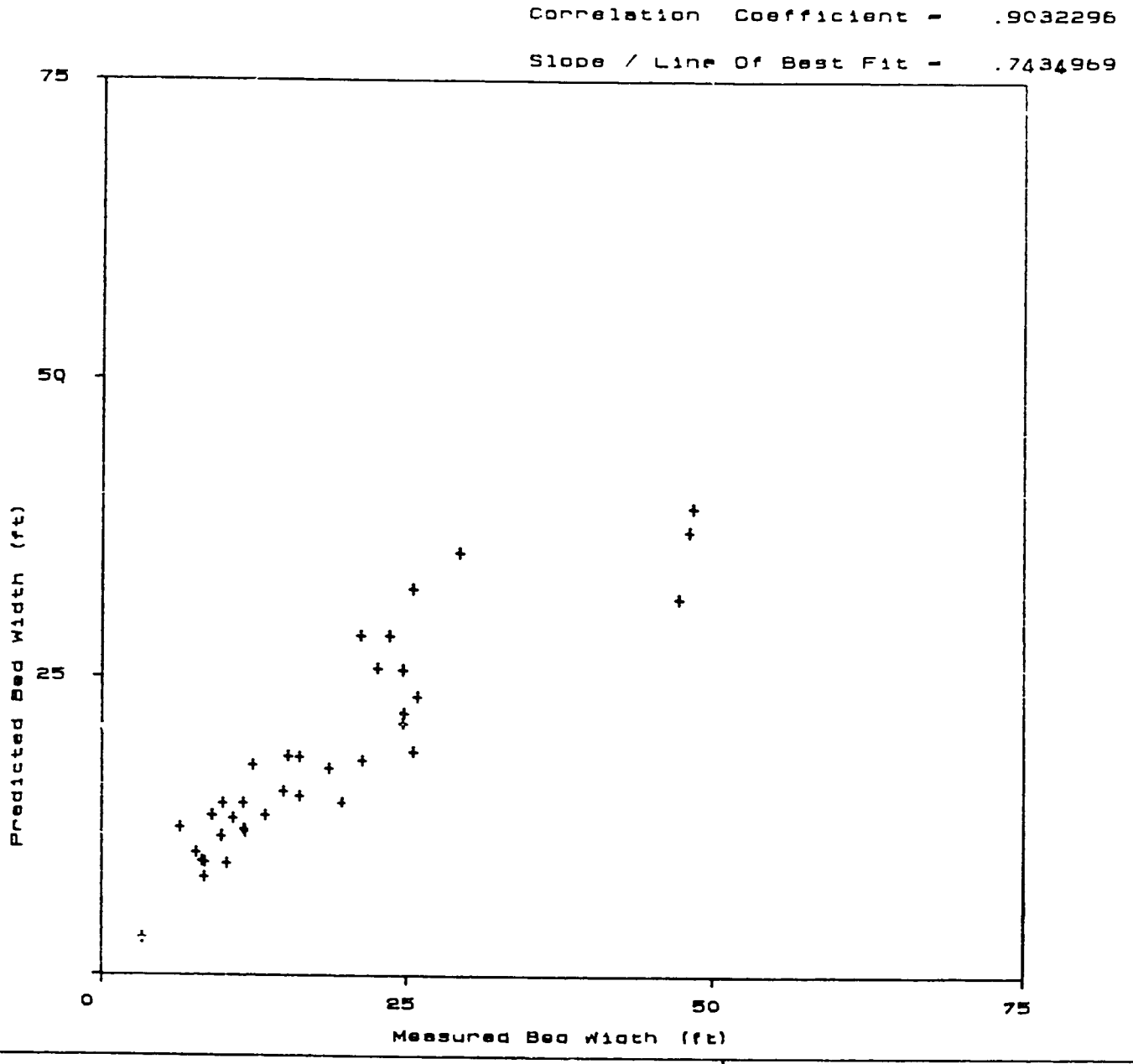
HYDRAULIC DESIGN CRITERIA	Upper Gugera Branch
Measured versus Predicted Bed Width	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·10



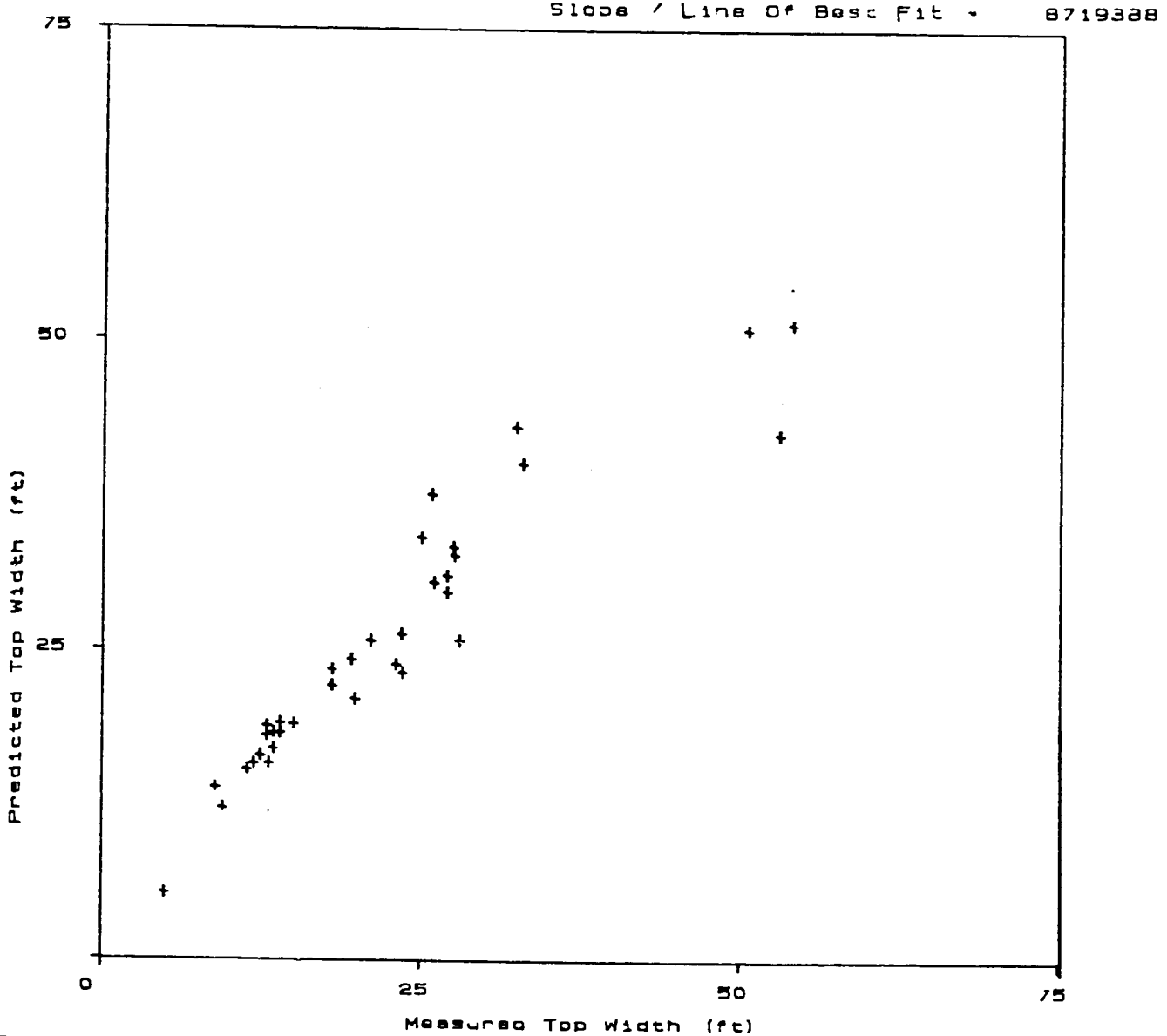
LACEY Measured versus Predicted Top Width	Upper Gugera Distties Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·11



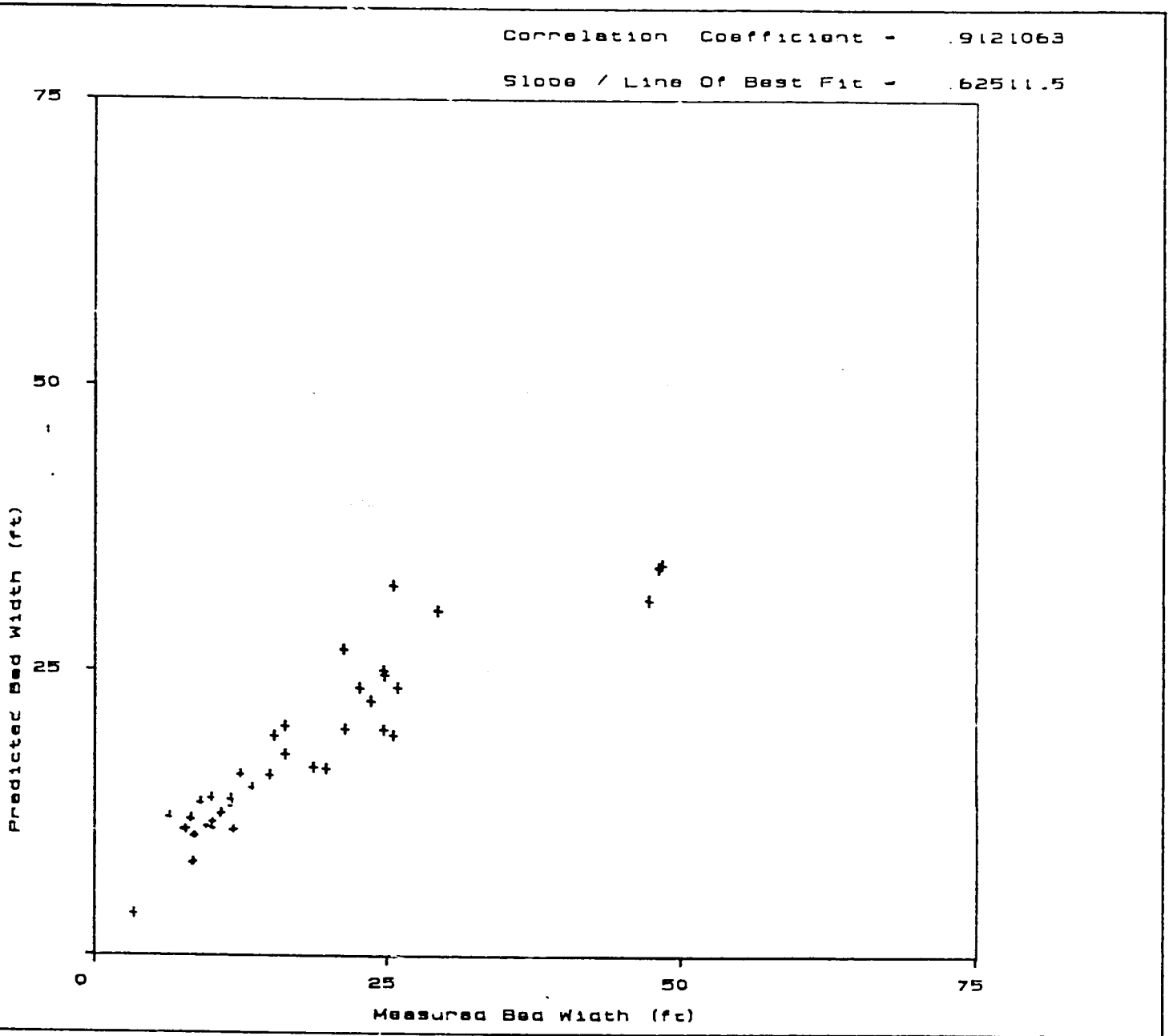
CHANG Measured versus Predicted Top Width	Upper Gugera Distics Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·12



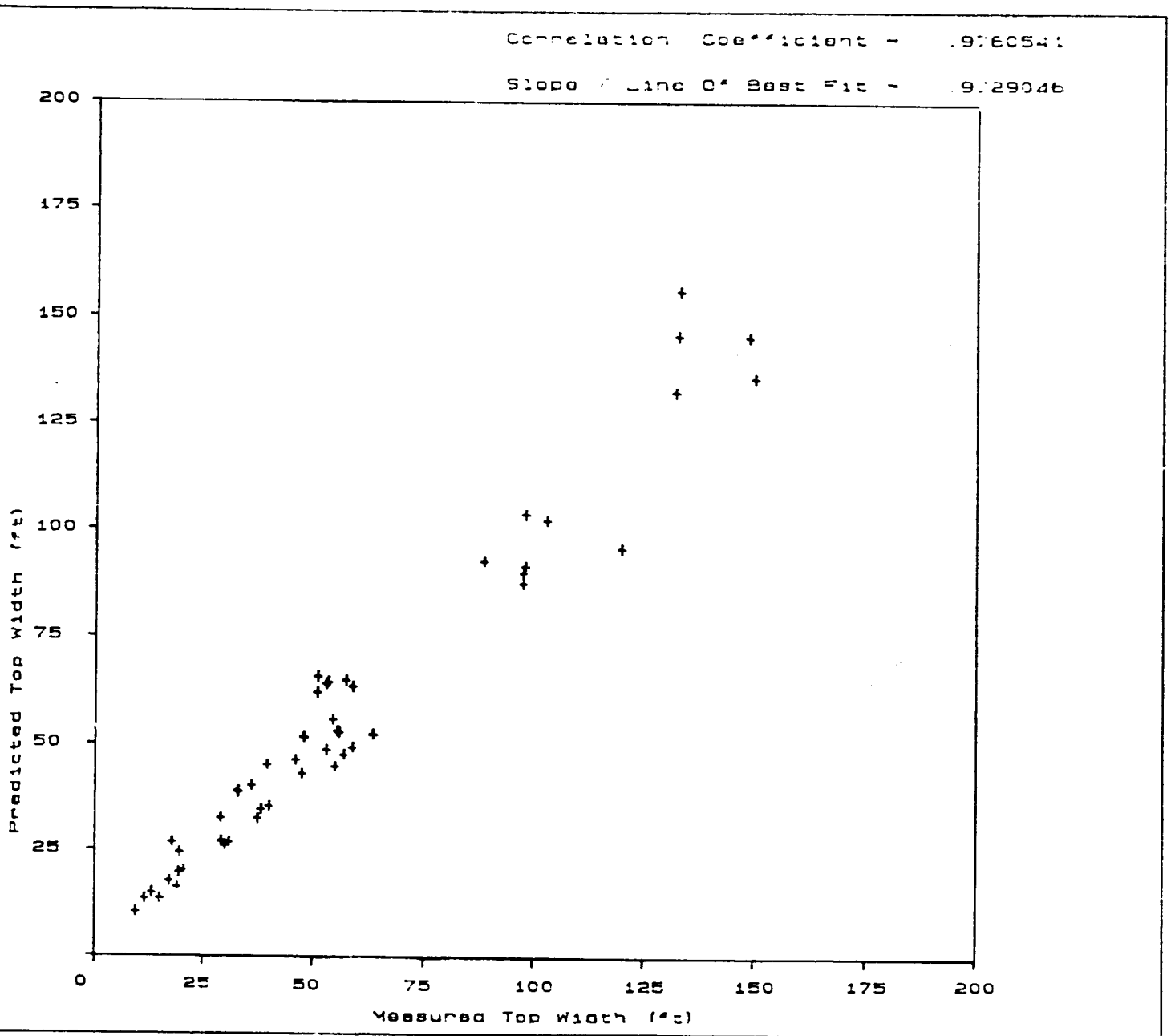
VELIKANOV Measured versus Predicted Bed Width	Upper Gugera Disties Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5.13



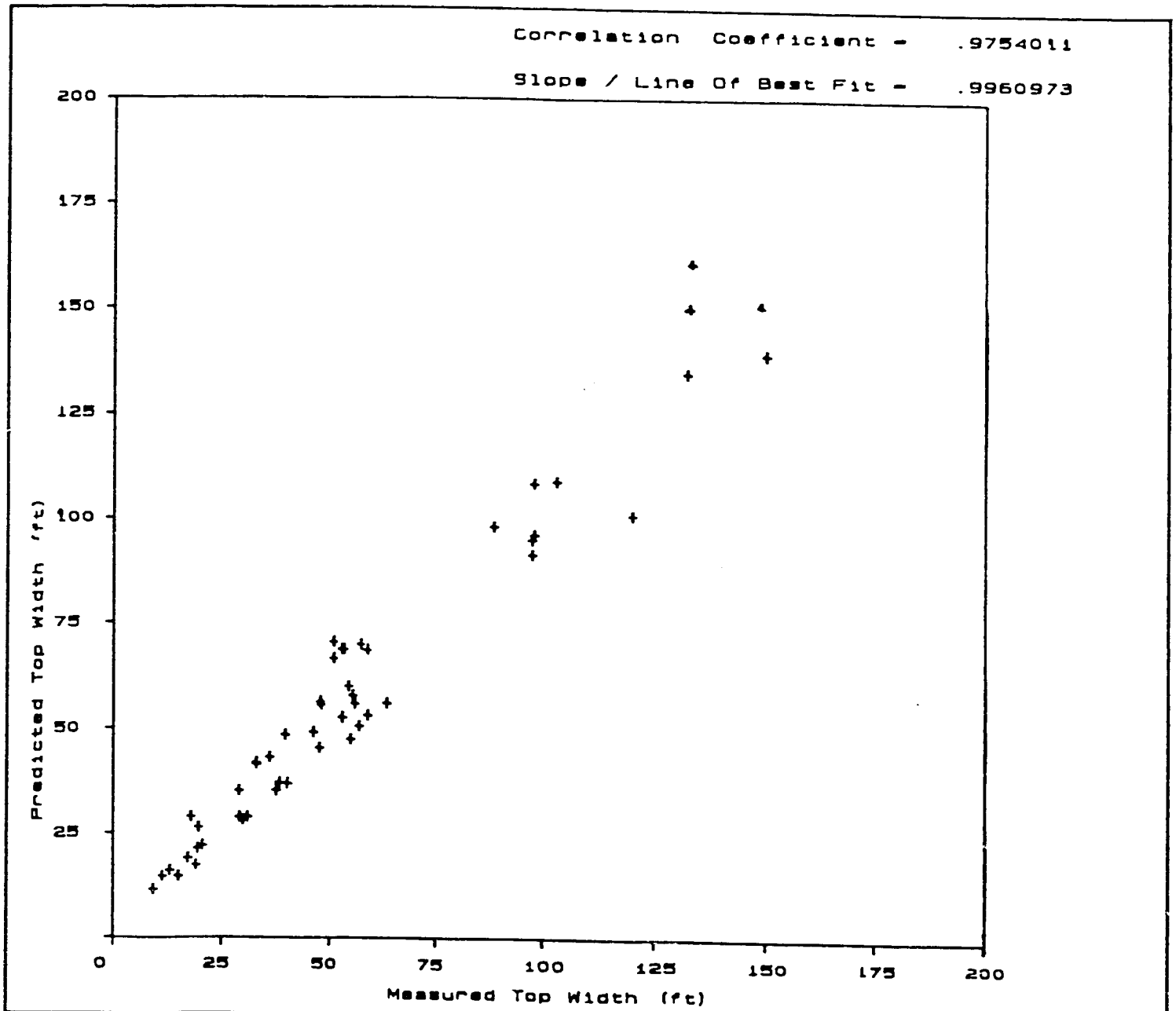
YALIN Measured versus Predicted Top Width	Upper Gugera Distries Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5-14



HYDRAULIC DESIGN CRITERIA	Upper Gugera Disties
Measured versus Predicted Bed Width	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PAC/CHECCHI	FIG. 5·15

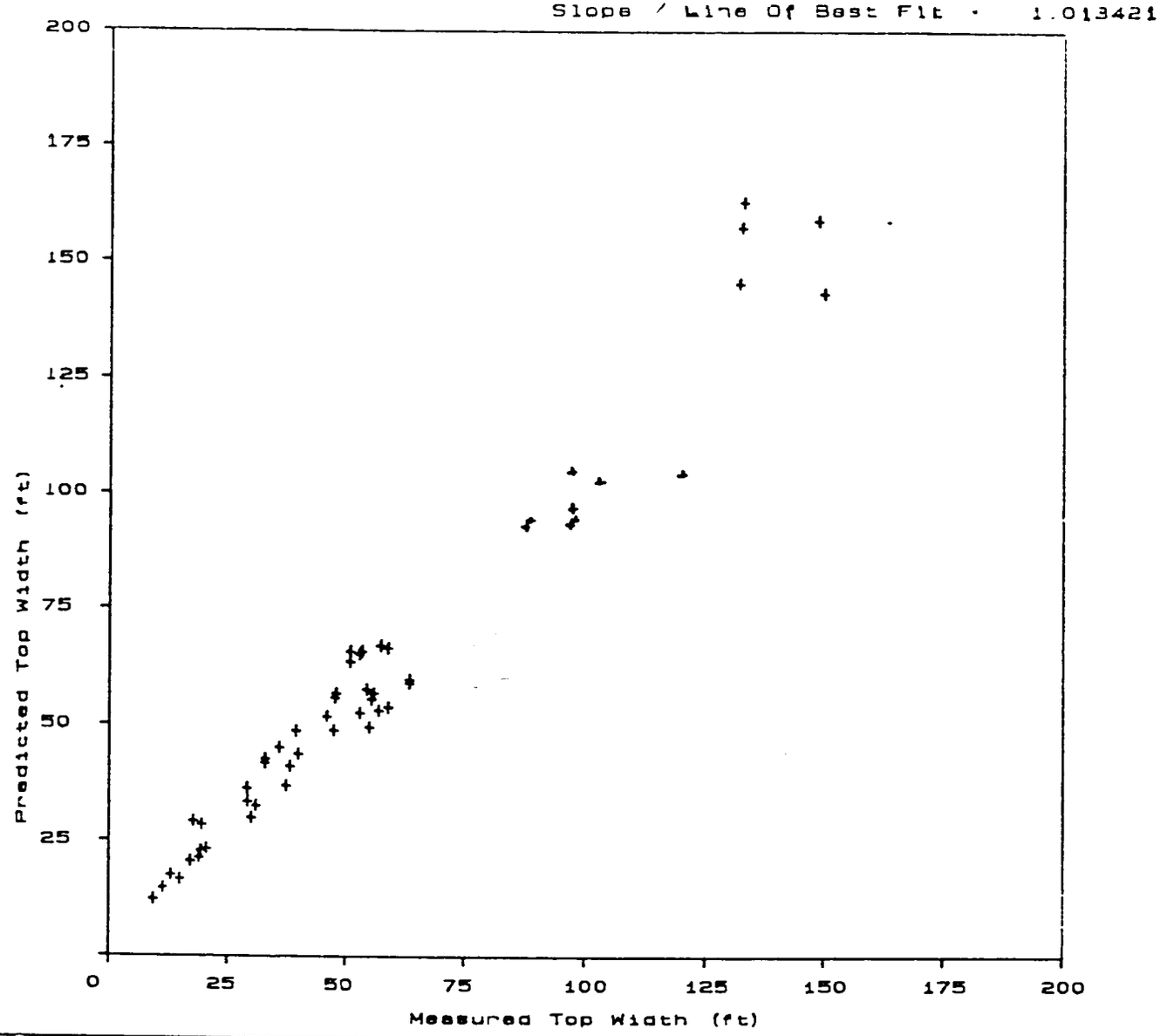


LACEY Measured Versus Predicted Top Width	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·16

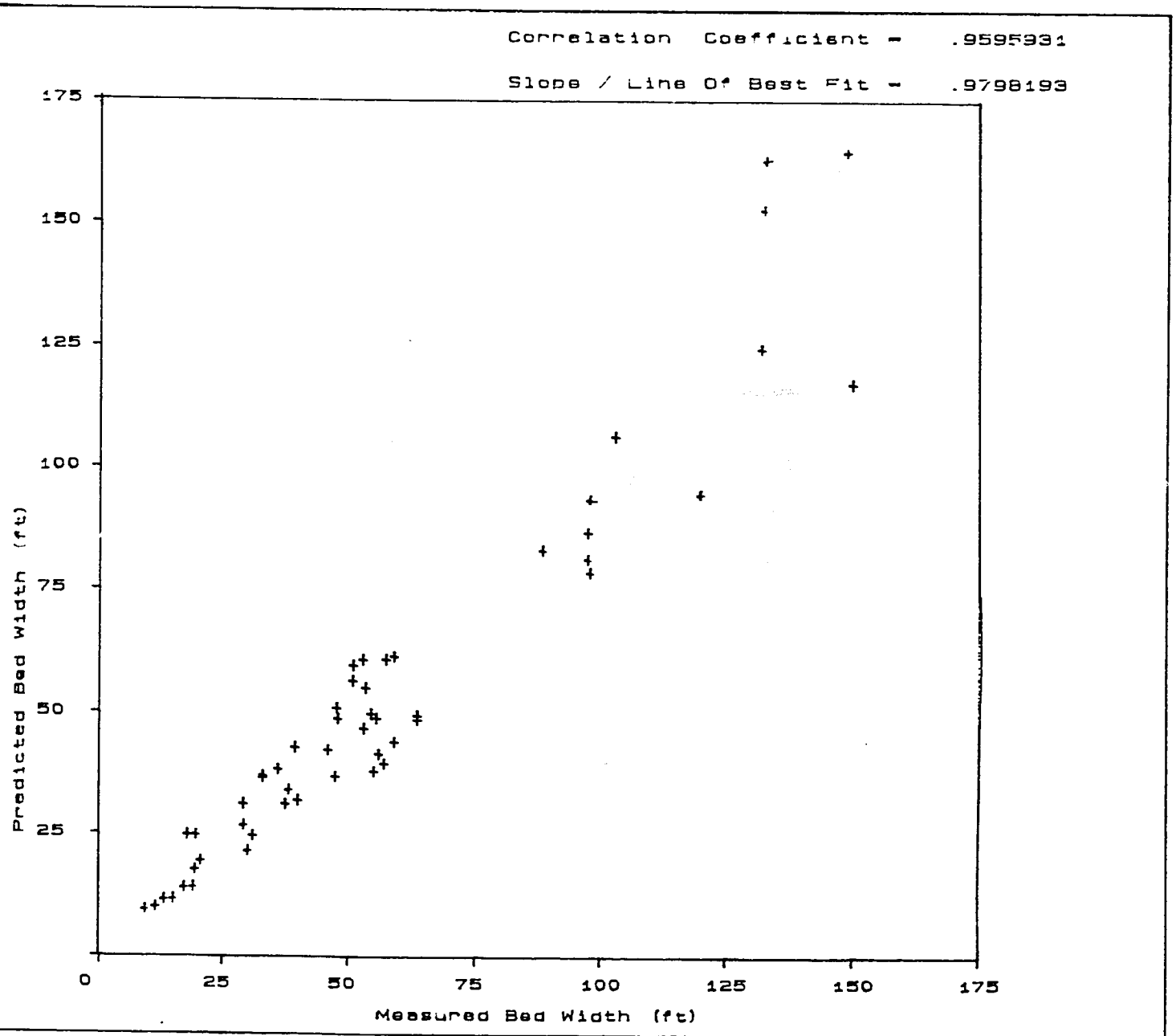


CHANG Measured versus Predicted Top Width	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·17

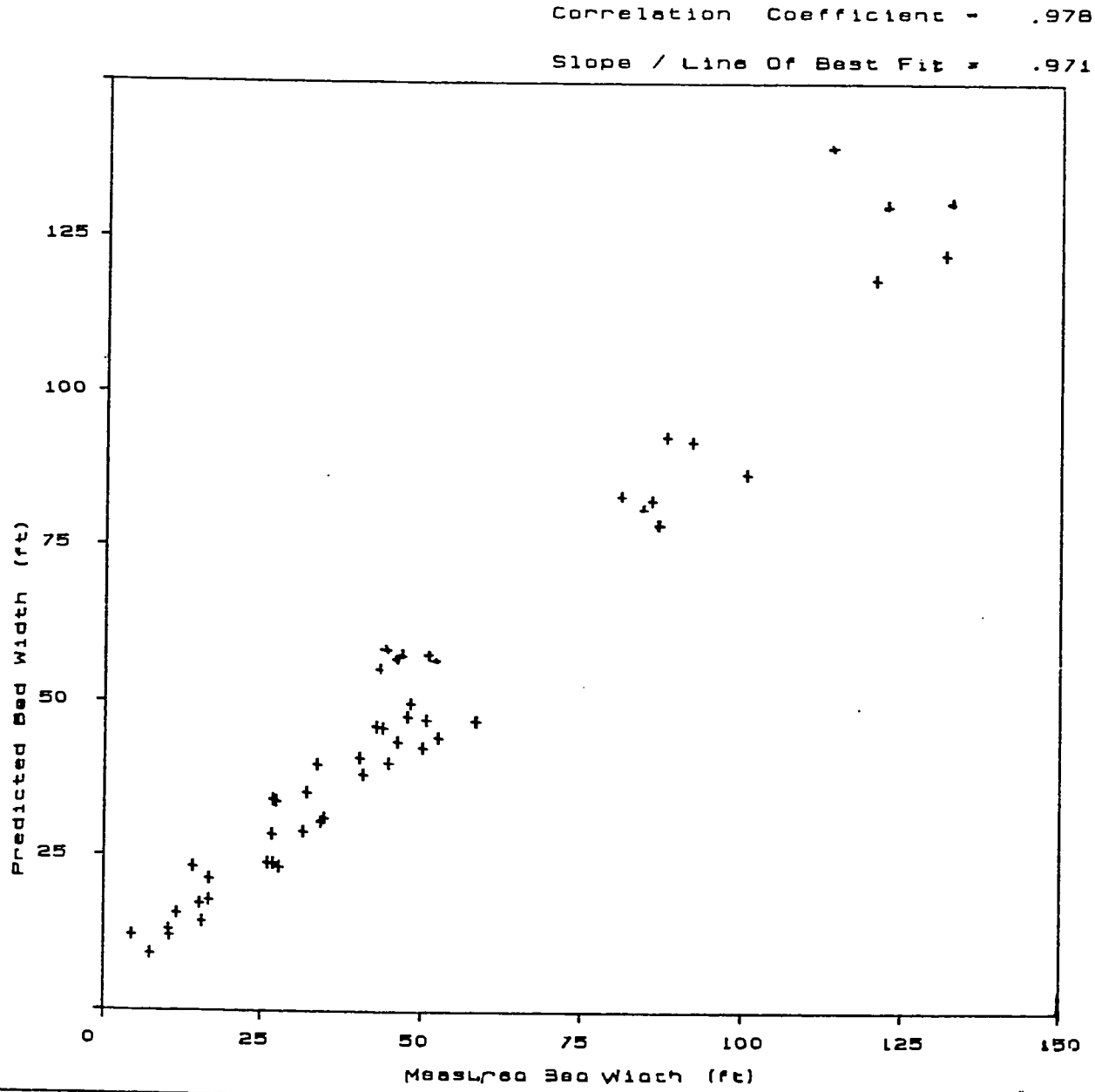
186



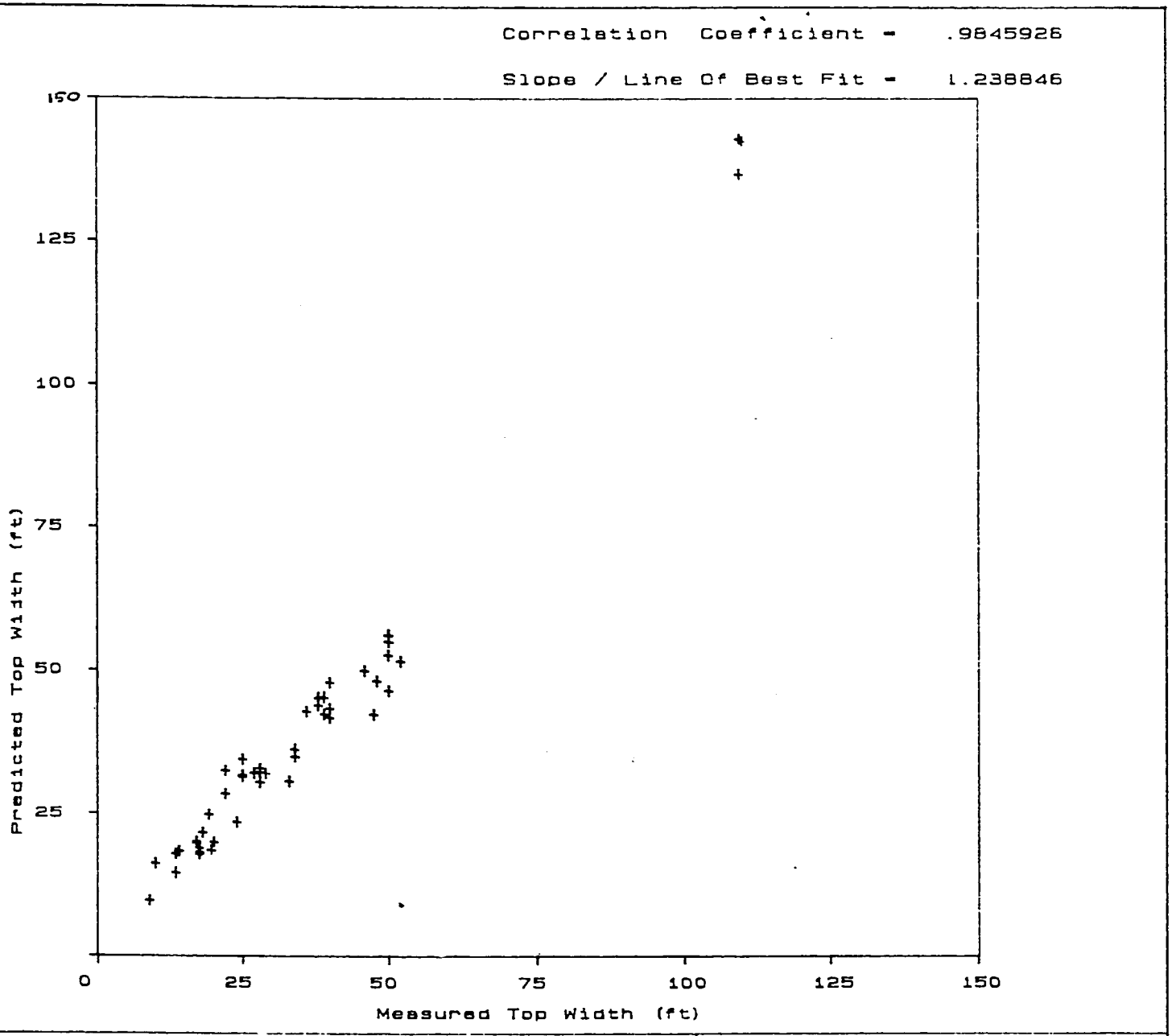
YALIN Measured versus Predicted Top Width	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·18



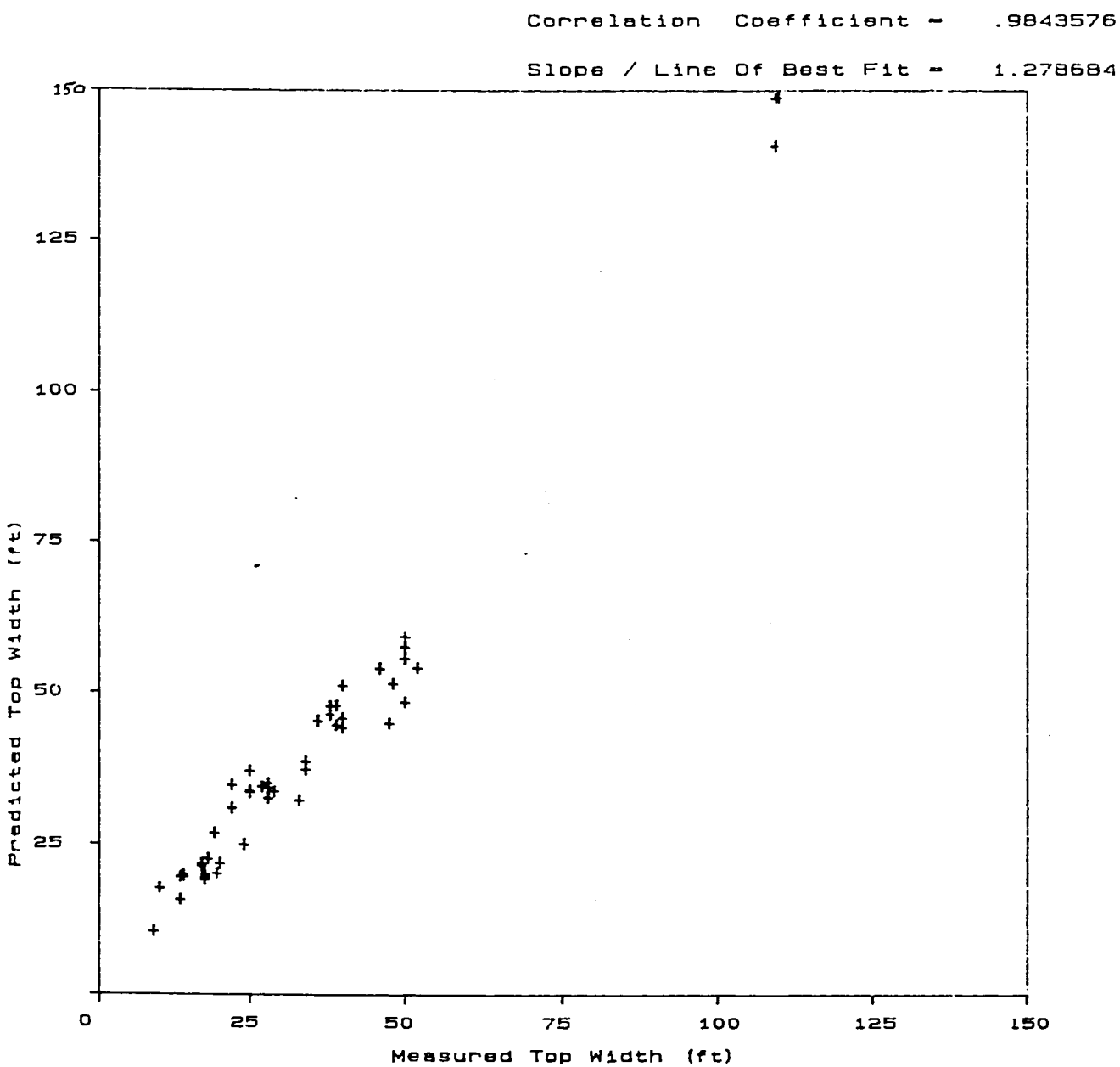
VELIKANOV Measured Versus Predicted Bed Width	Mailsi Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·19



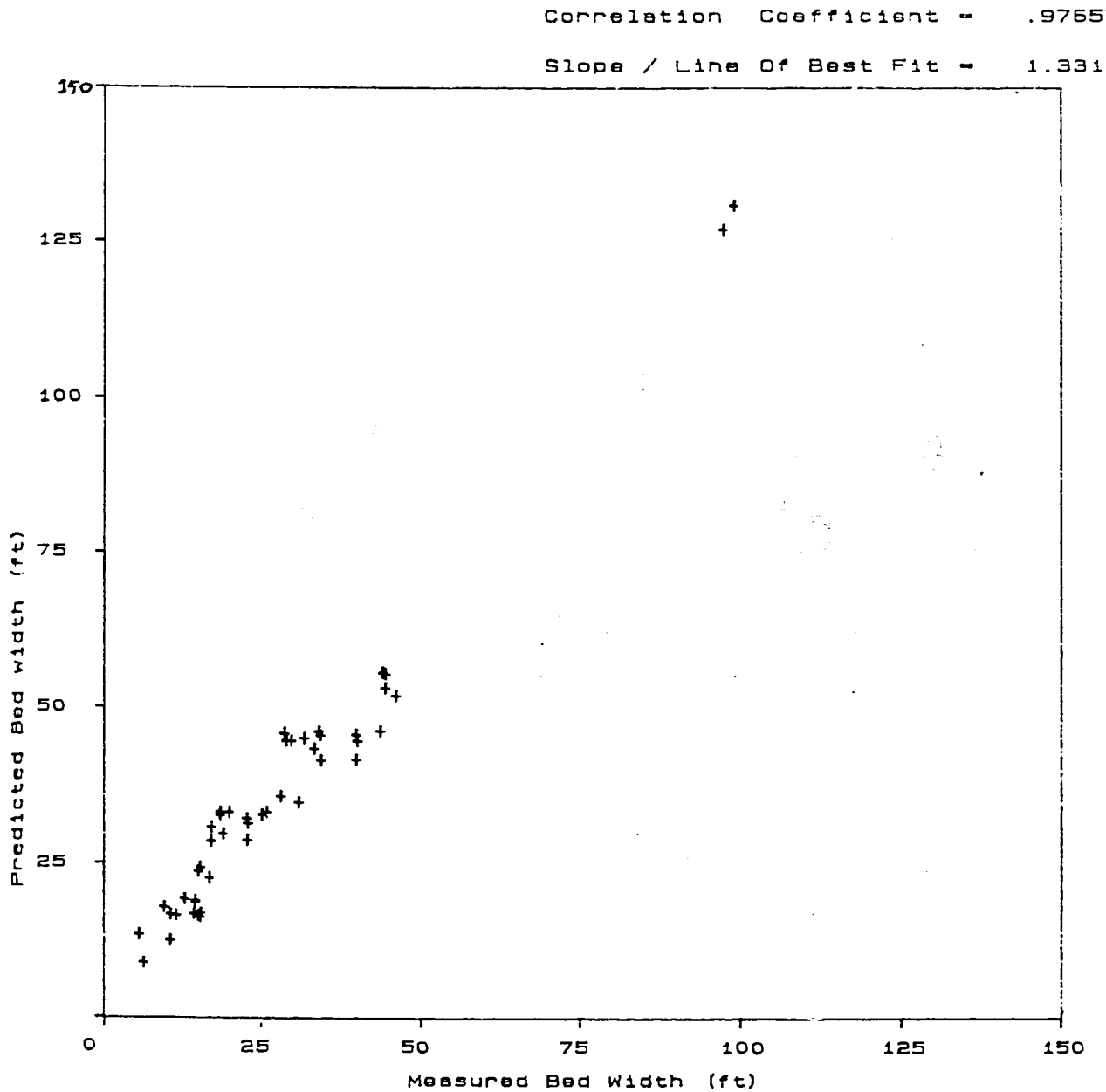
Hydraulic Design Criteria	Malsi Canal System
Measured Versus Predicted Bed Width	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·20



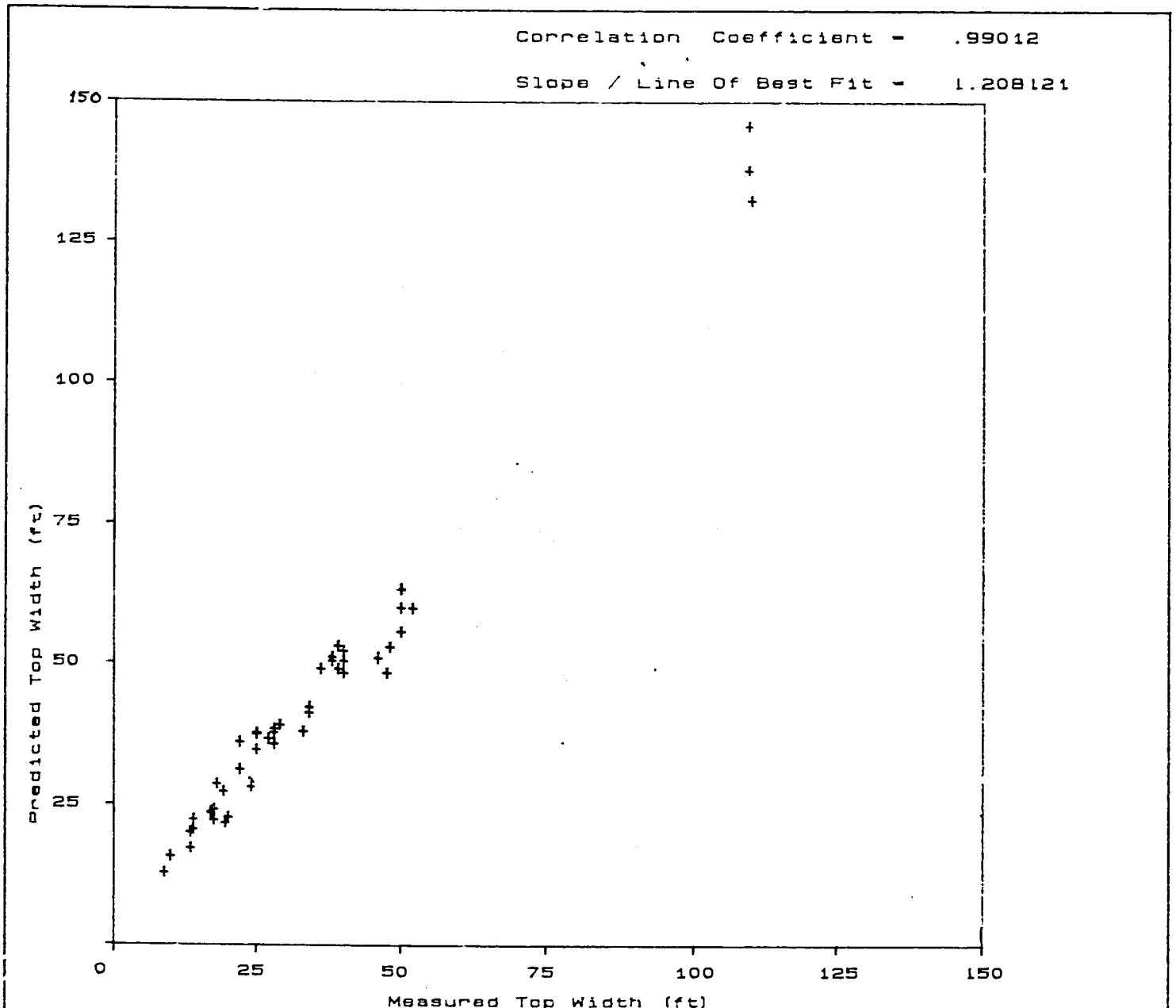
LACEY Measured versus Predicted Top width	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·21



CHANG Measured versus Predicted Top Width	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·22

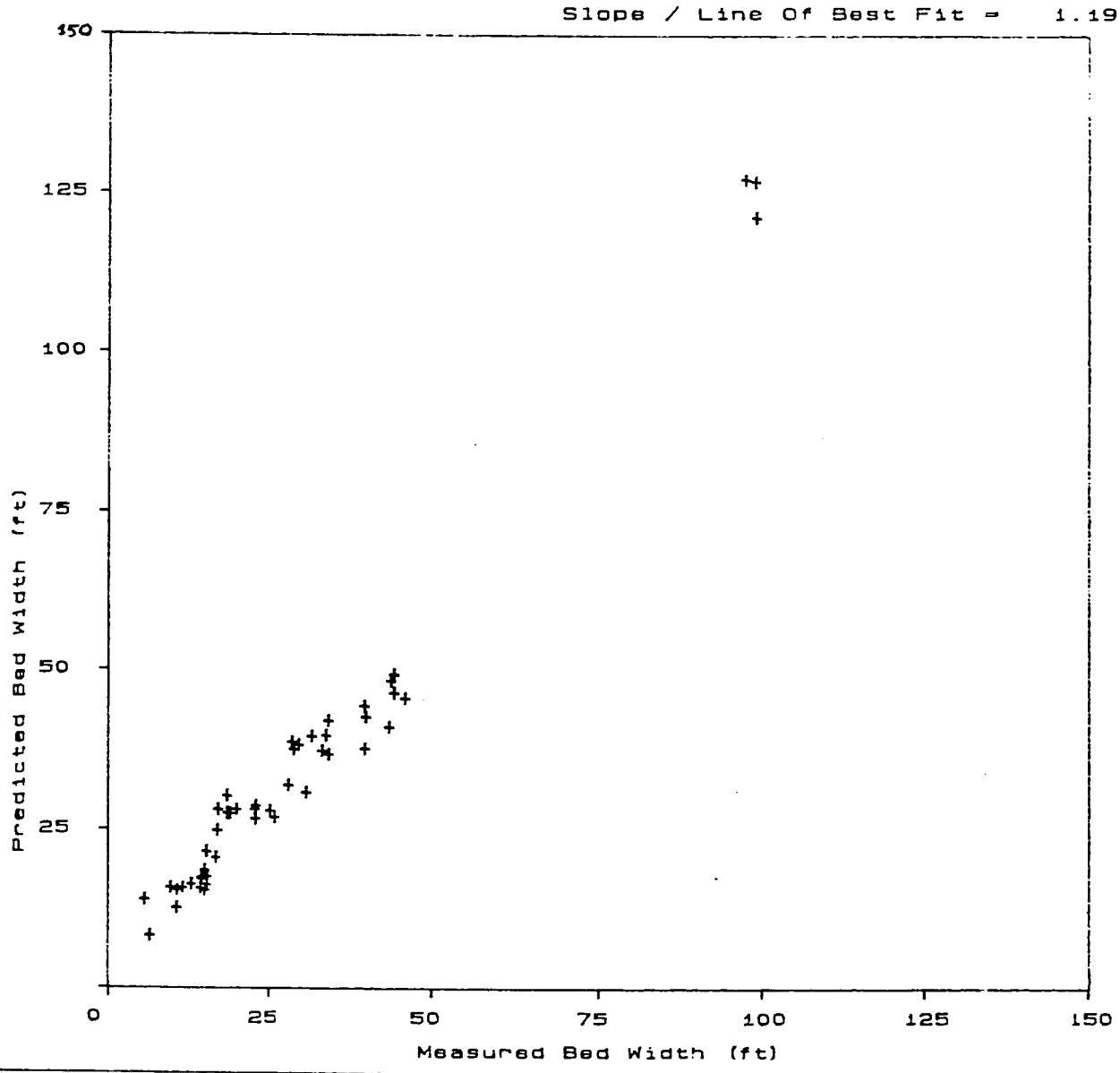


VELIKANOV	Sind Canal Systems
Measured versus Predicted Bed Width	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·23

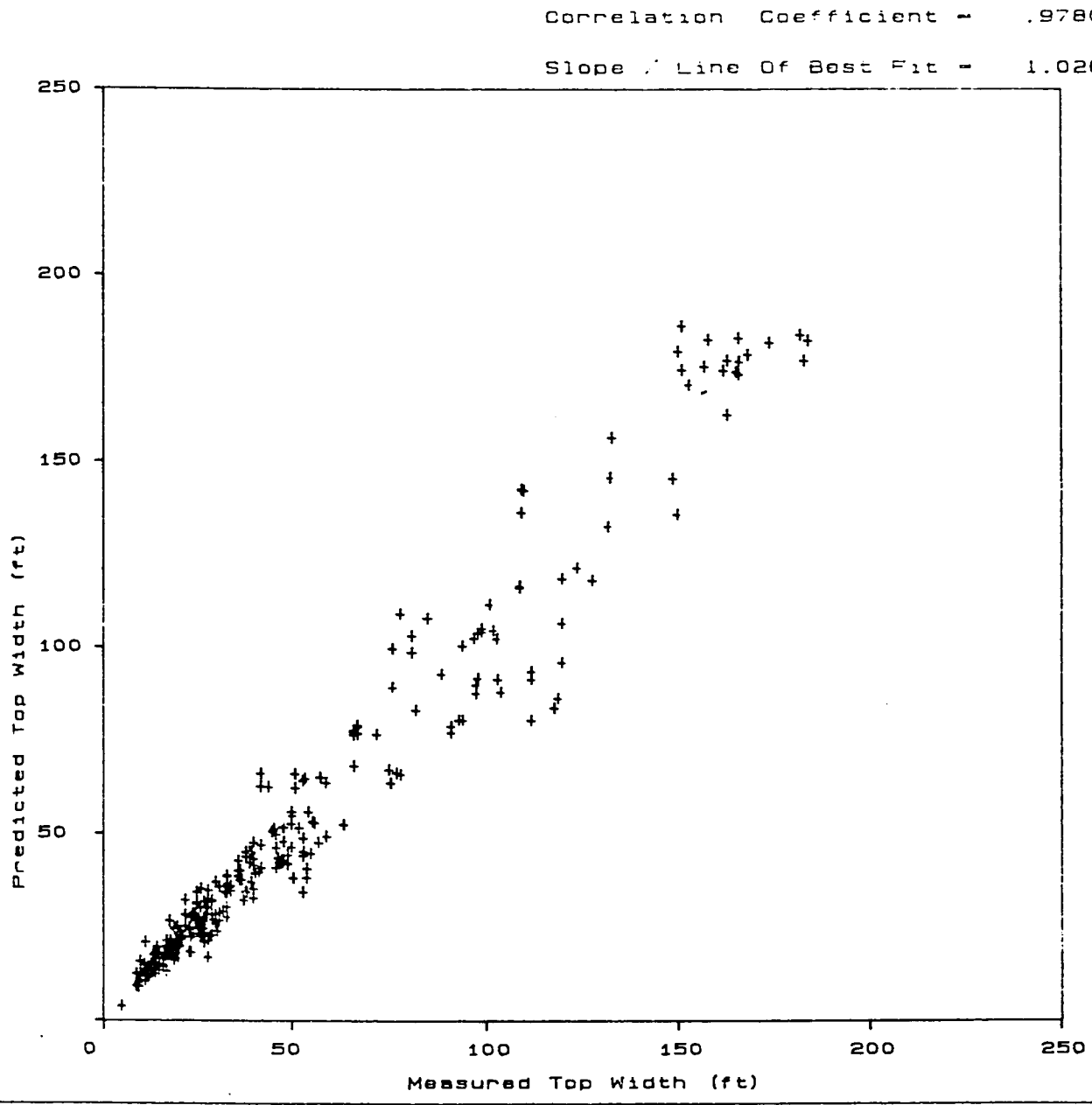


YALIN Measured versus Predicted Top Width	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·24

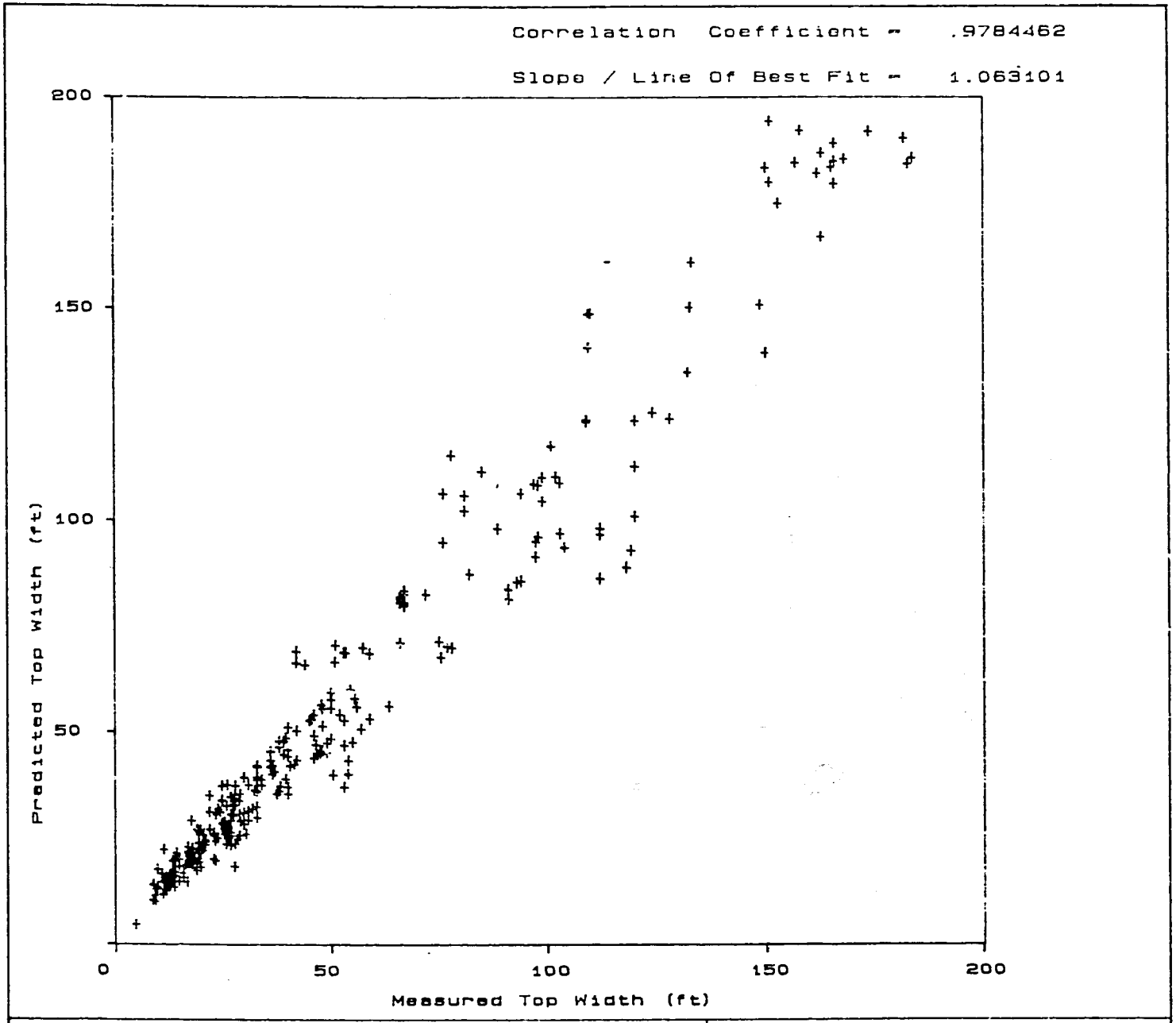
(91)



HYDRAULIC DESIGN CRITERIA	Sind Canal System
Measured versus Predicted Bed Width	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·25

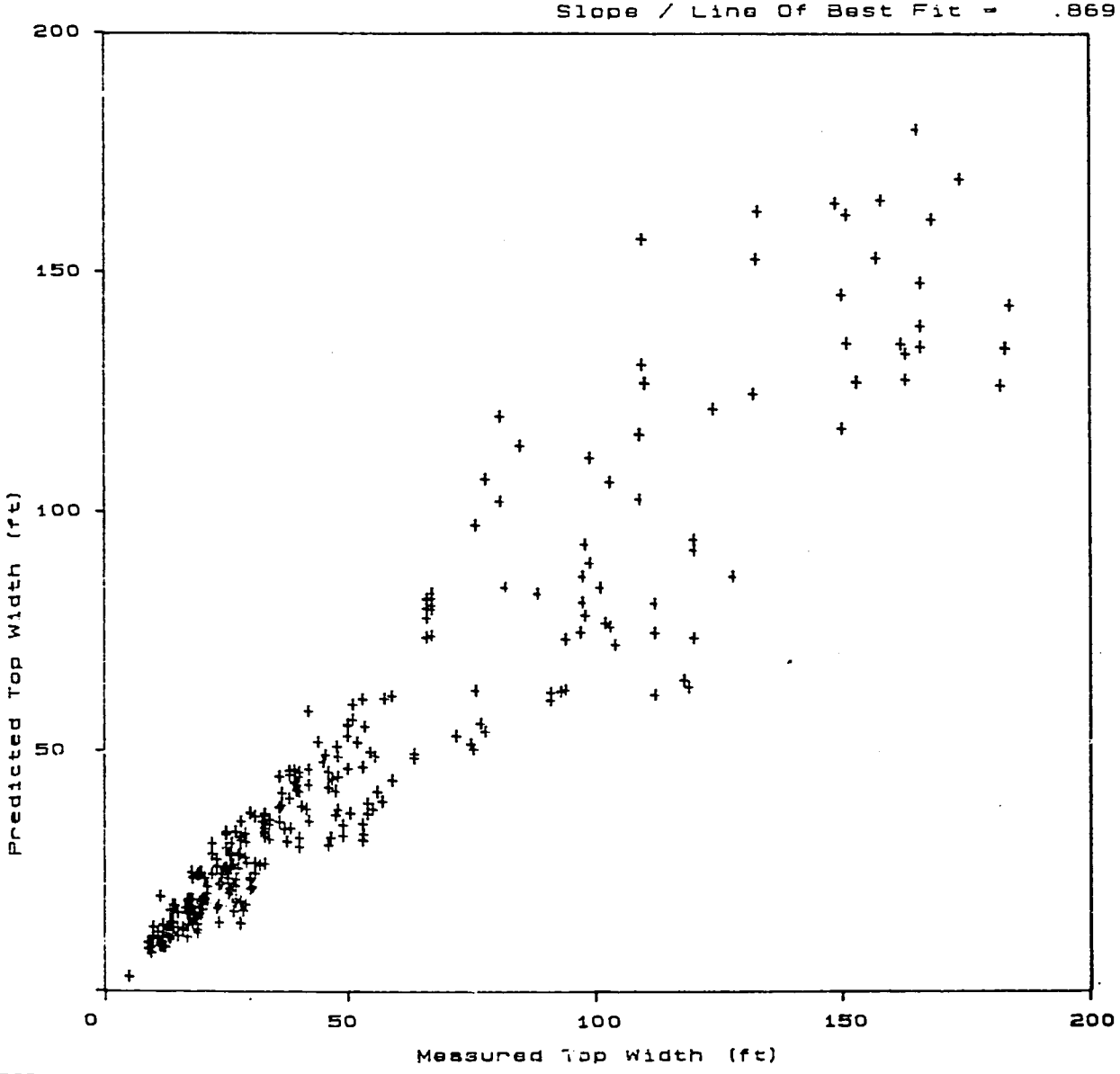


LACEY Measured Versus Predicted Top Width	Canals Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·26

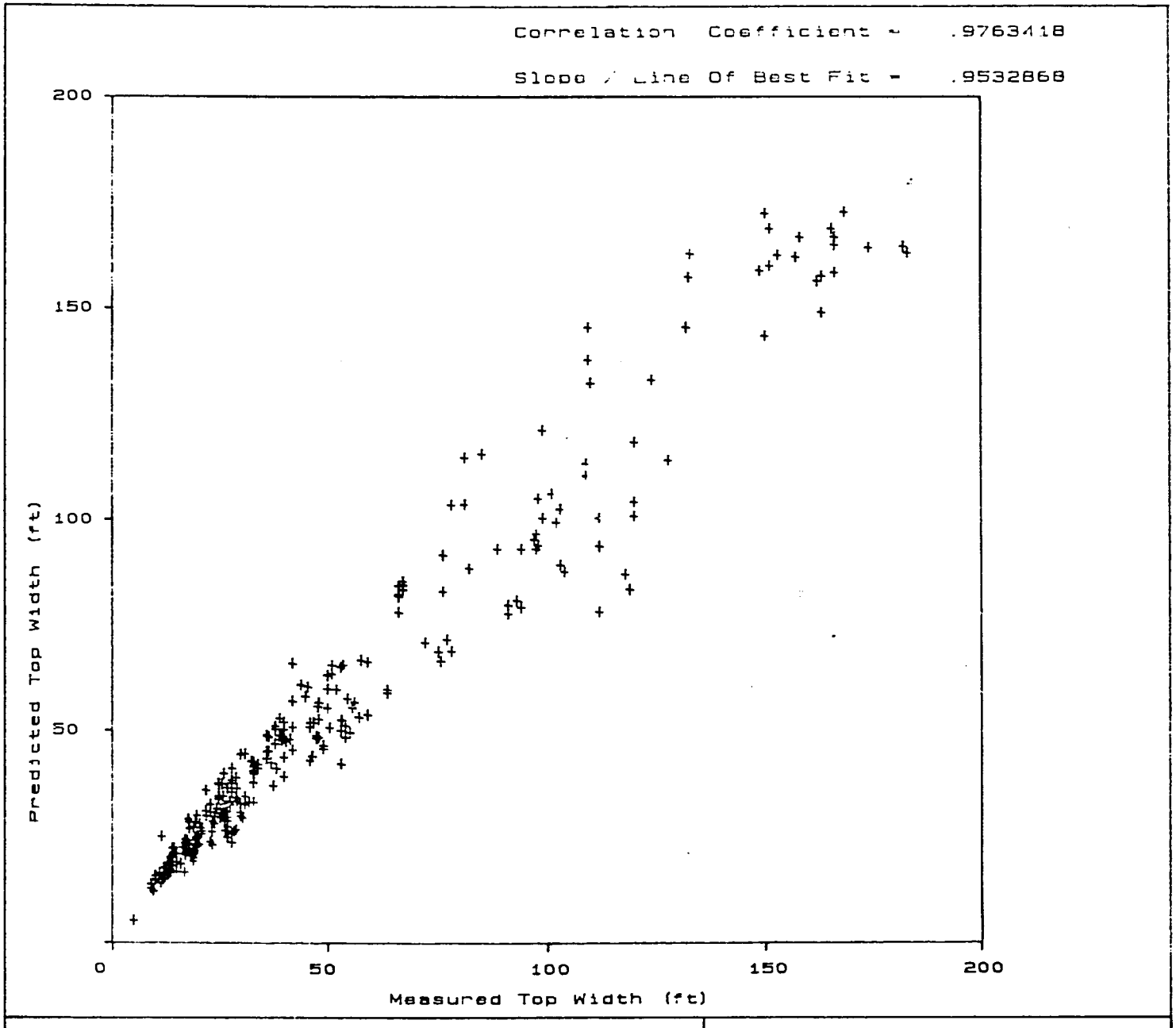


CHANG Measured Versus Predicted Top Width	Canals Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·27

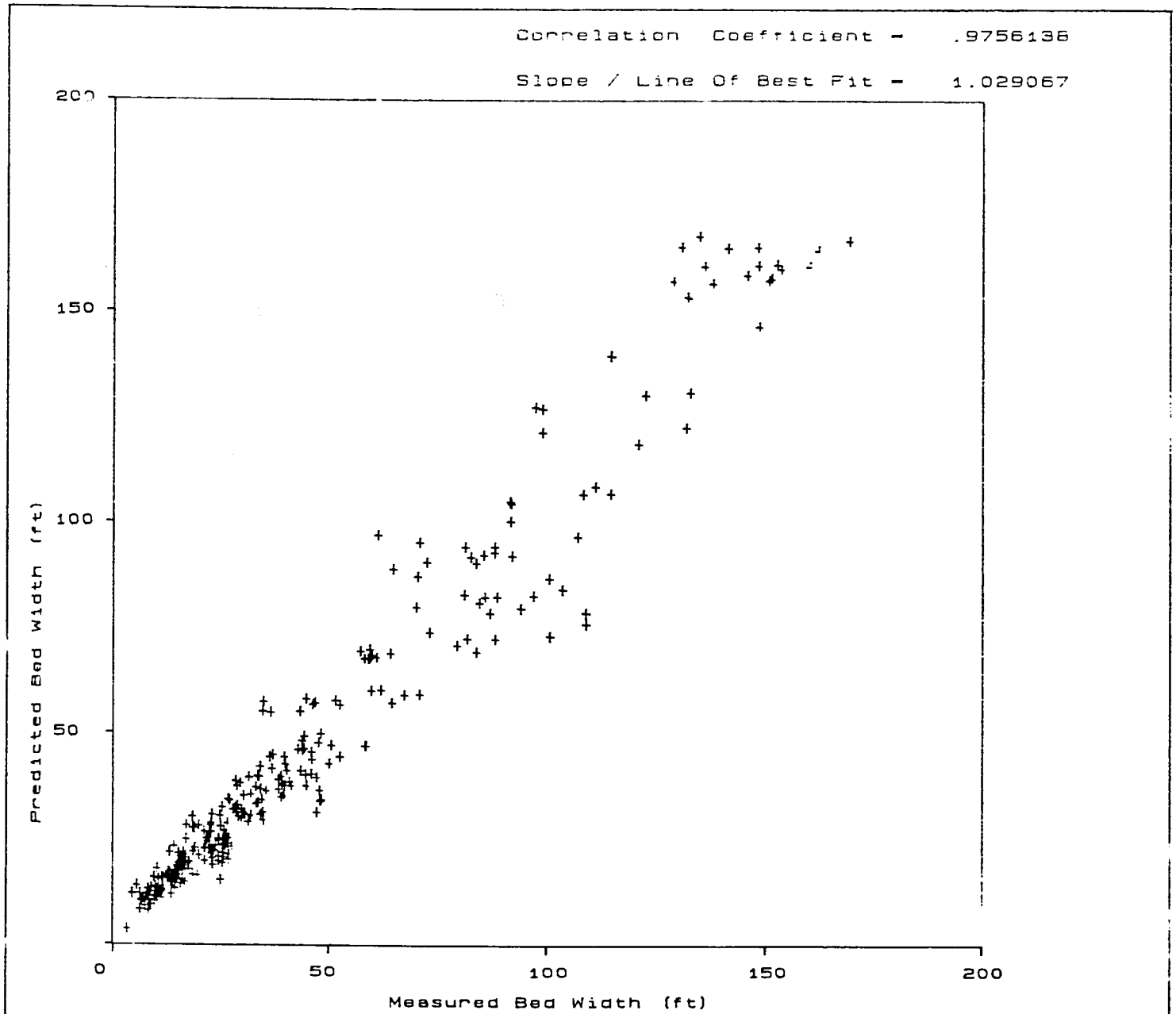
196



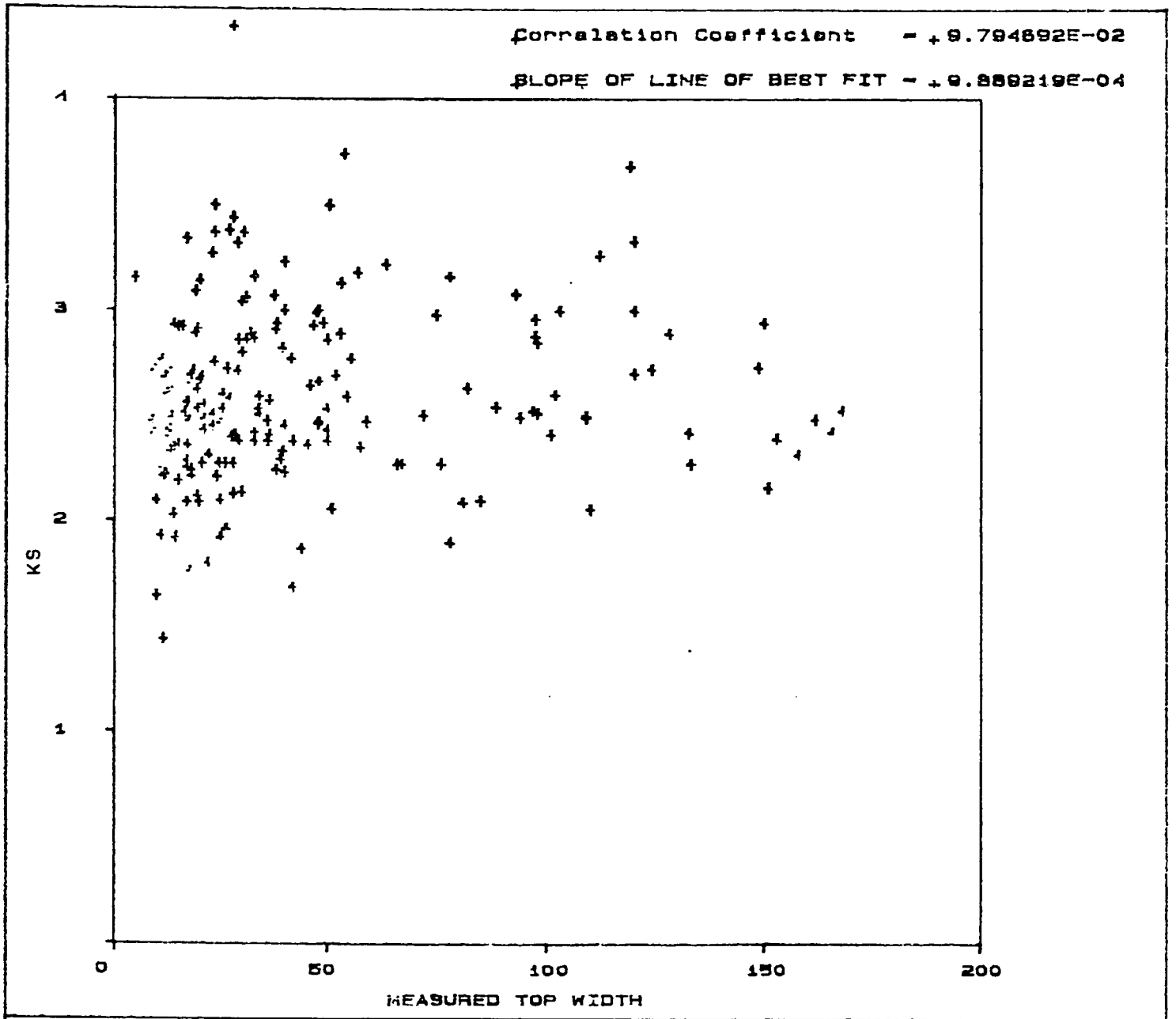
VELIKANOV	Canals Systems
Measured Versus Predicted Bed Width	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·28



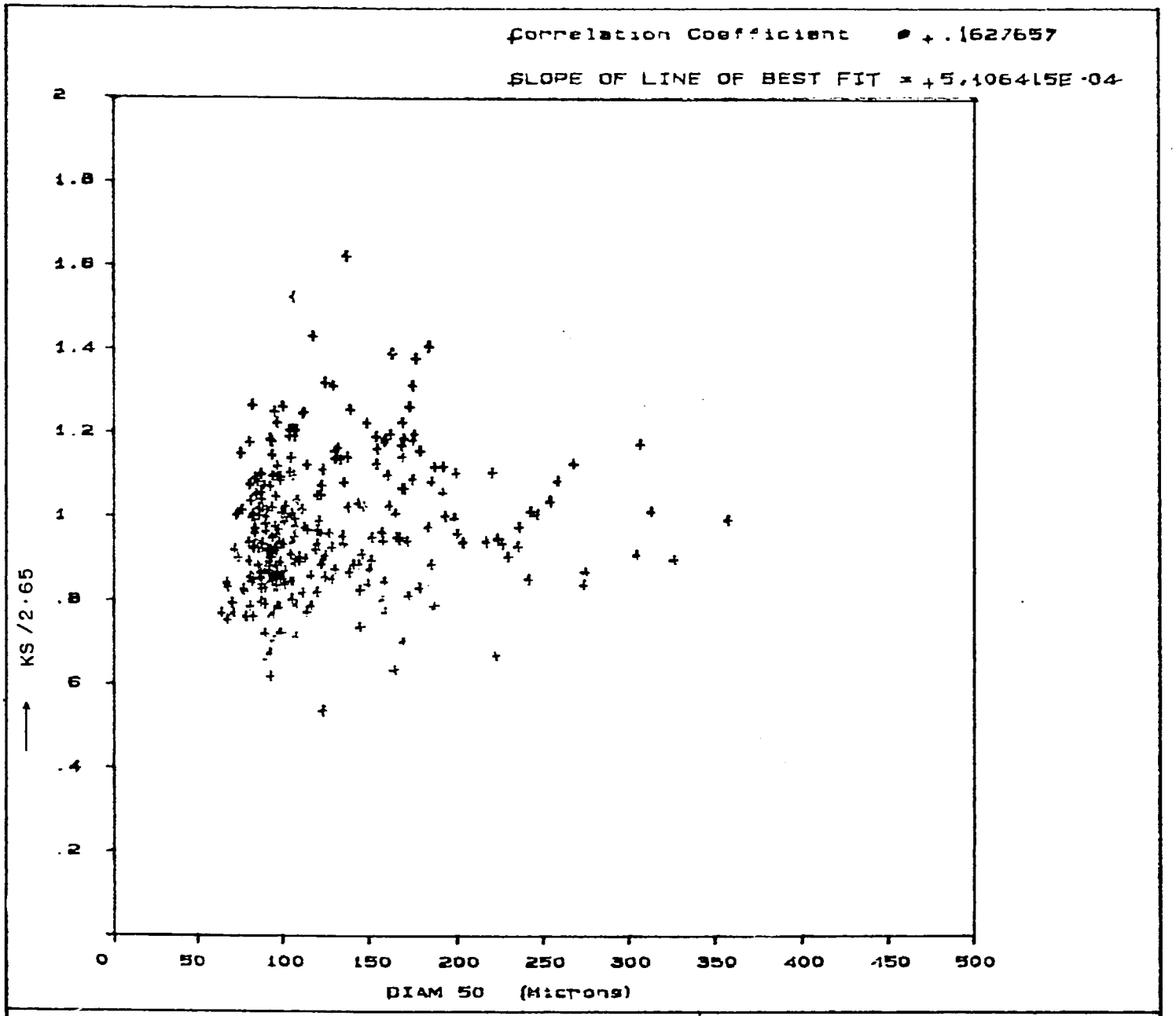
YALIN Measured Versus Predicted Top Width	Canals Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5-29



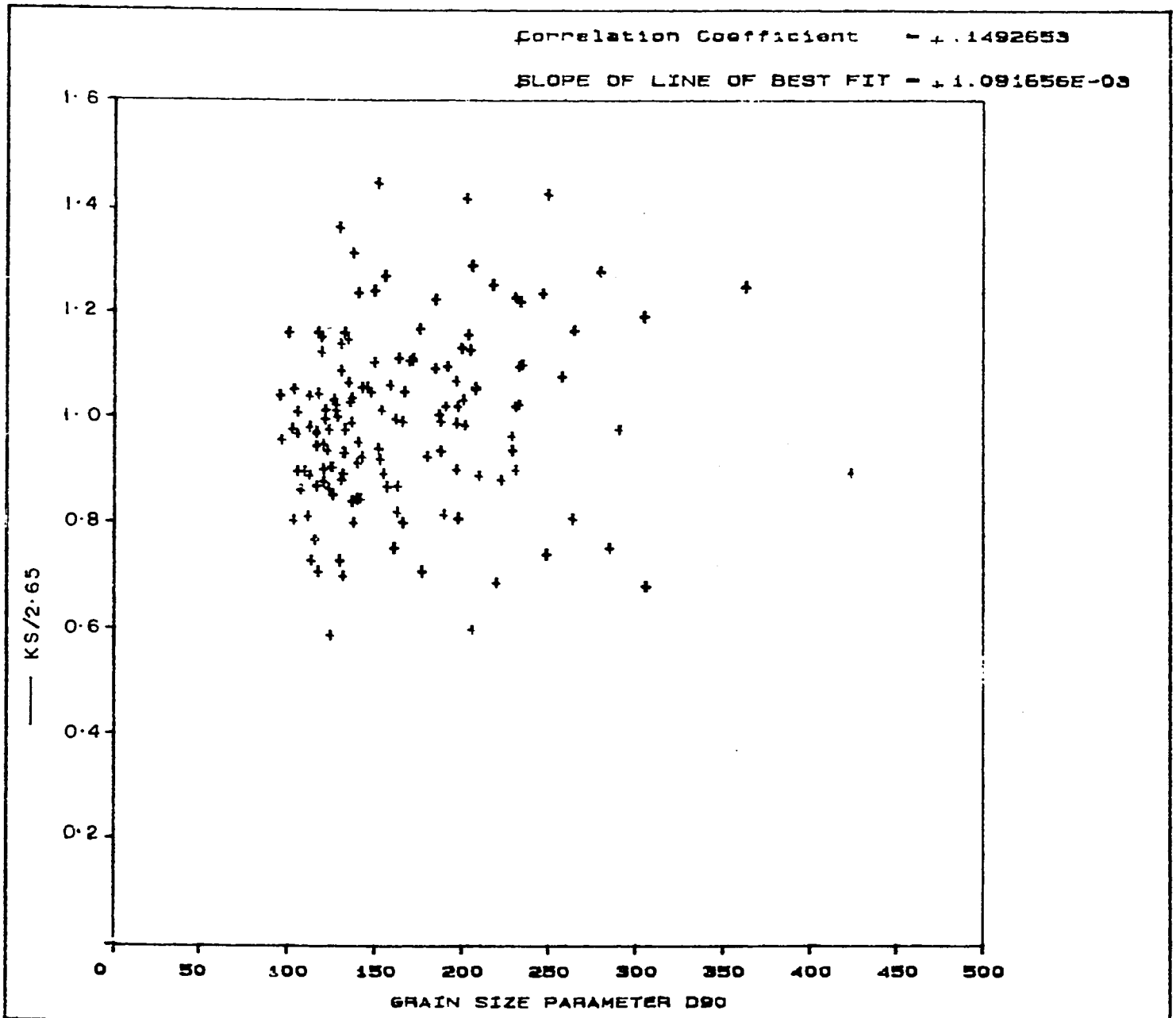
HYDRAULIC DESIGN CRITERIA	Canal System
Measured Versus Predicted Bed Width	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·30



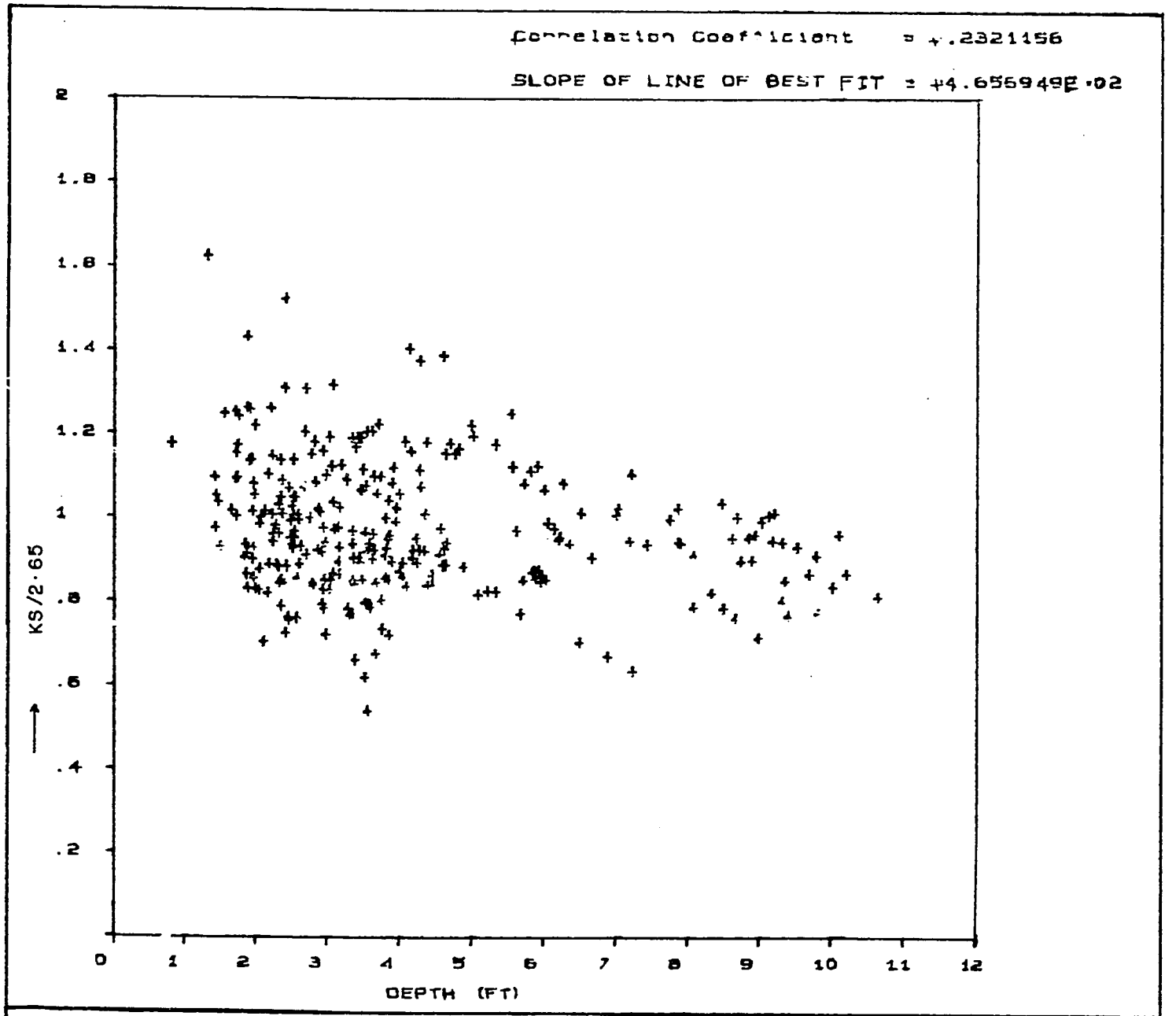
HDC—KS FACTOR	SIND AND PUNJAB
	CANAL SYSTEMS
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 5·31



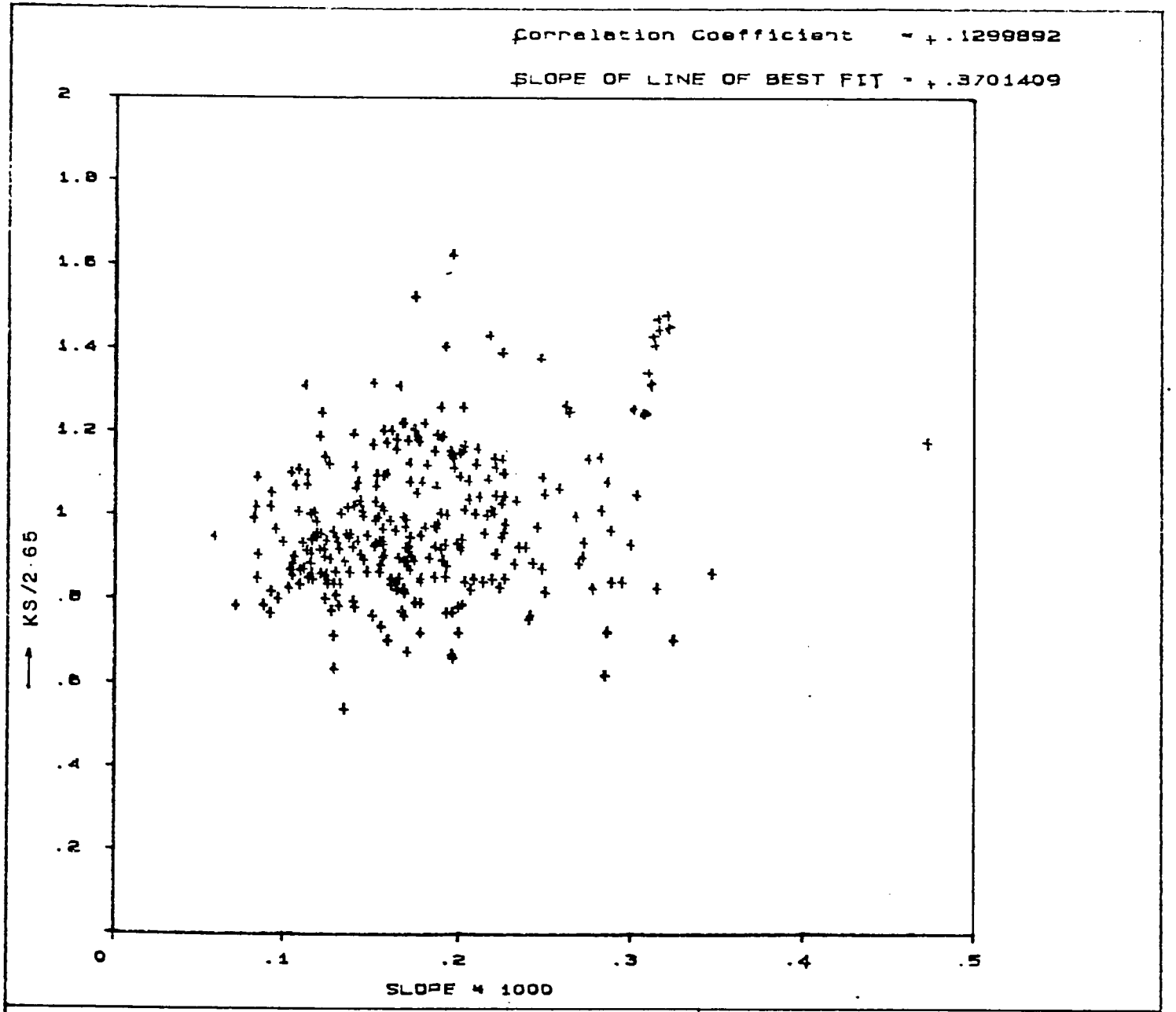
NORMALIZED KS VS D 50	SIND AND PUNJAB
	CANAL SYSTEMS
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·32



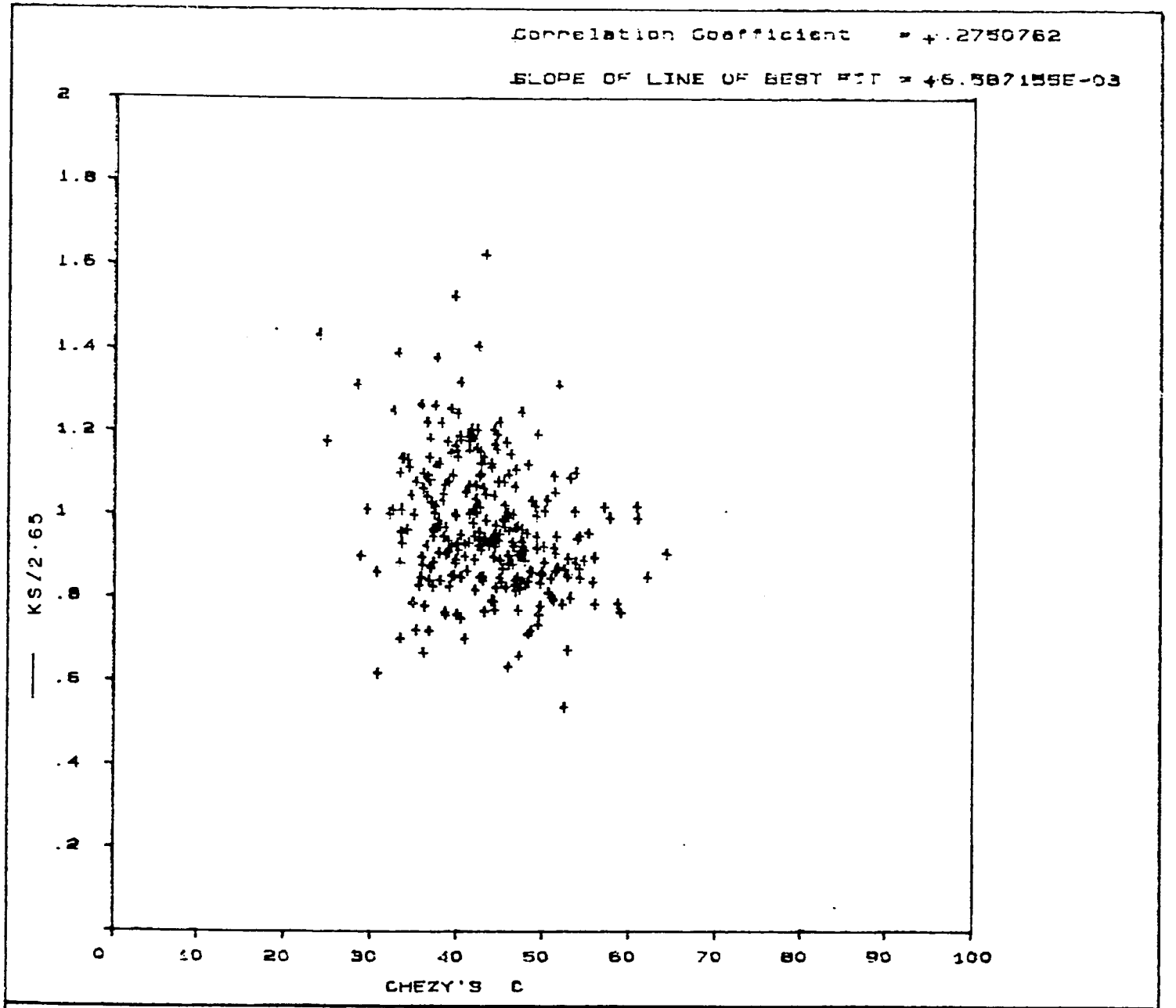
NORMALIZED KS VS D90	SIND AND PUNJAB
	CANAL SYSTEMS
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·33



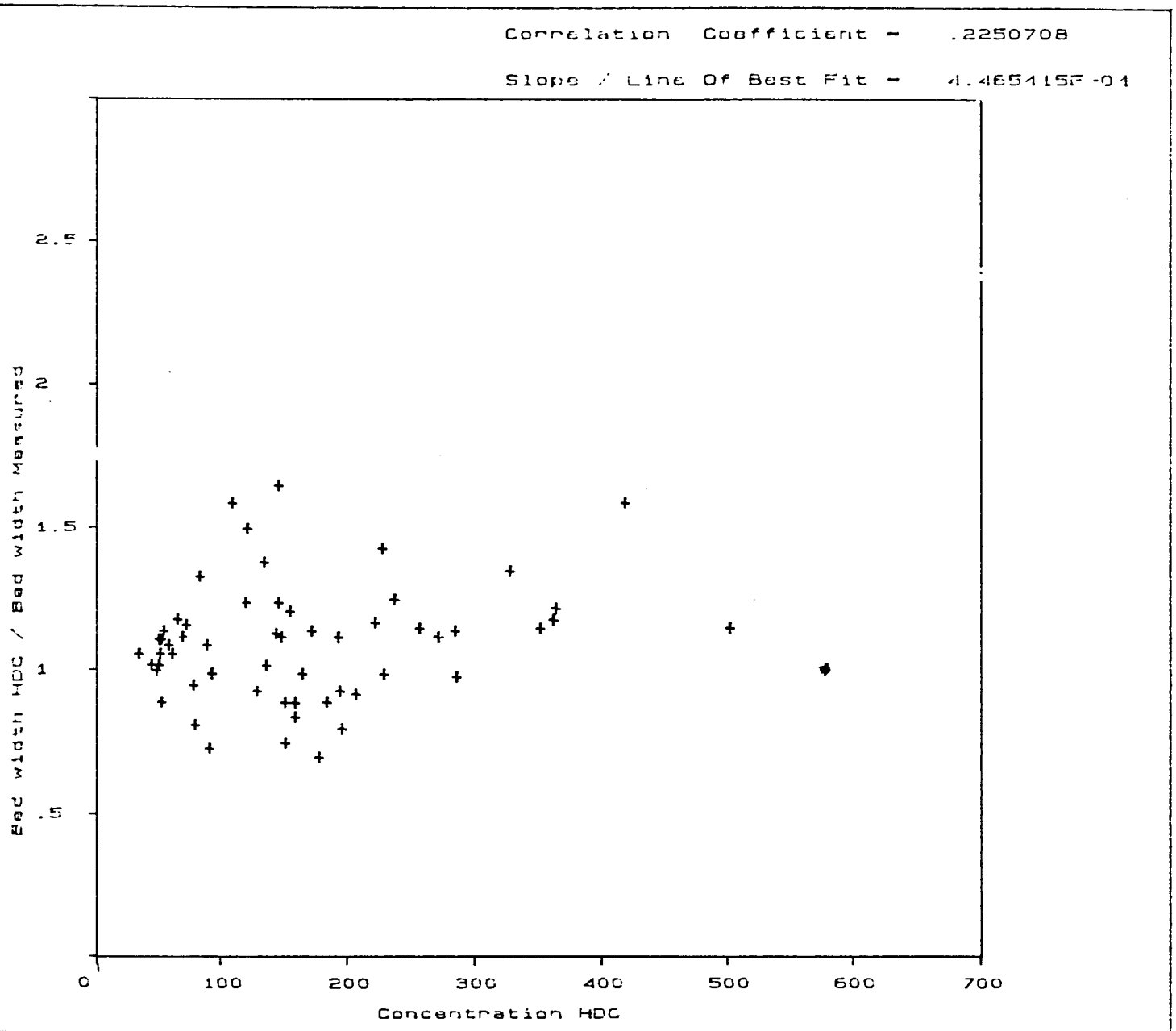
NORMALIZED KS VS DEPTH	SIND AND PUNJAB
	CANAL SYSTEMS
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·34



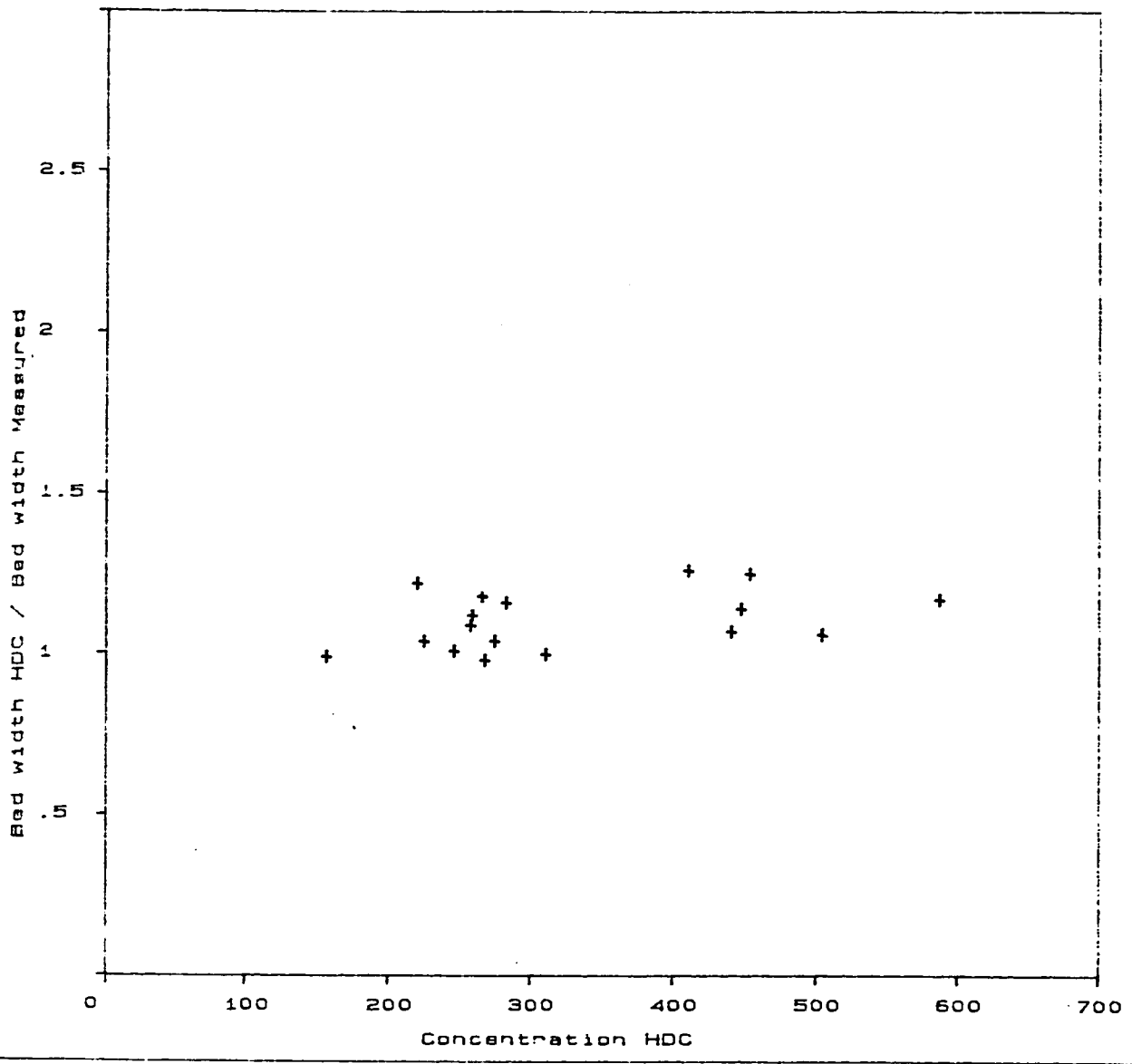
NORMALIZED KS VS SLOPE	SIND AND PUNJAB
	CANAL SYSTEM
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·35



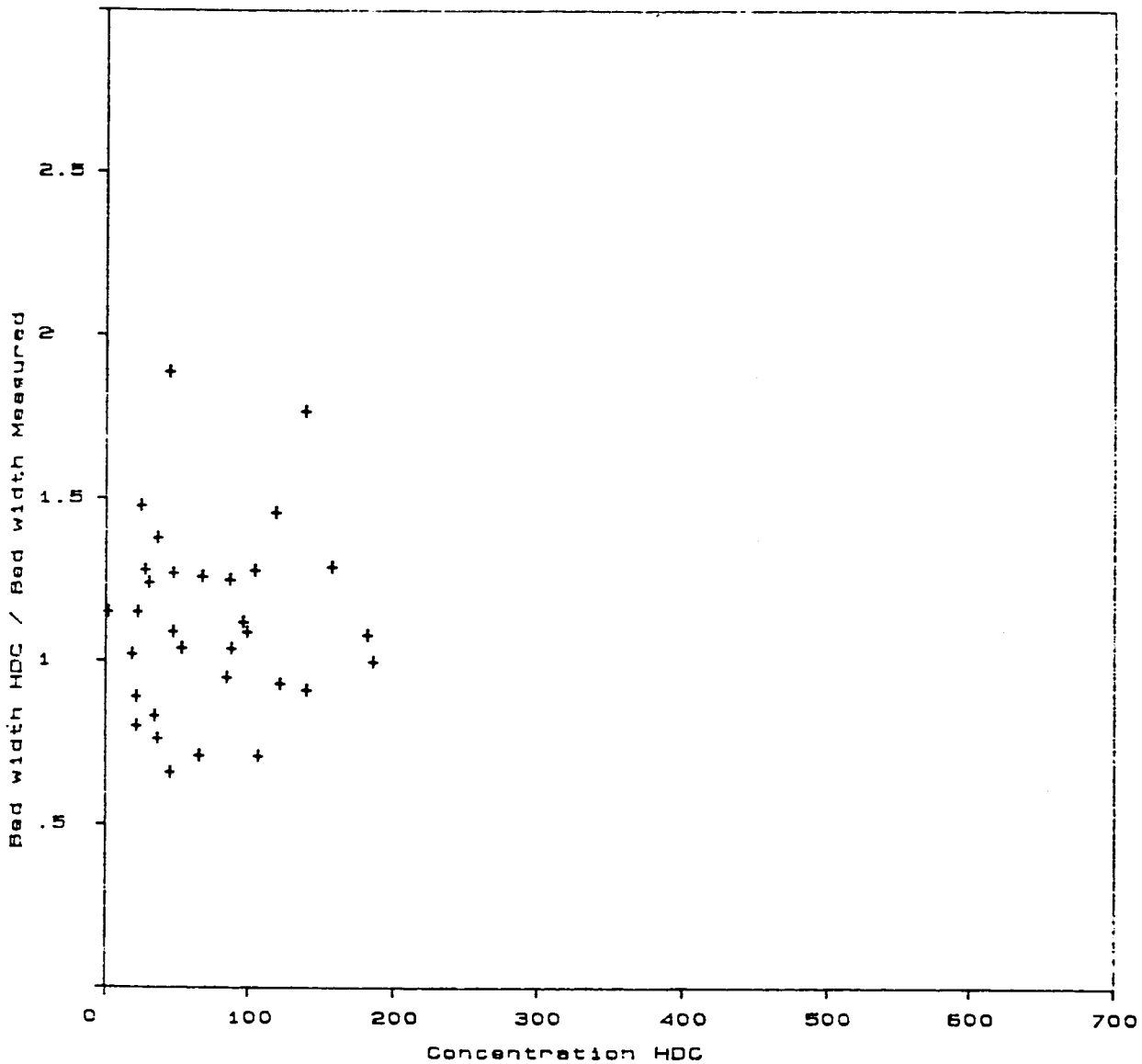
NORMALIZED KS VS CHEZY	SIND AND PUNJAB
	CANAL SYSTEMS
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG. 5·36



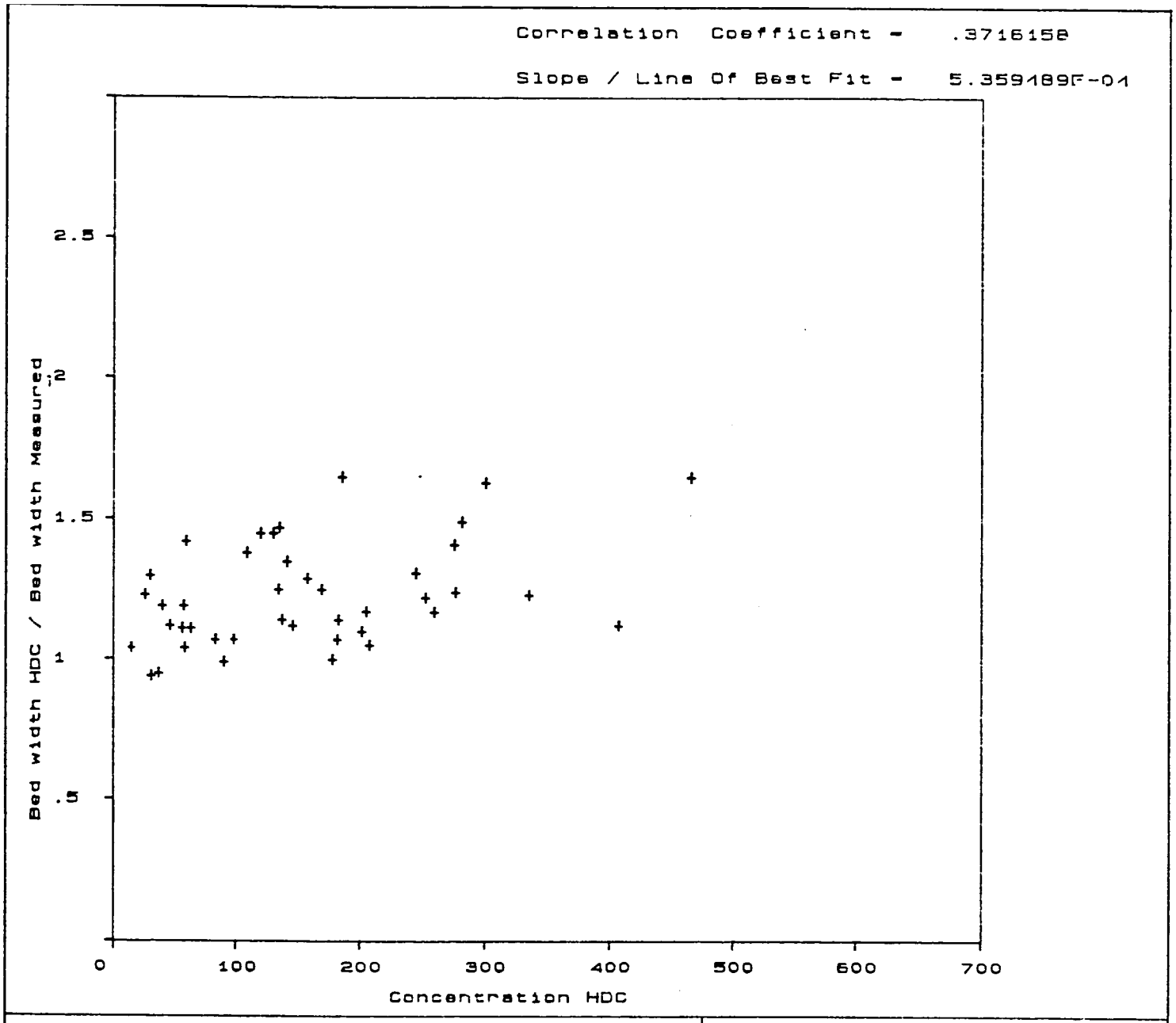
Concentration HDC versus Ratio of Bed width HDC over Meas. Bed width 57 Data Sets	Punjab Province Depalpur Canal System
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 5-37



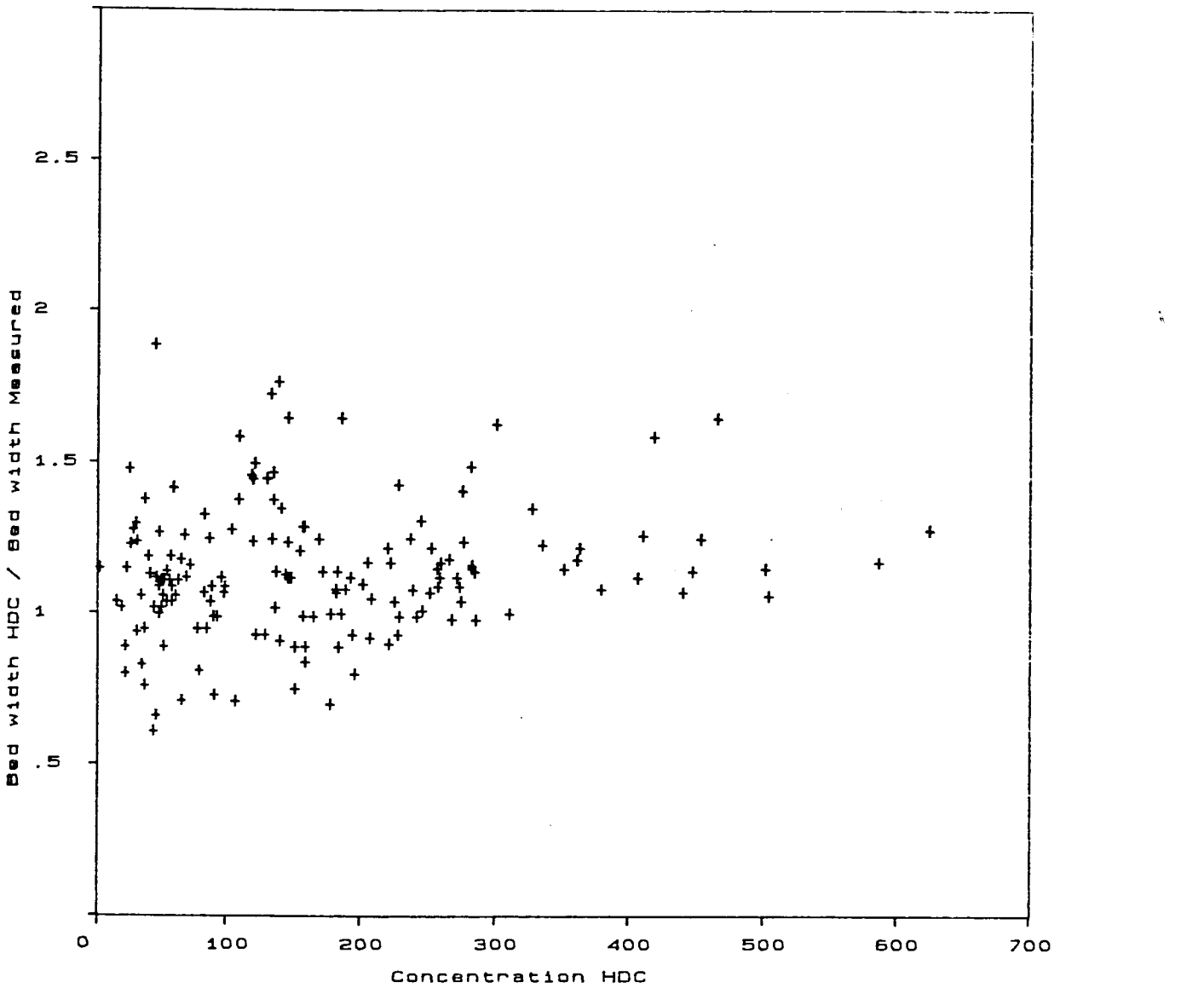
Concentration HDC versus Ratio of Bed width HDC over Meas. Bed width 19 Data Sets	Punjab Province Upper Gugera Branch
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 5·38



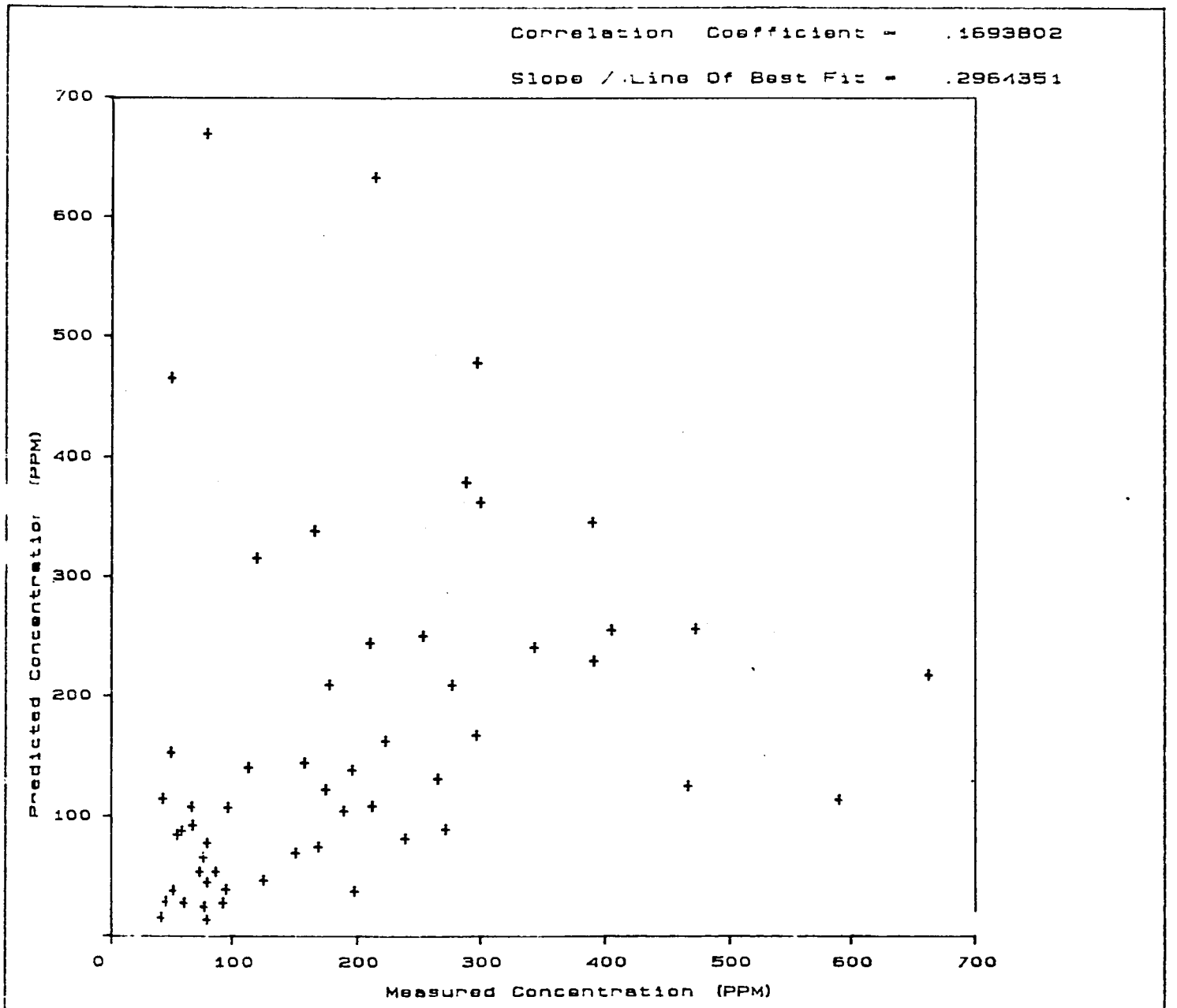
Concentration HDC versus Ratio of Bed width HDC over Meas. Bed width 32 Data Sets	Punjab Province Upper Gugera Disties
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 5·39



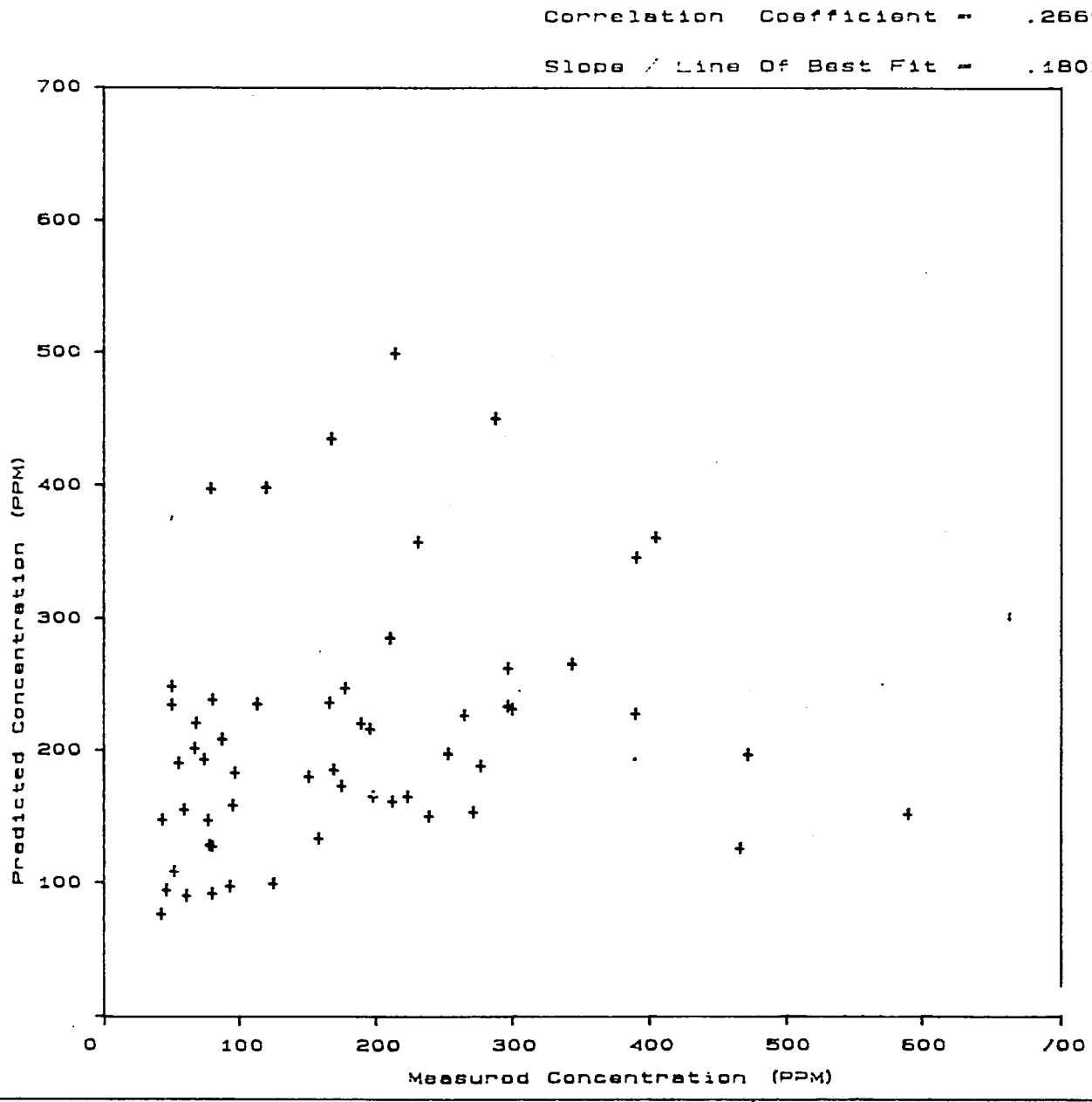
Concentration HDC versus Ratio of Bed width HDC over Meas. Bed width 43 Data Sets	Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG .5·40



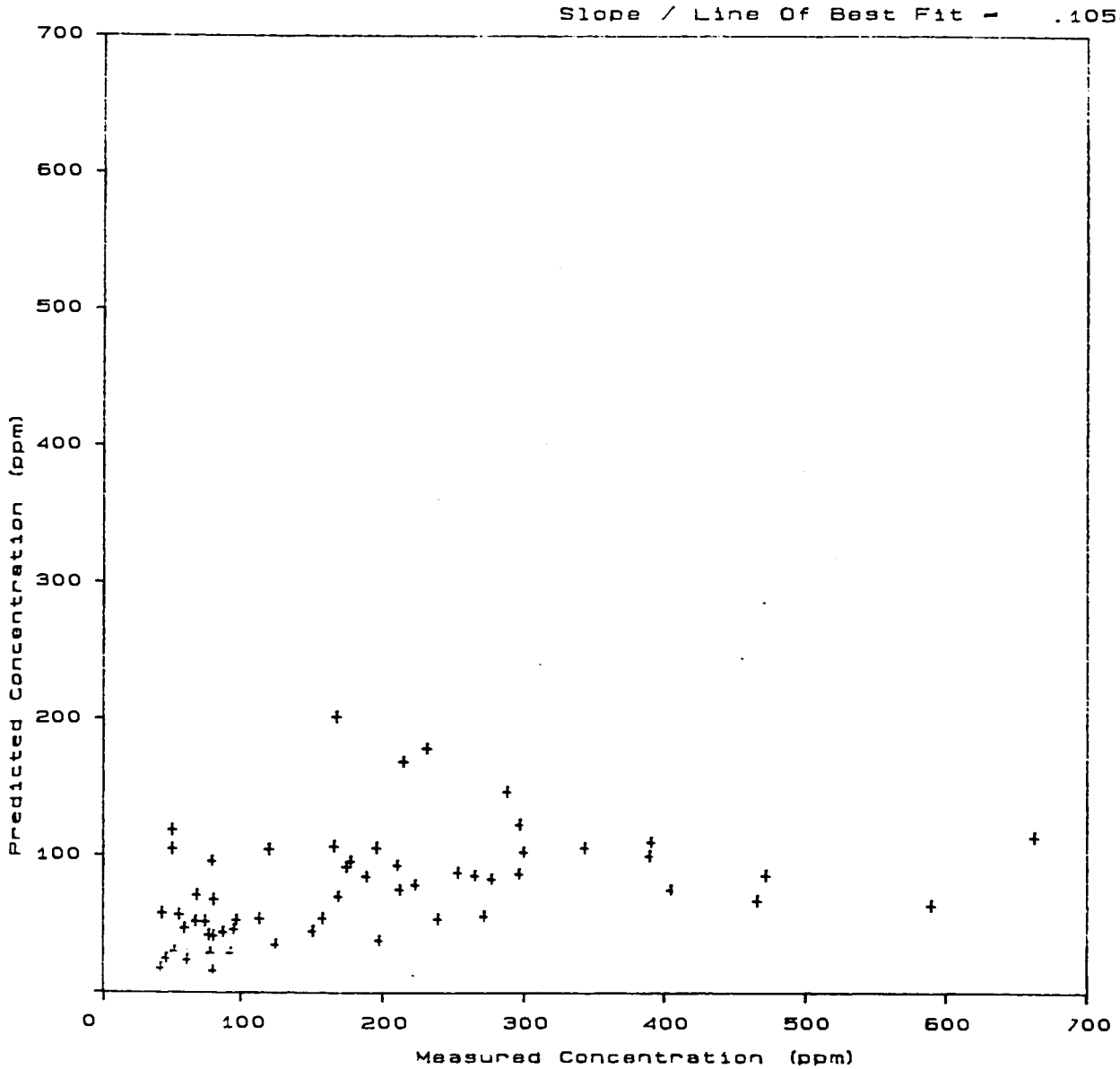
Concentration HDC versus Ratio of Bed width HDC over Meas. Bed width 163 Data Sets	Canal Systems Punjab & Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 5·41



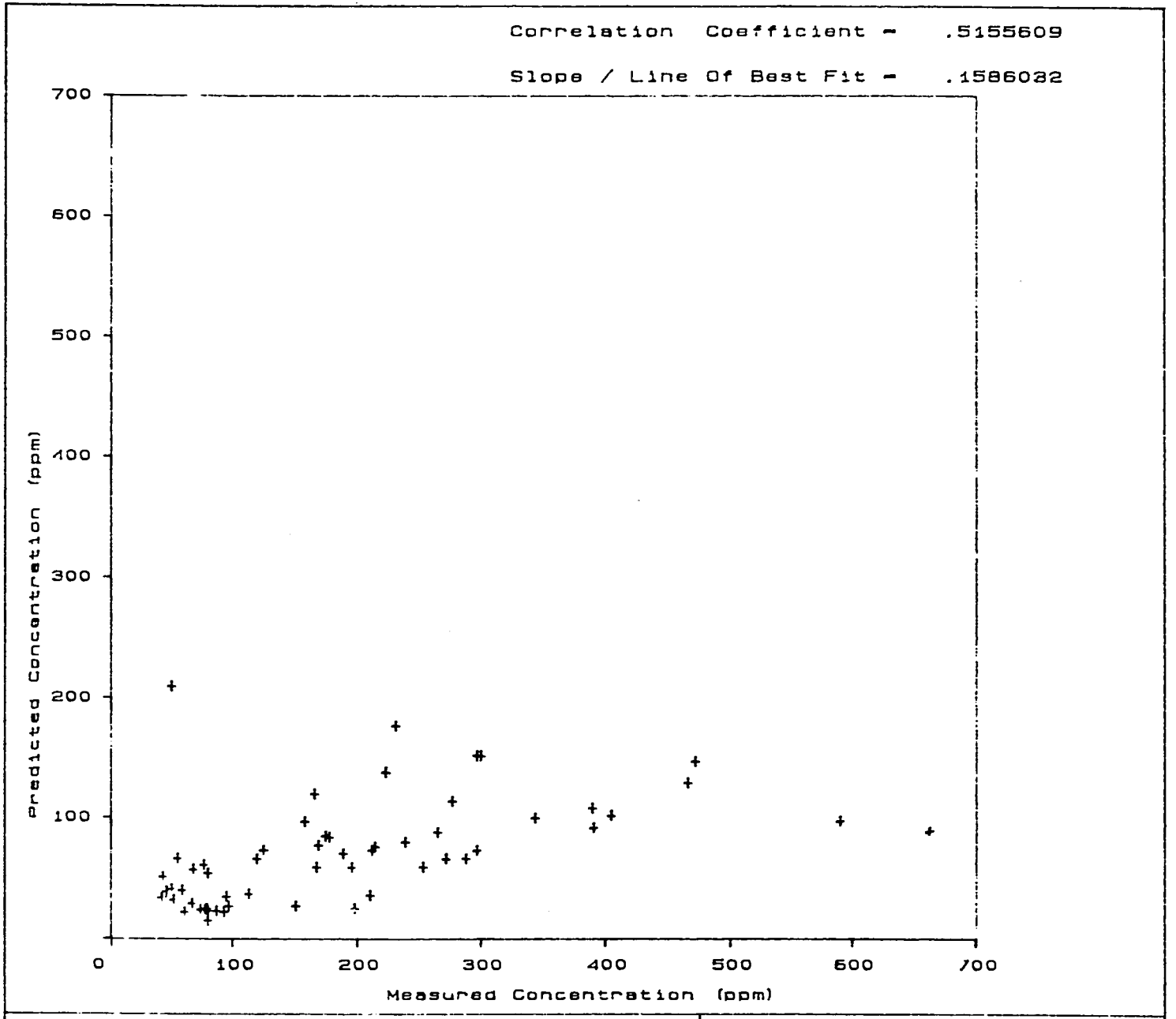
ACKERS AND WHITE	Depalpur Canal System
Measured VS Predicted Concentration	Total Data Sets
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·1



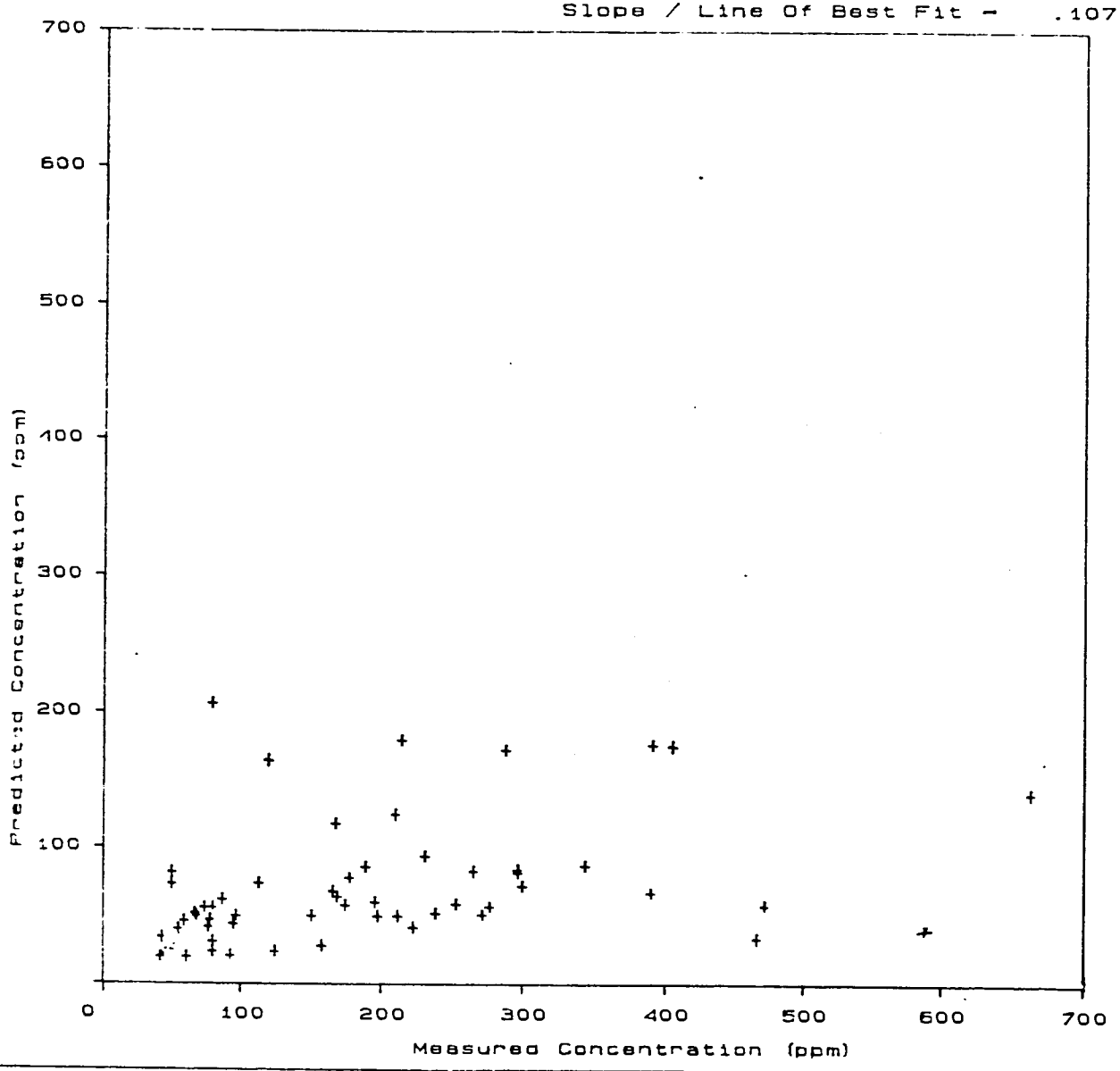
ENGELUND AND HANSEN	Depalpur Canal System
Measured VS Predicted Concentration	Total Data Sets
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG .6·2



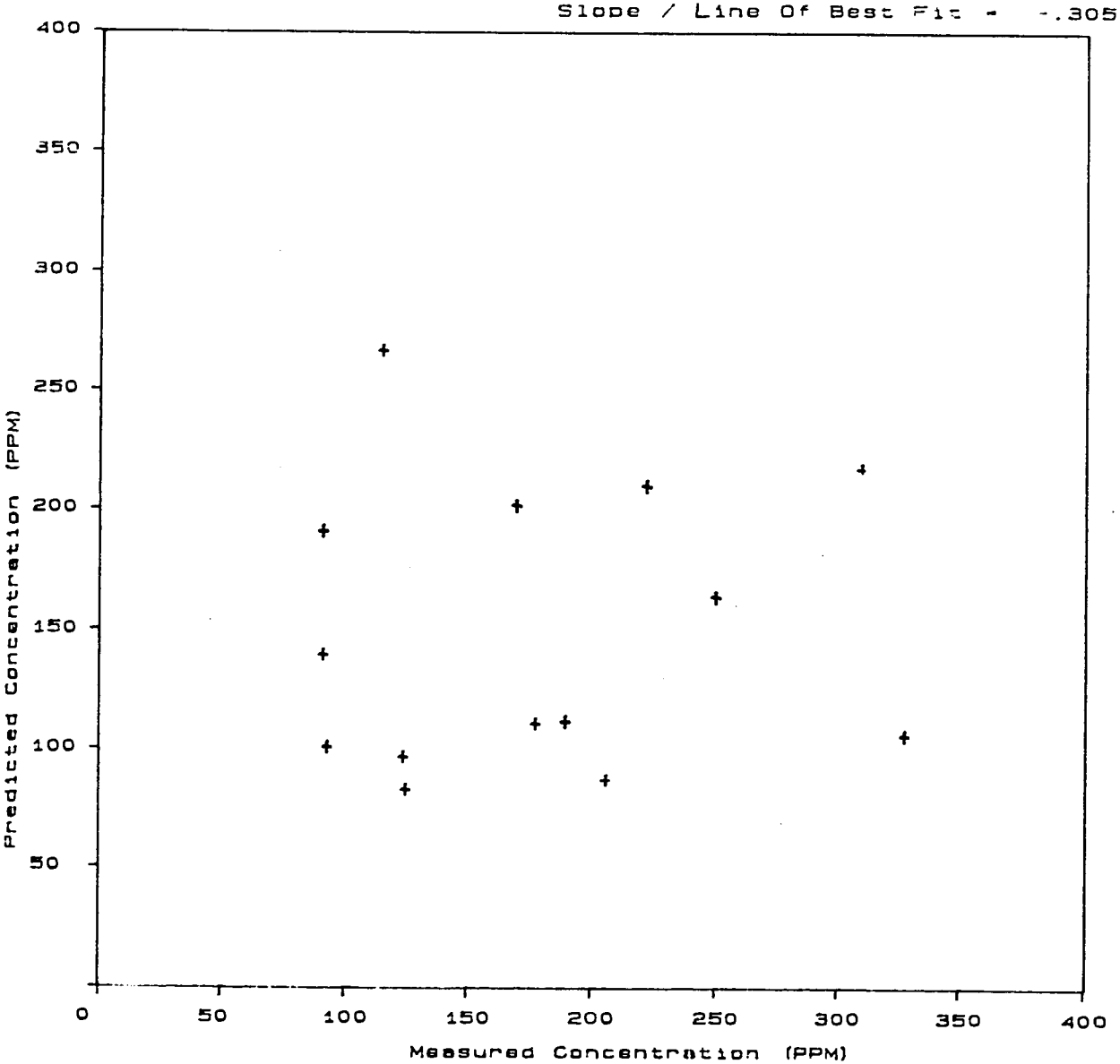
KARIM AND KENNEDY	Depalpur Canal System
Measured Vs Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·3



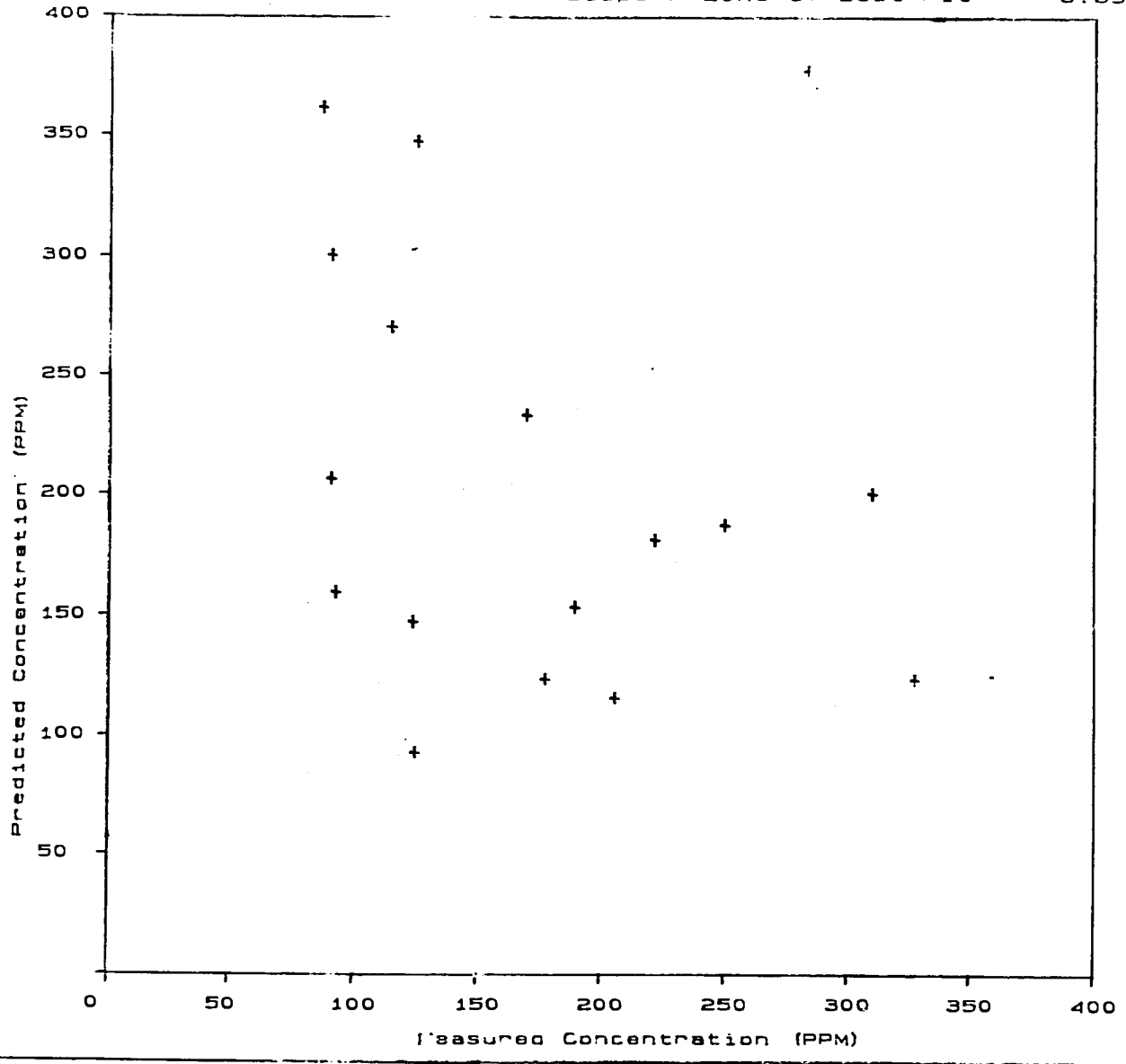
VAN RIJN Measured Vs Predicted Concentration	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·4



YANG Measured Vs Predicted Concentration	Depalpur Canal System Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·5

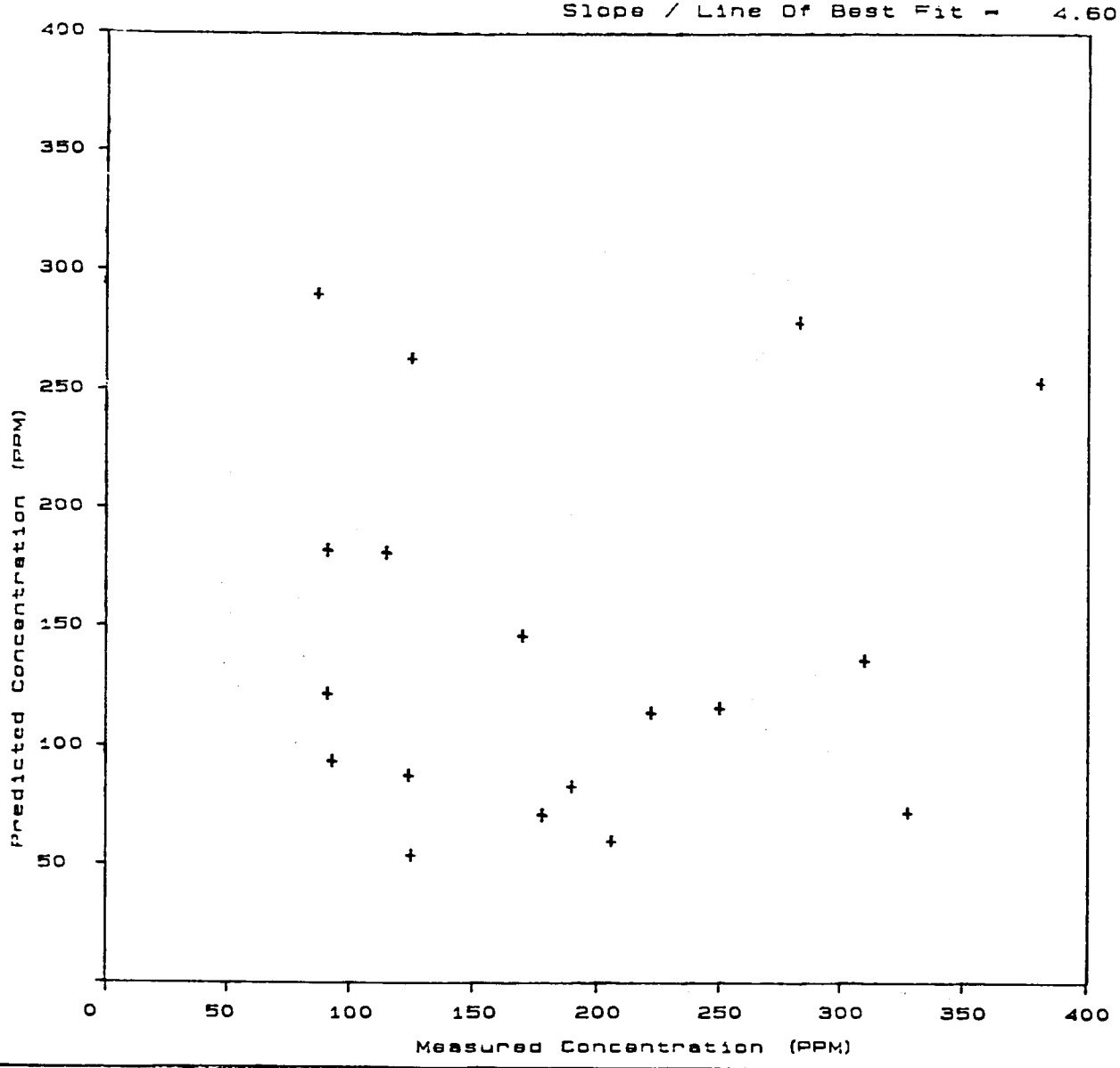


ACKERS AND WHITE Measured VS Predicted Concentration	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·6

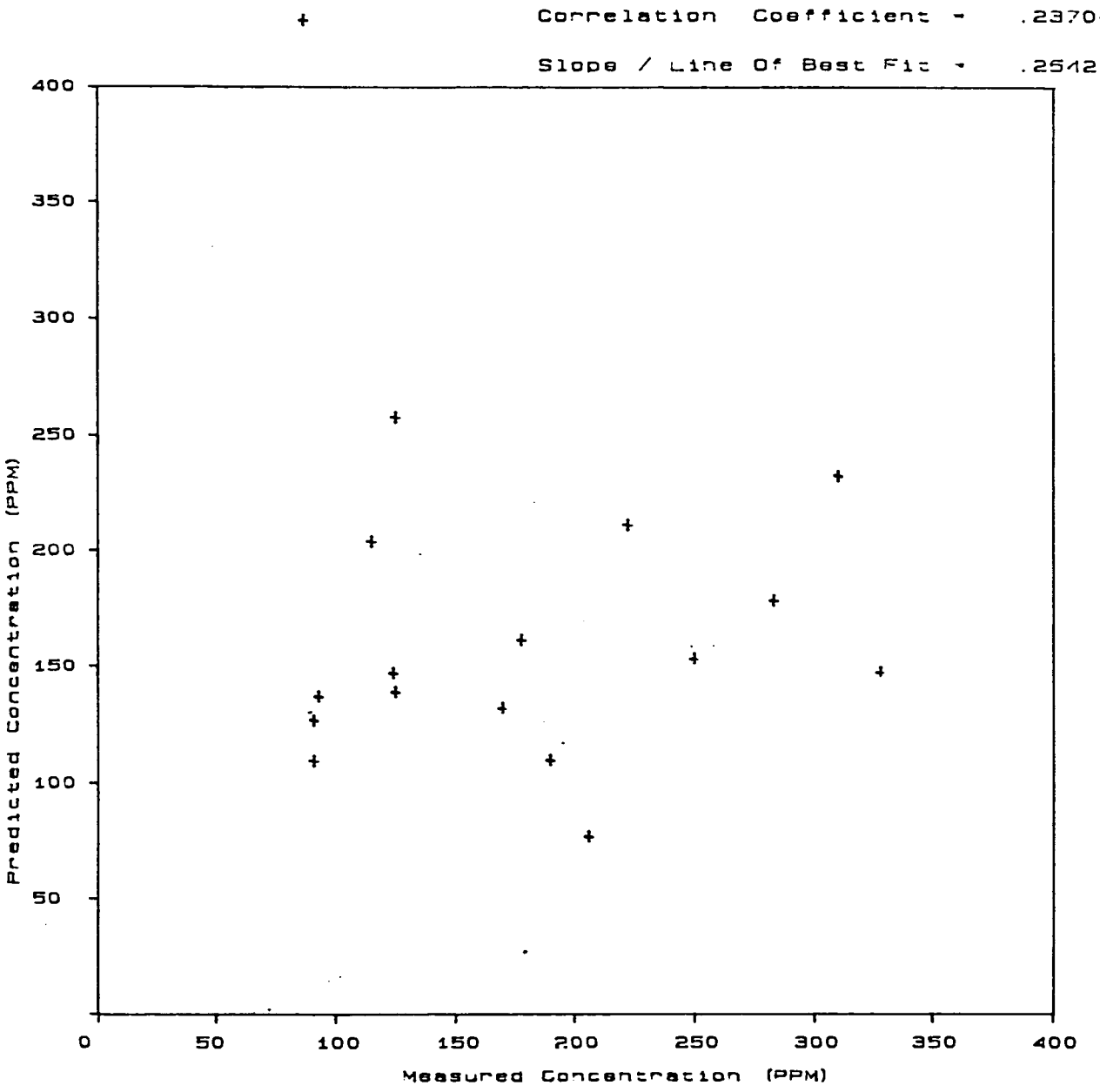


ENGELUND AND HANSEN Measured VS Predicted Concentration	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6.7

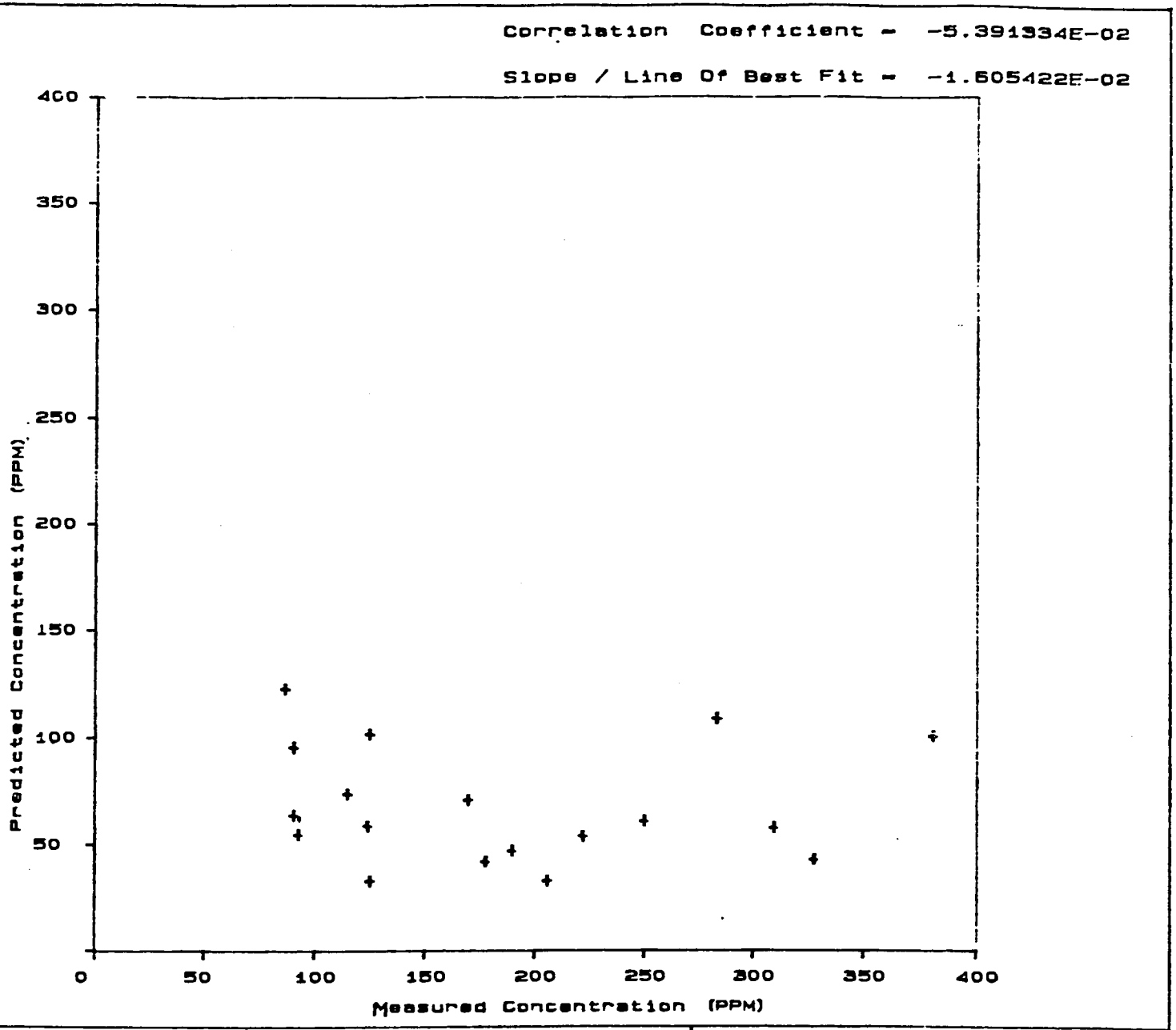
247



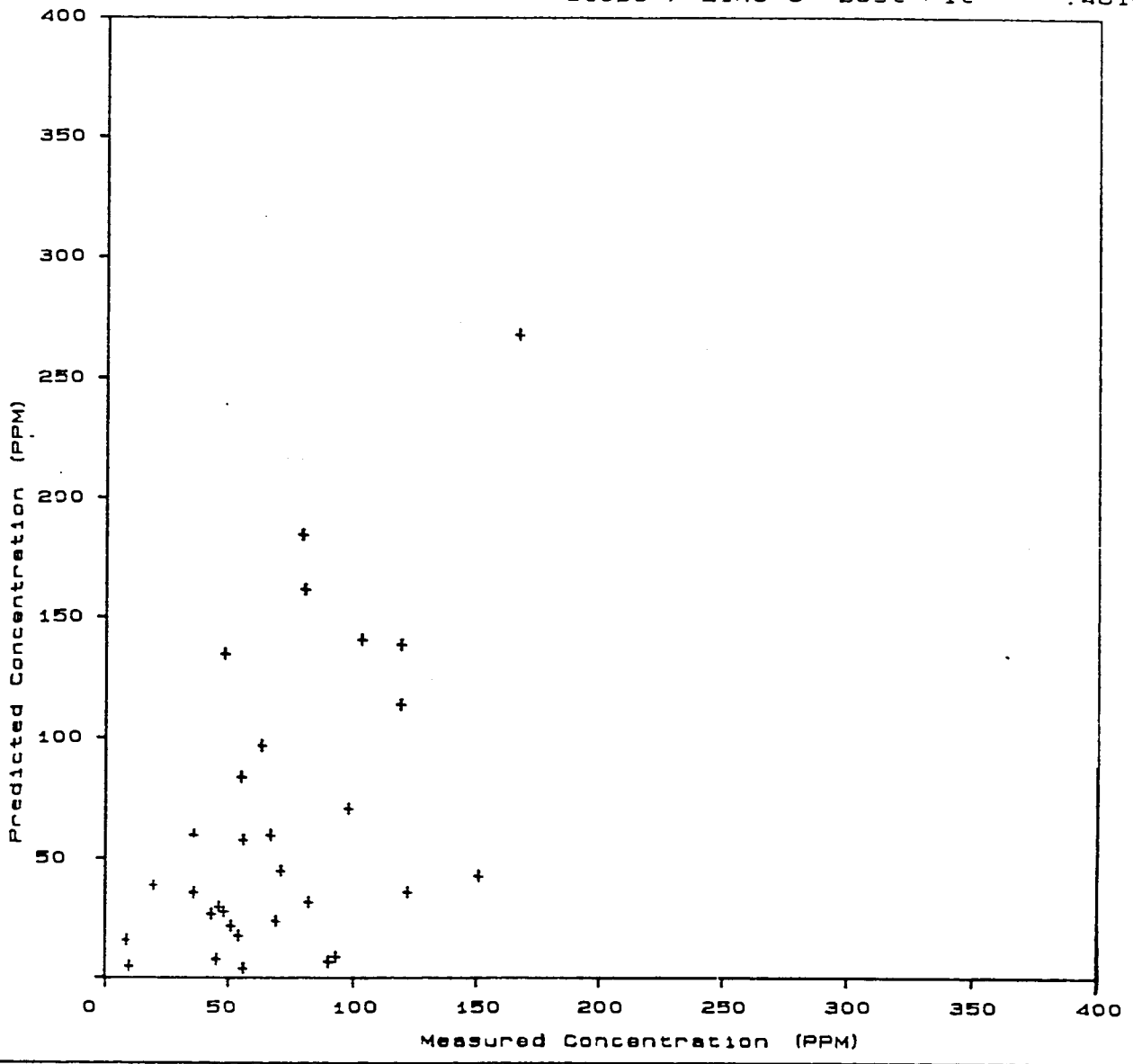
KARIM KENNEDY Measured VS Predicted Concentration	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHFCCHI	FIG . 6·8



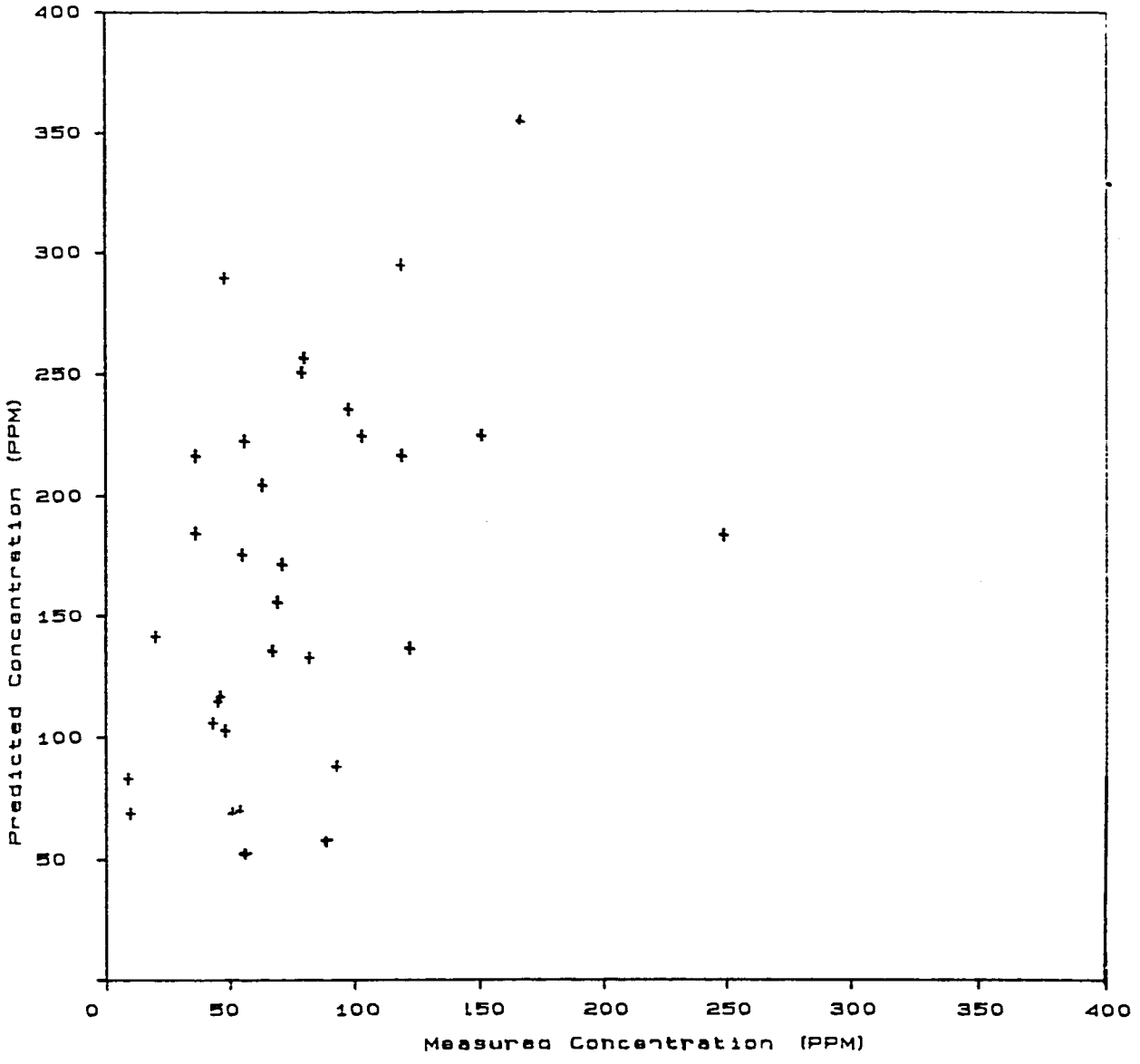
VAN RIJN Measured VS Predicted Concentration	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·9



YANG Measured VS Predicted Concentration	Upper Gugera Branch Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·10

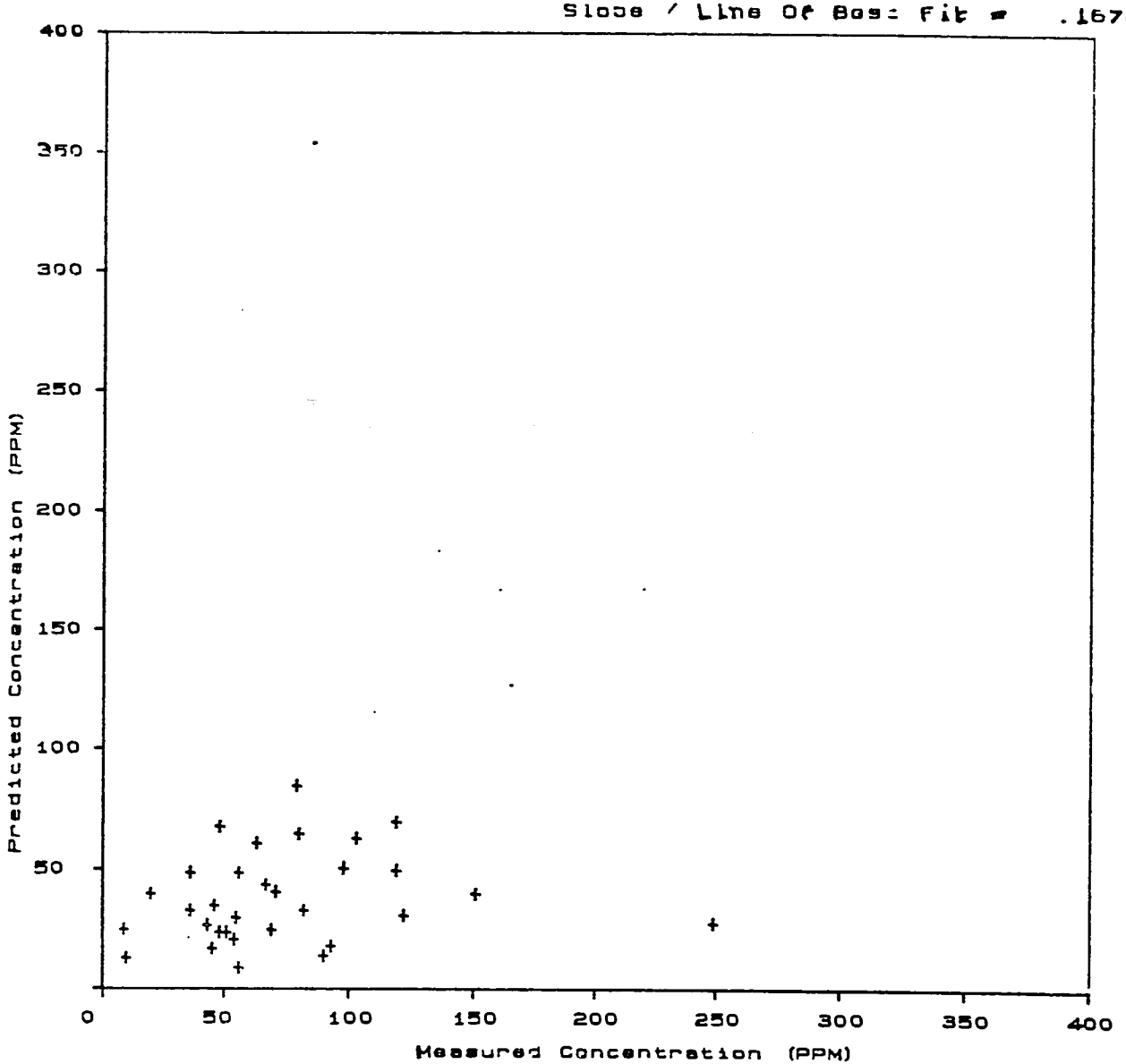


ACKERS AND WHITE	Upper Gugera Disties
Measured VS Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·11

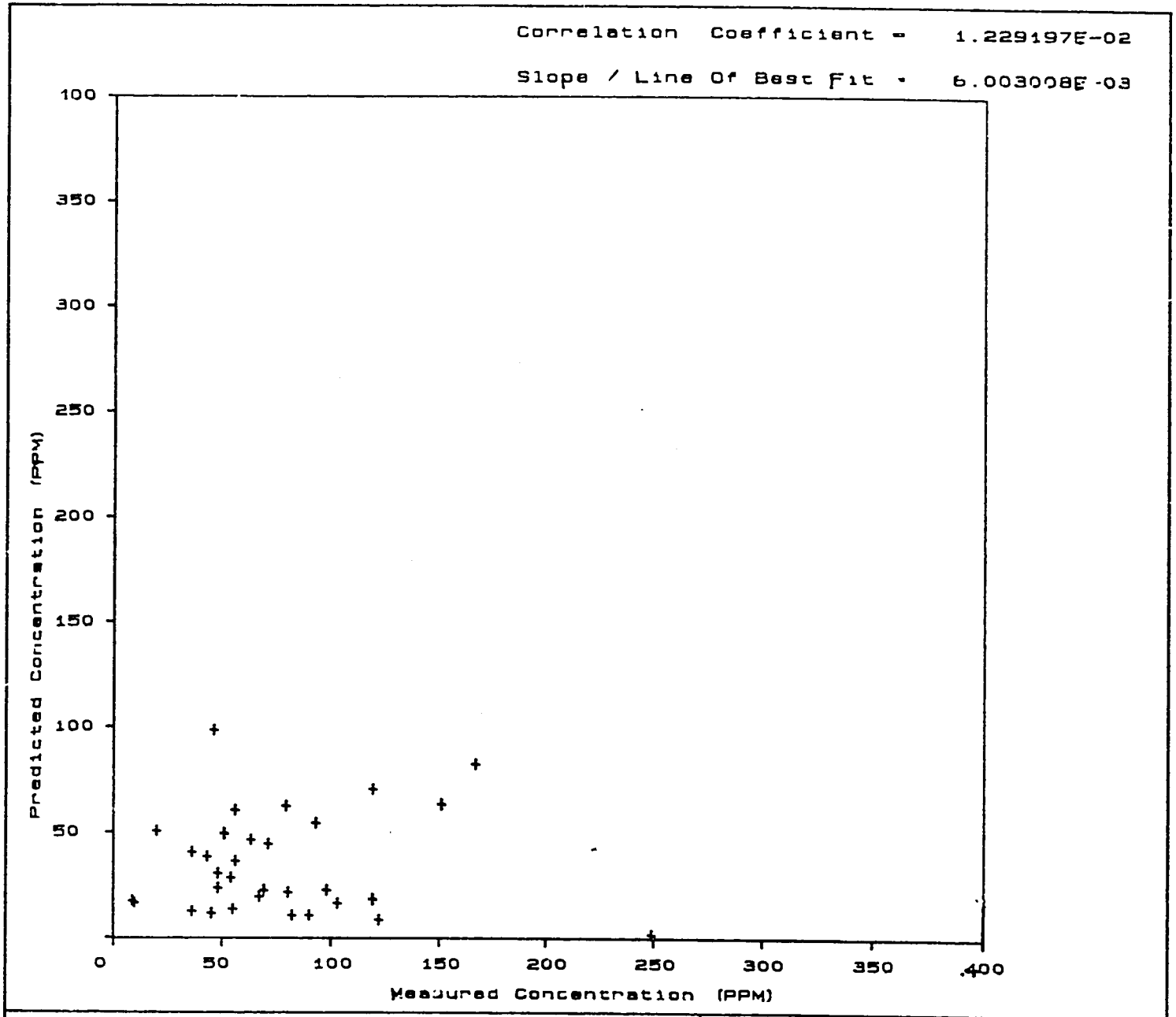


ENGELUND AND HANSEN	Upper Gugera Disties
Measured VS Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·12

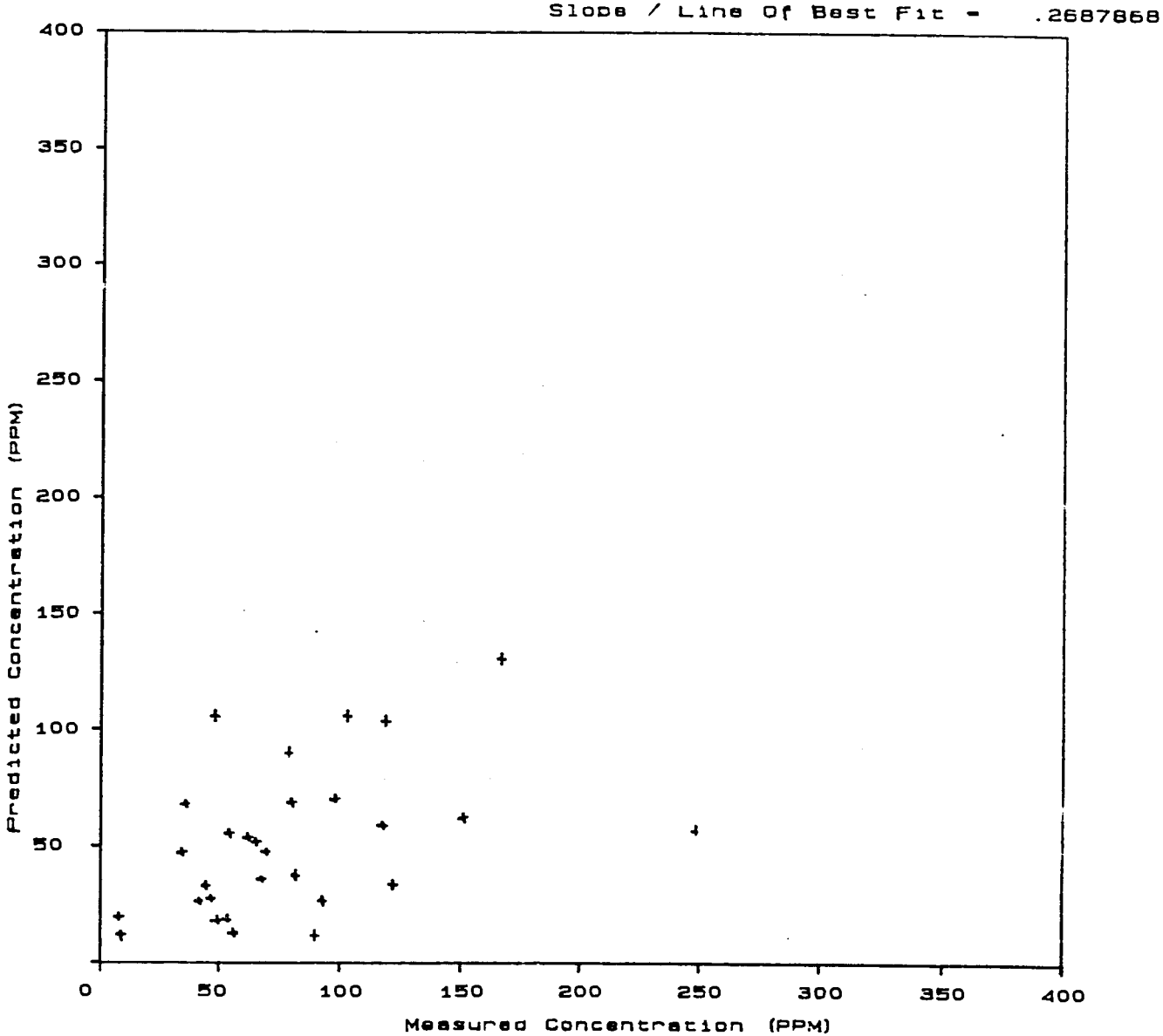
222.



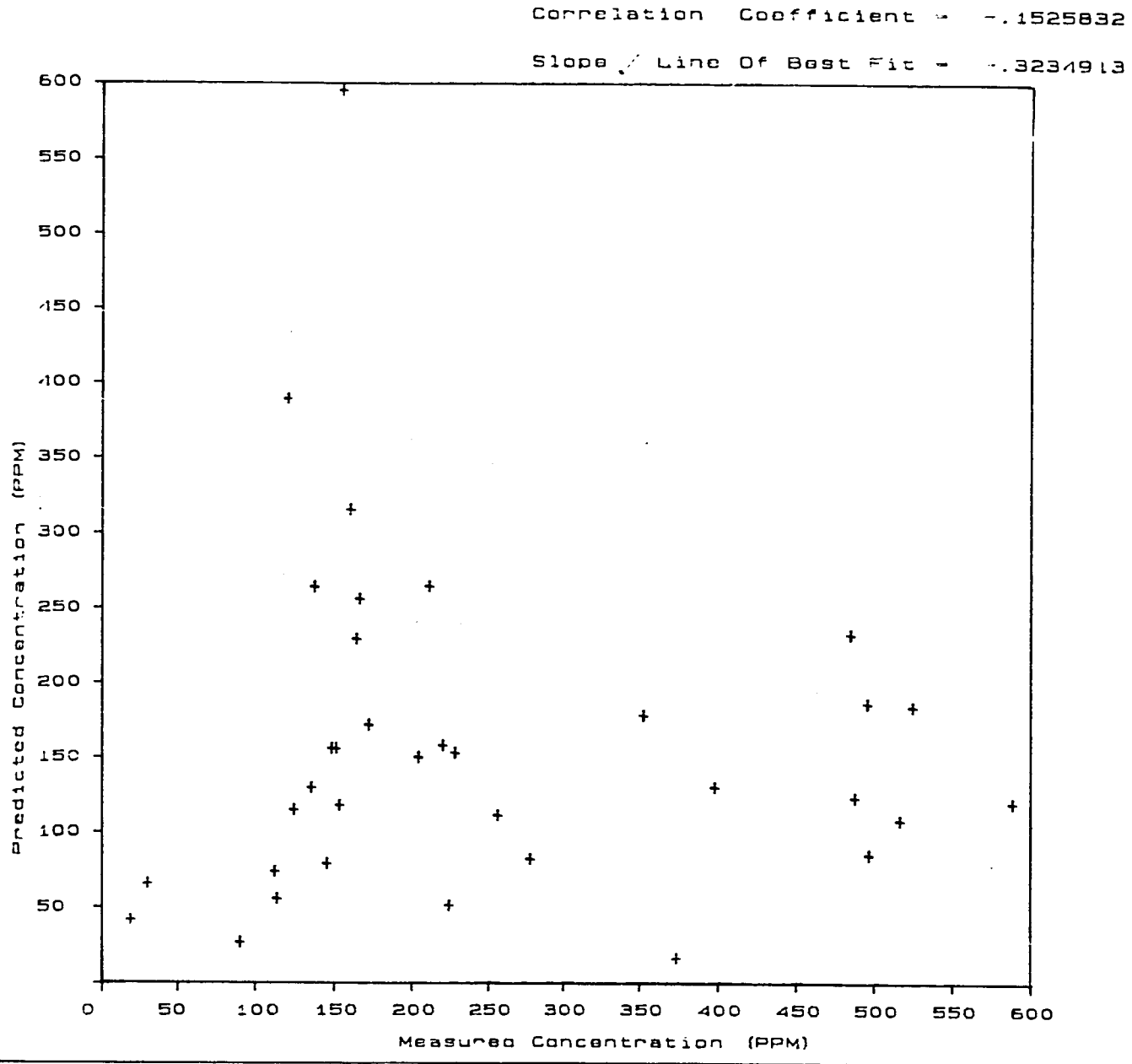
KARIM AND KENNEDY	Upper Gugera Distios
Measured VS Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·13



VAN RIJN	Upper Gugera Distles
Measured VS Predictec Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·14

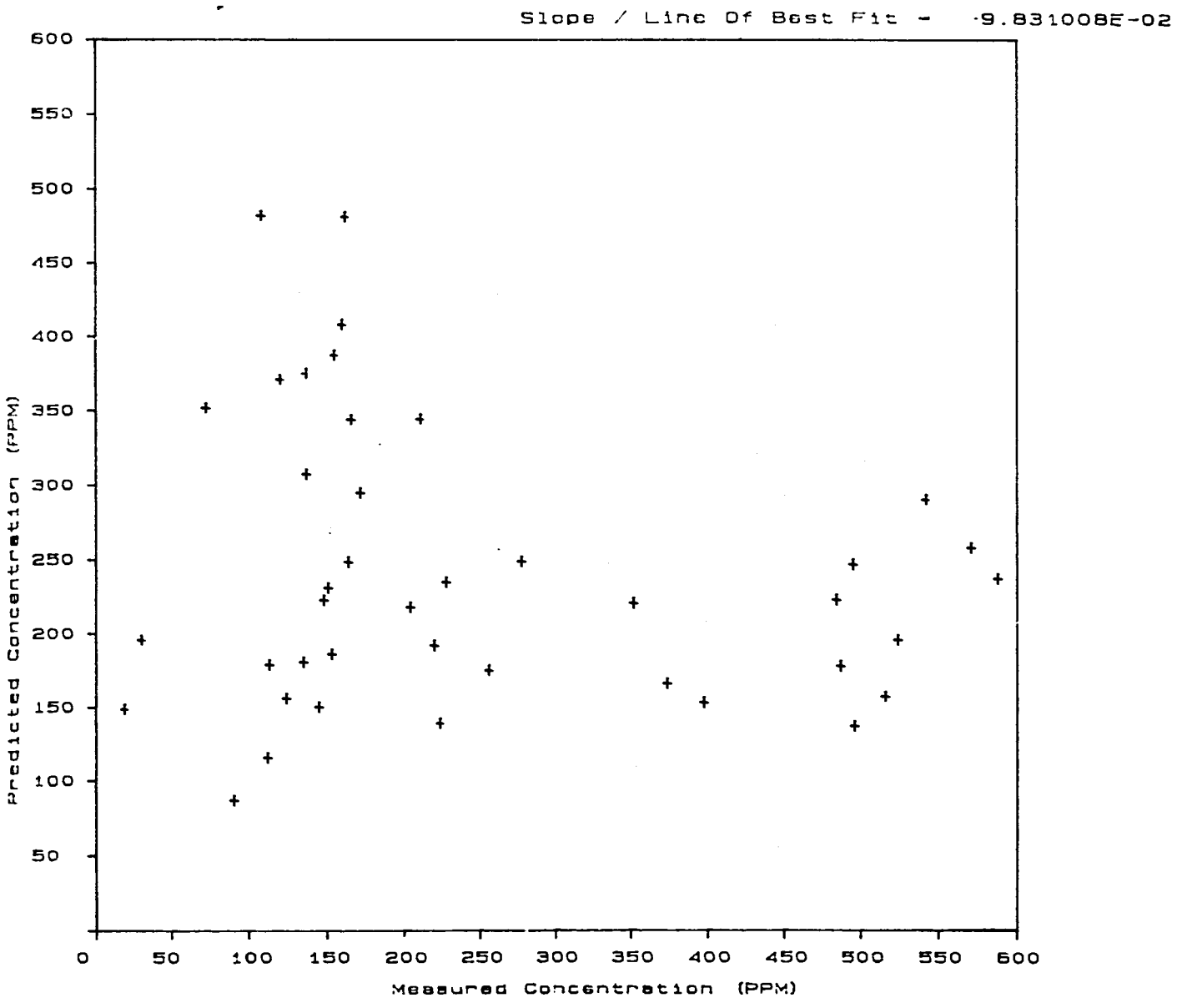


YANG	Upper Gugera Disties
Measured VS Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·15



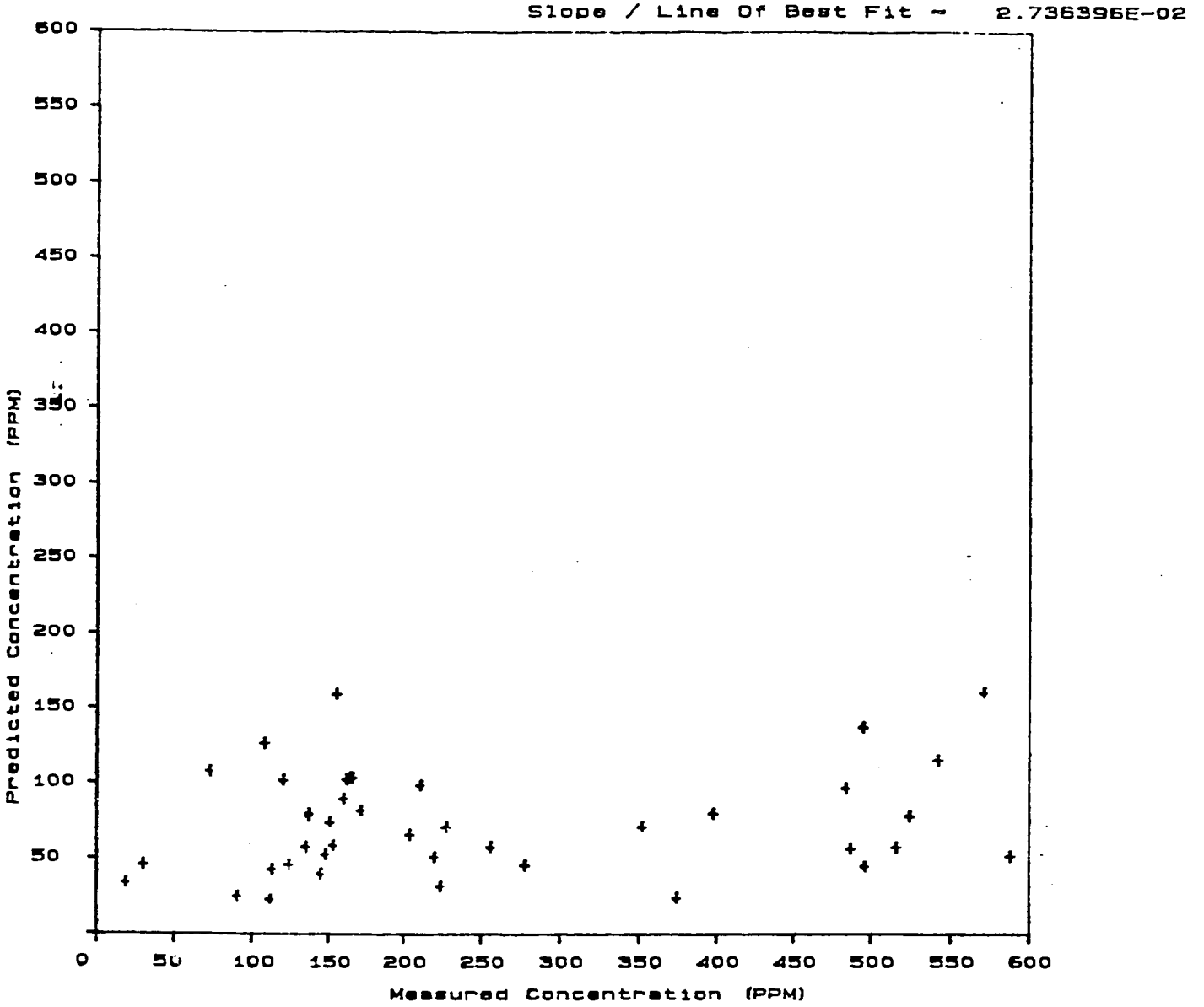
ACKERS AND WHITE	Sind Canal Systems
Measured VS Predicted Concentration	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·16

226

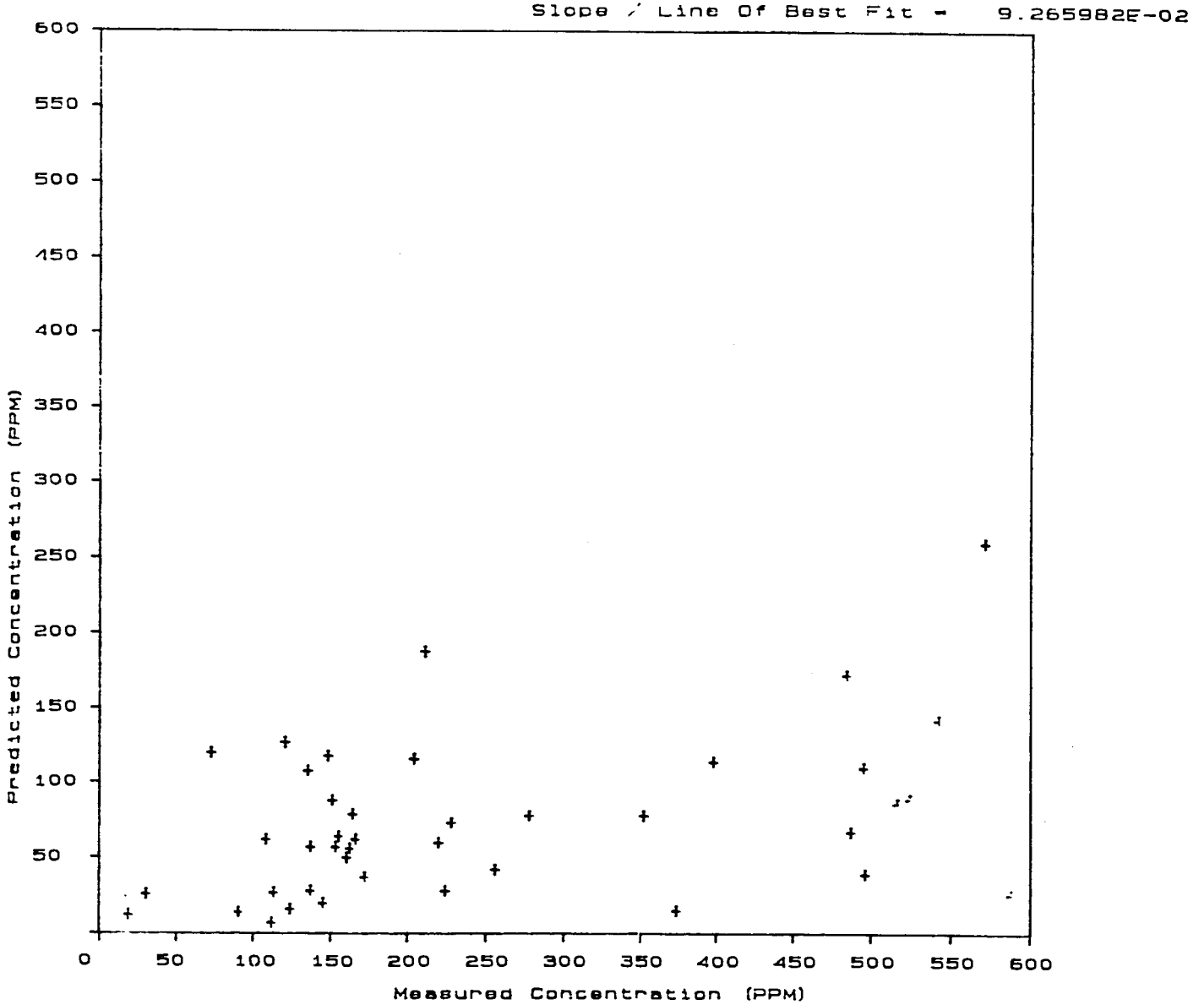


ENGELUND AND HANSEN	Sind Canal Systems
Measured VS Predicted Concentration	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·17

227

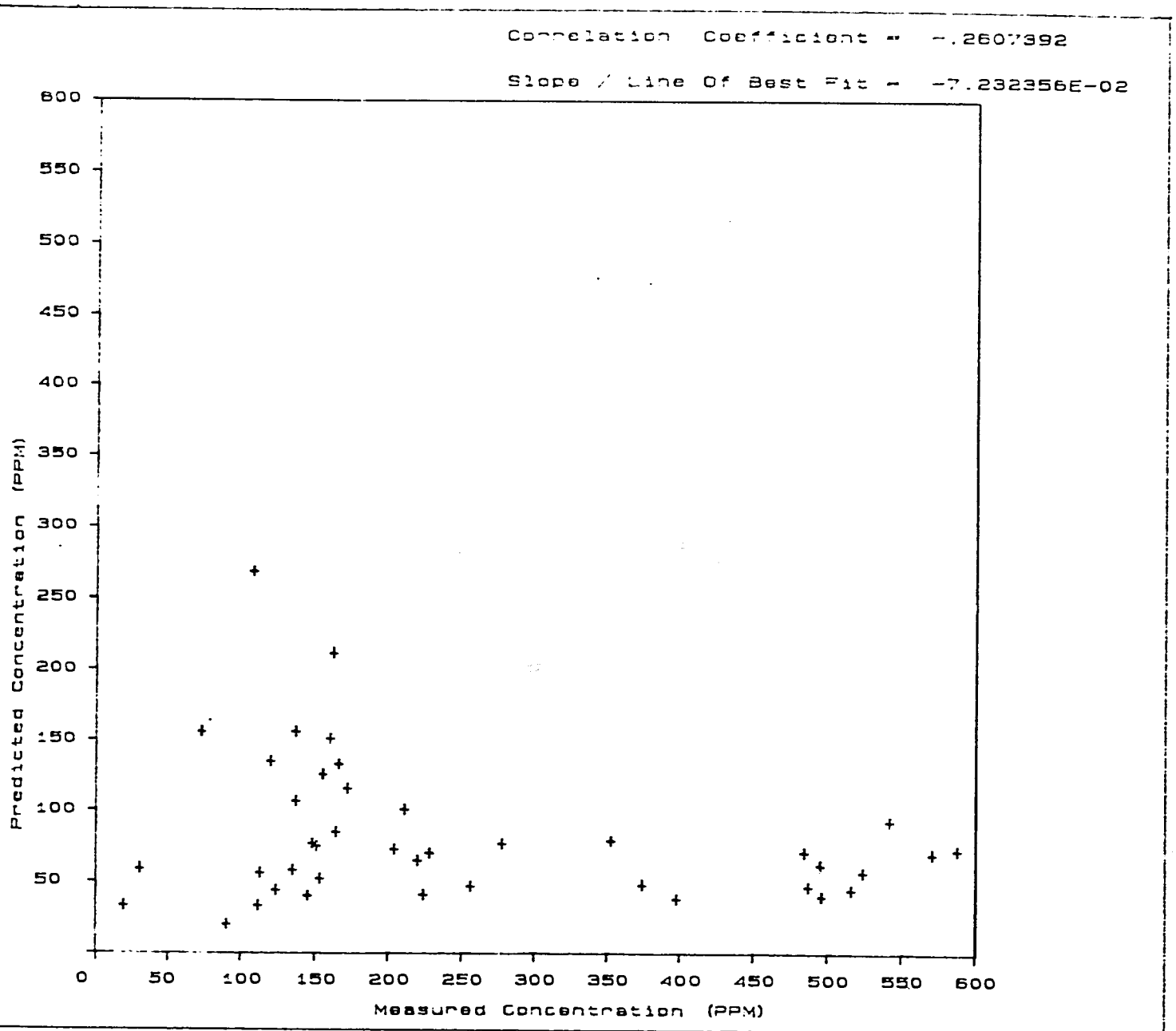


KARIM AND KENNEDY	Sind Canal Systems
Measured VS Predicted Concentration	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·18



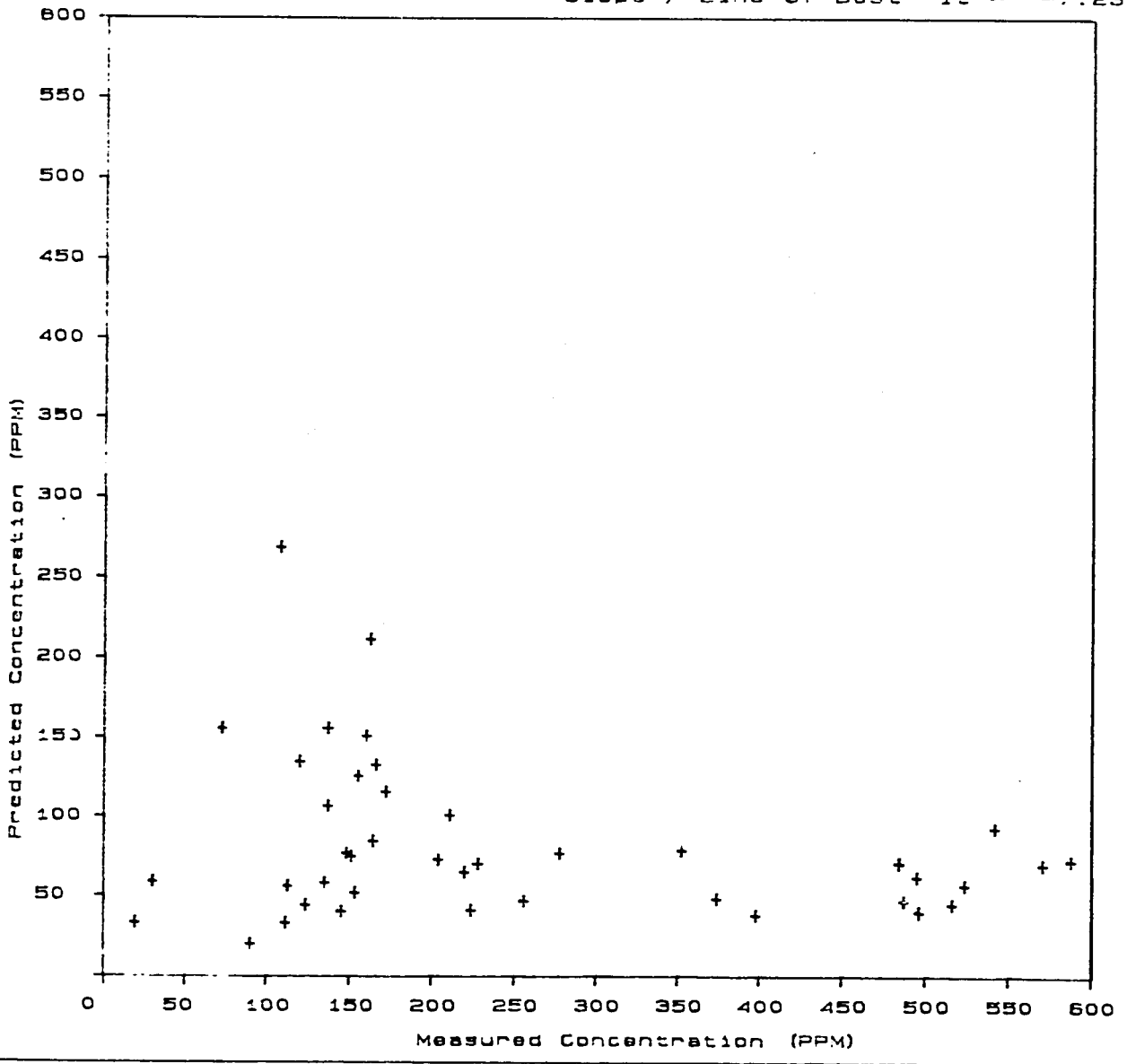
VAN RIJN Measured VS Predicted Concentration	Sind Canal System Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·19

229.

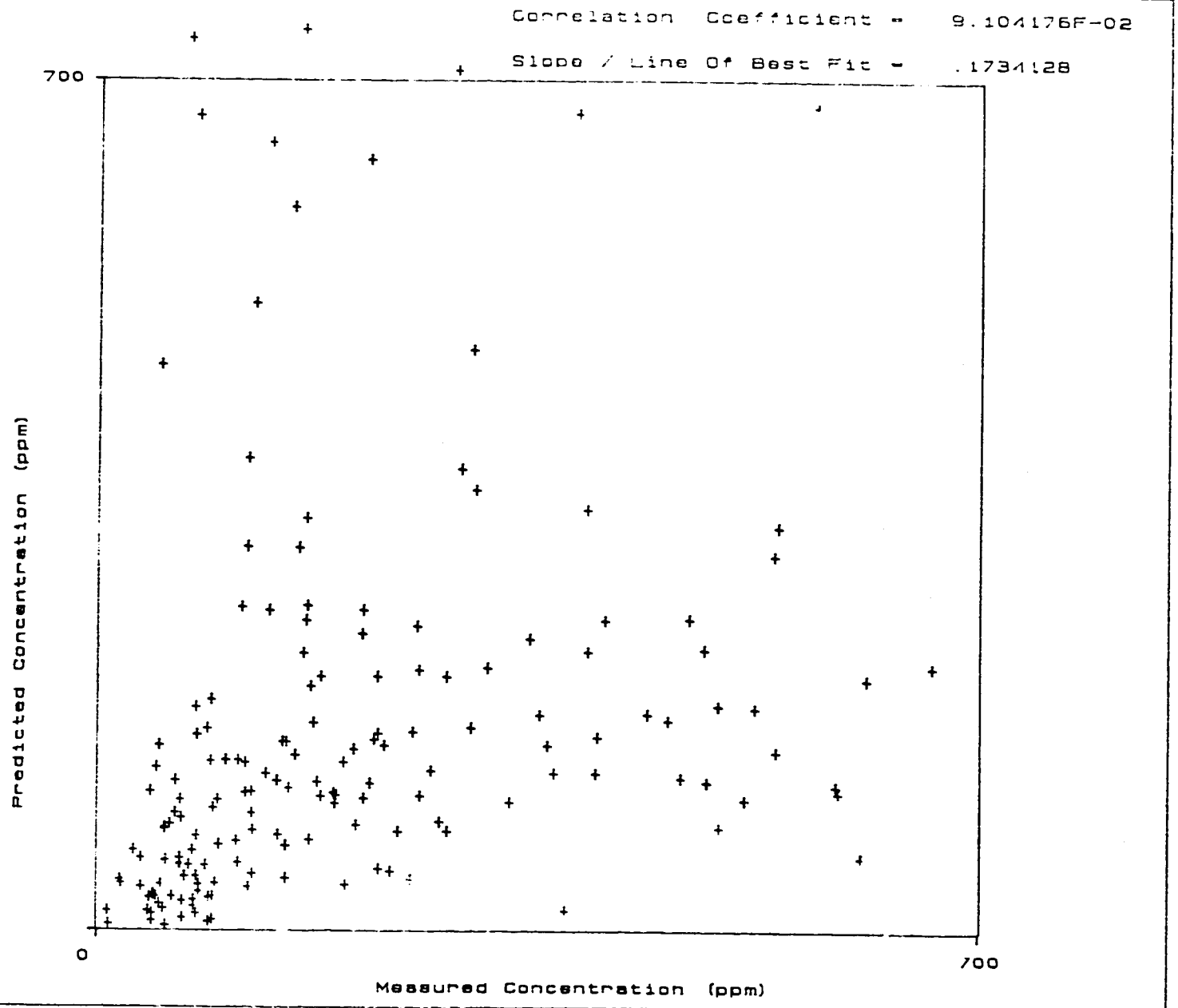


YANG Measured VS Predicted Concentration	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·20

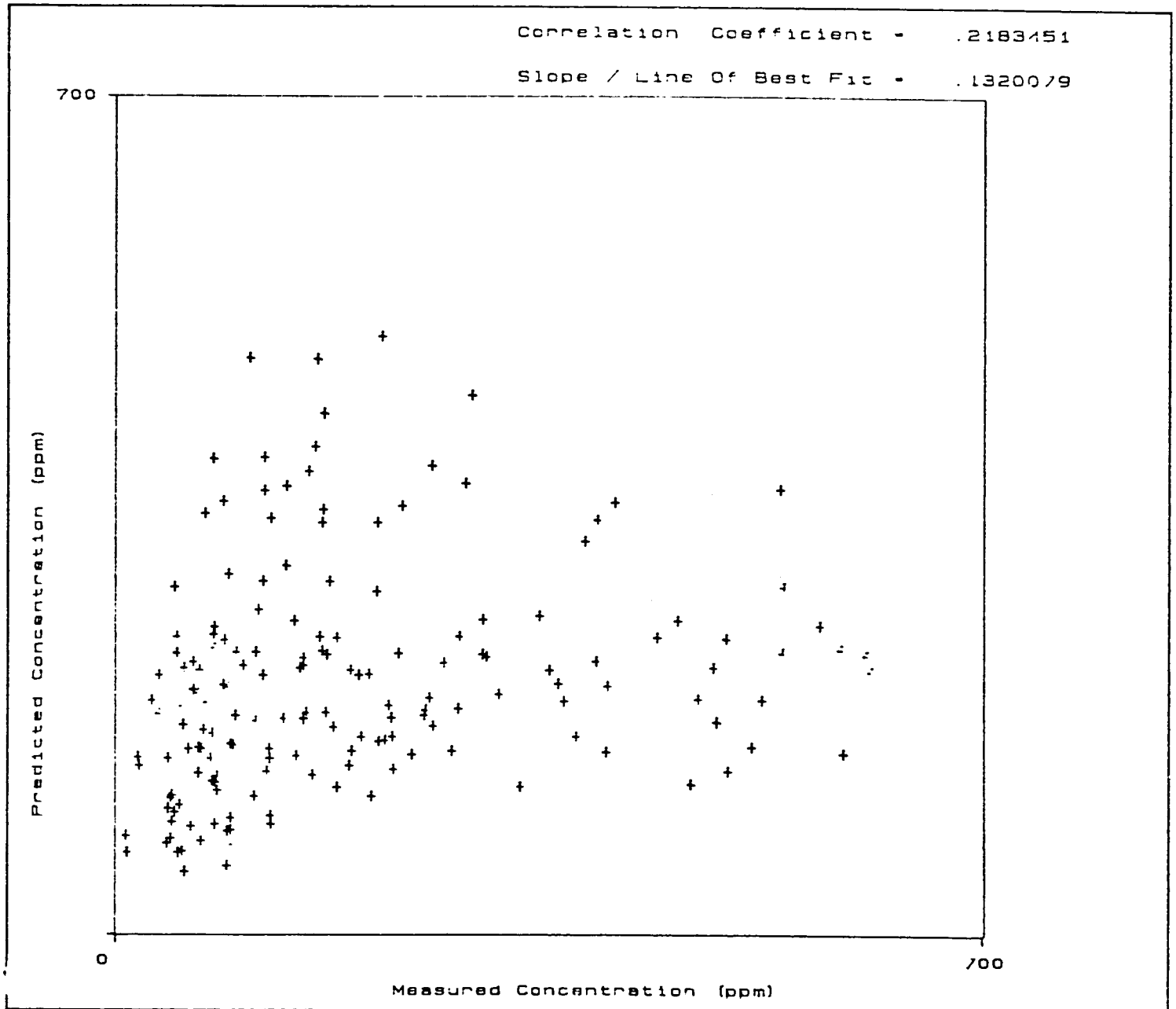
230



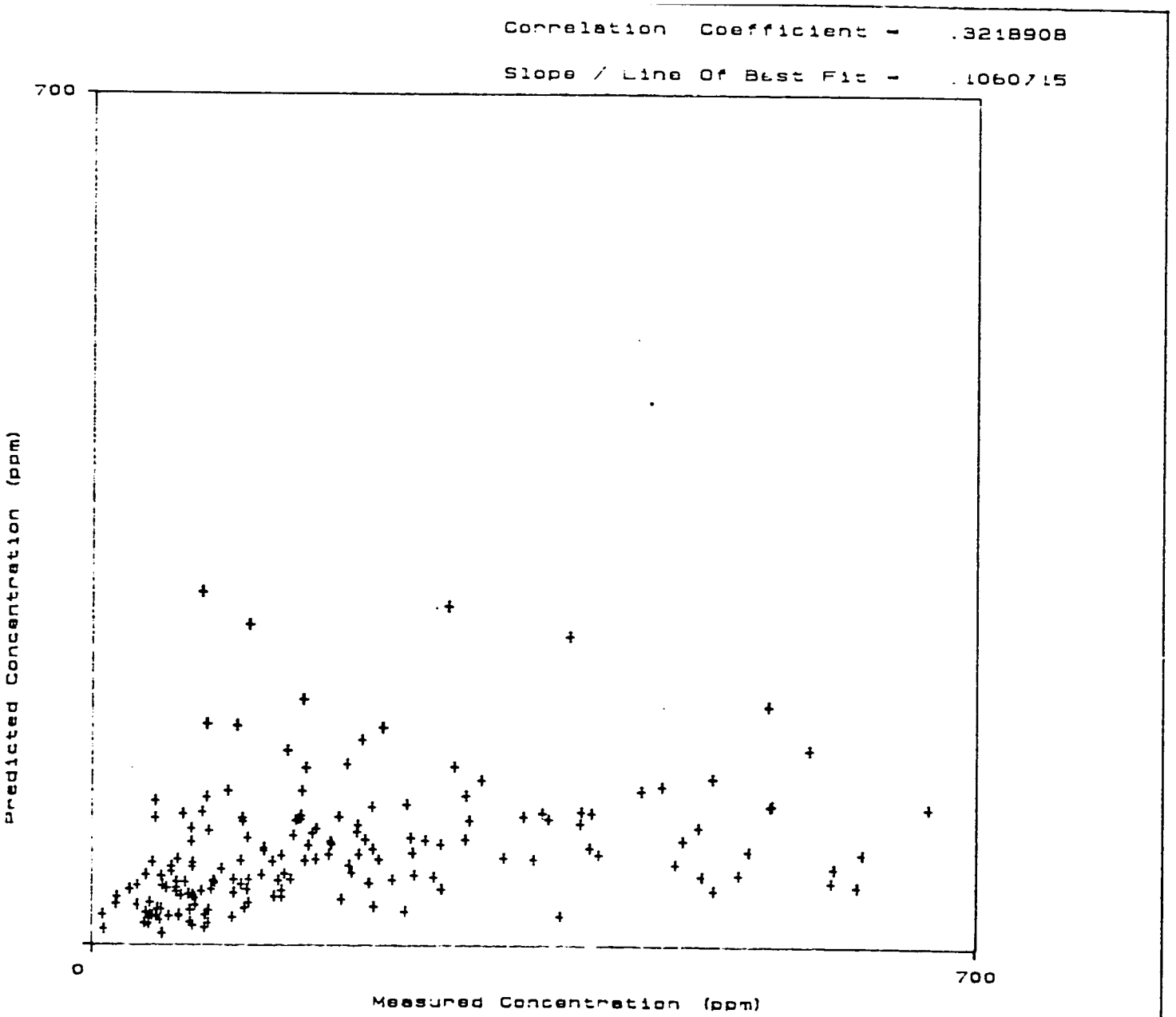
YANG Measured VS Predicted Concentration	Sind Canal Systems Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·20



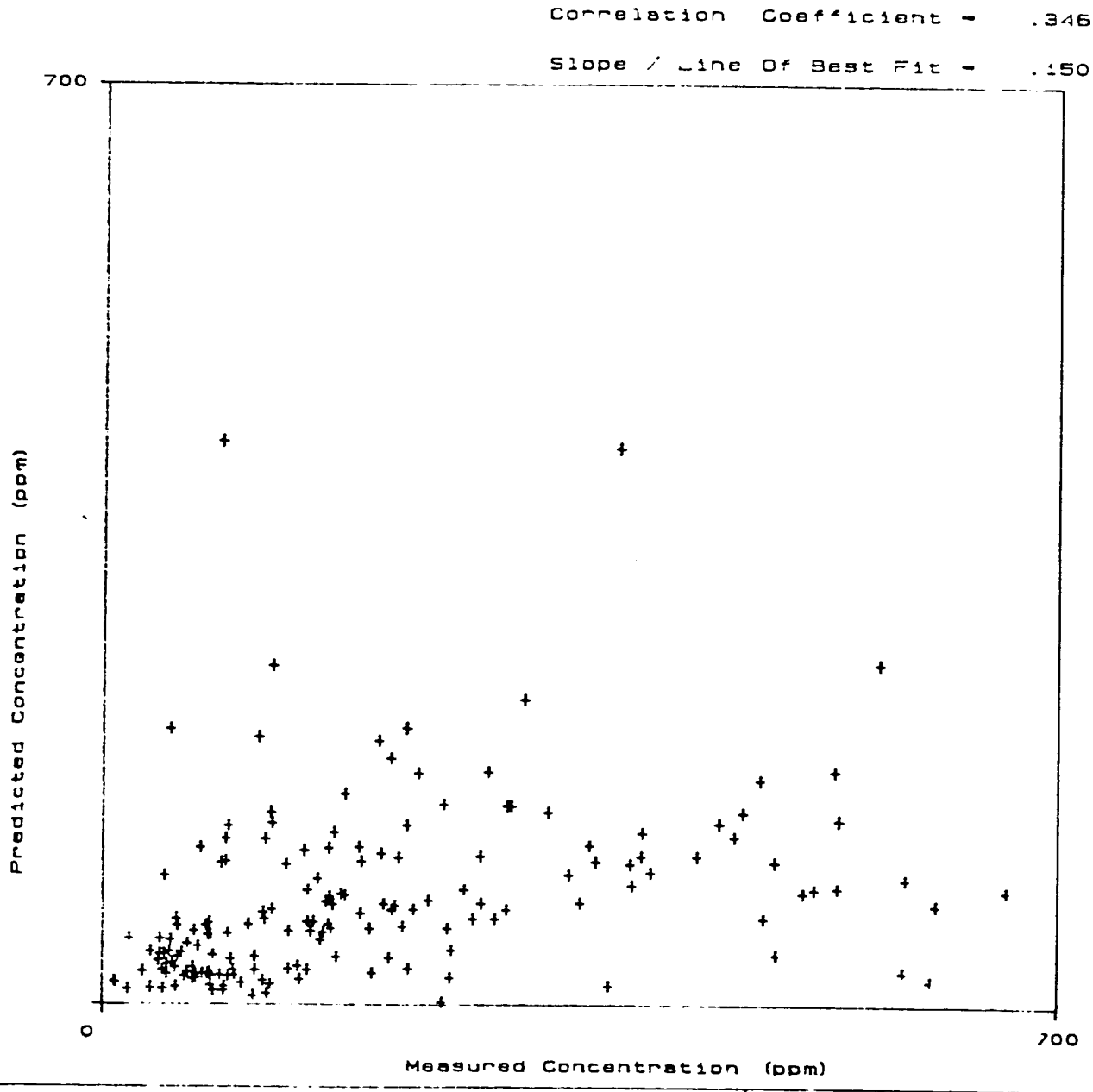
ACKERS AND WHITE	Canal Systems
Measured Vs Predicted Concentration	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·21



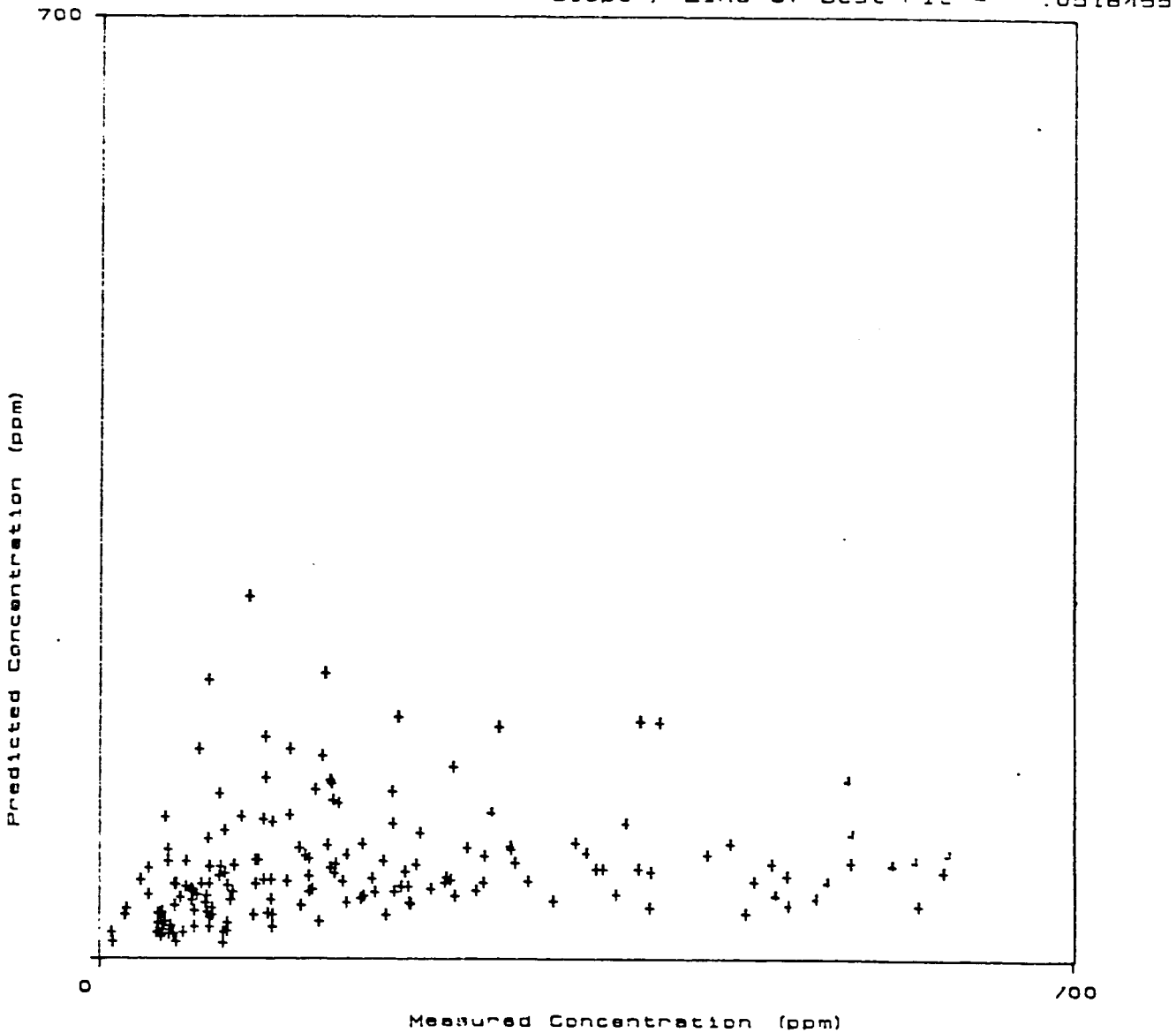
ENGELUND AND HANSEN	Canals Systems
Measured Vs Predicted Concentration	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·22



KARIM AND KENNEDY Measured Vs Predicted Concentration	Canal Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG 6·23

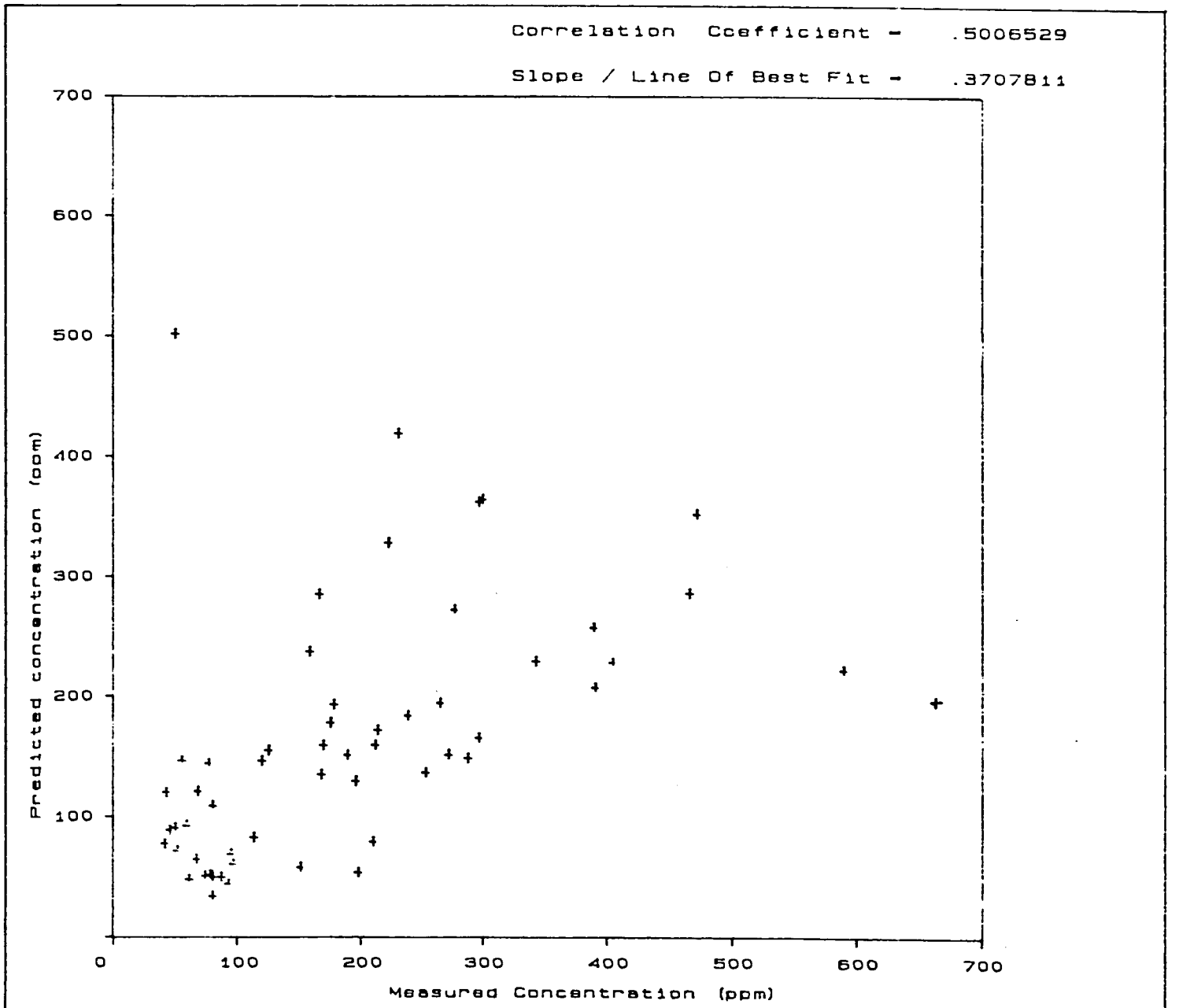


VAN RIJN	Canal Systems
Measured Vs Predicted Concentration	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·24

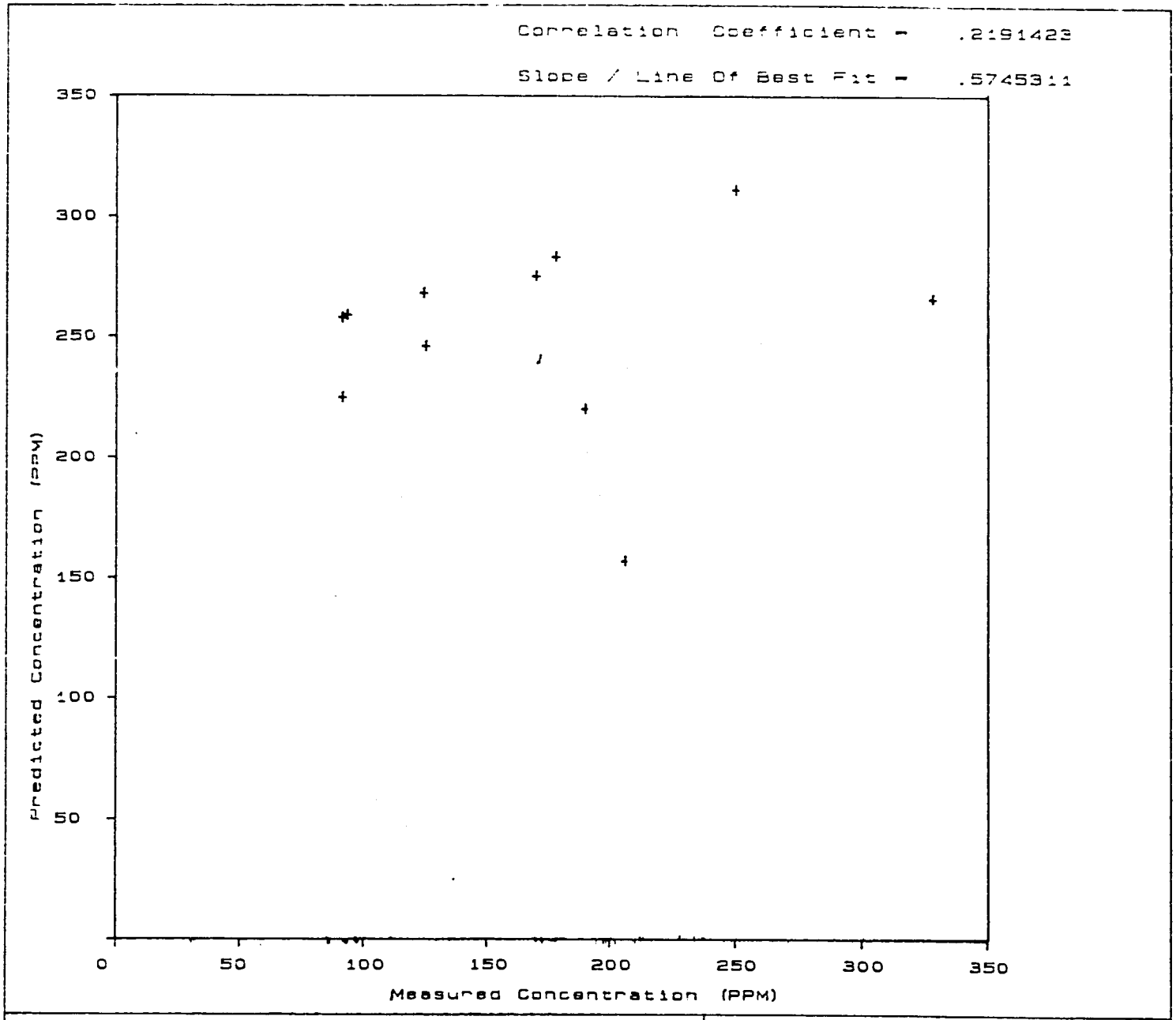


YANG Measured Vs Predicted Concentration	Canals Systems Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·25

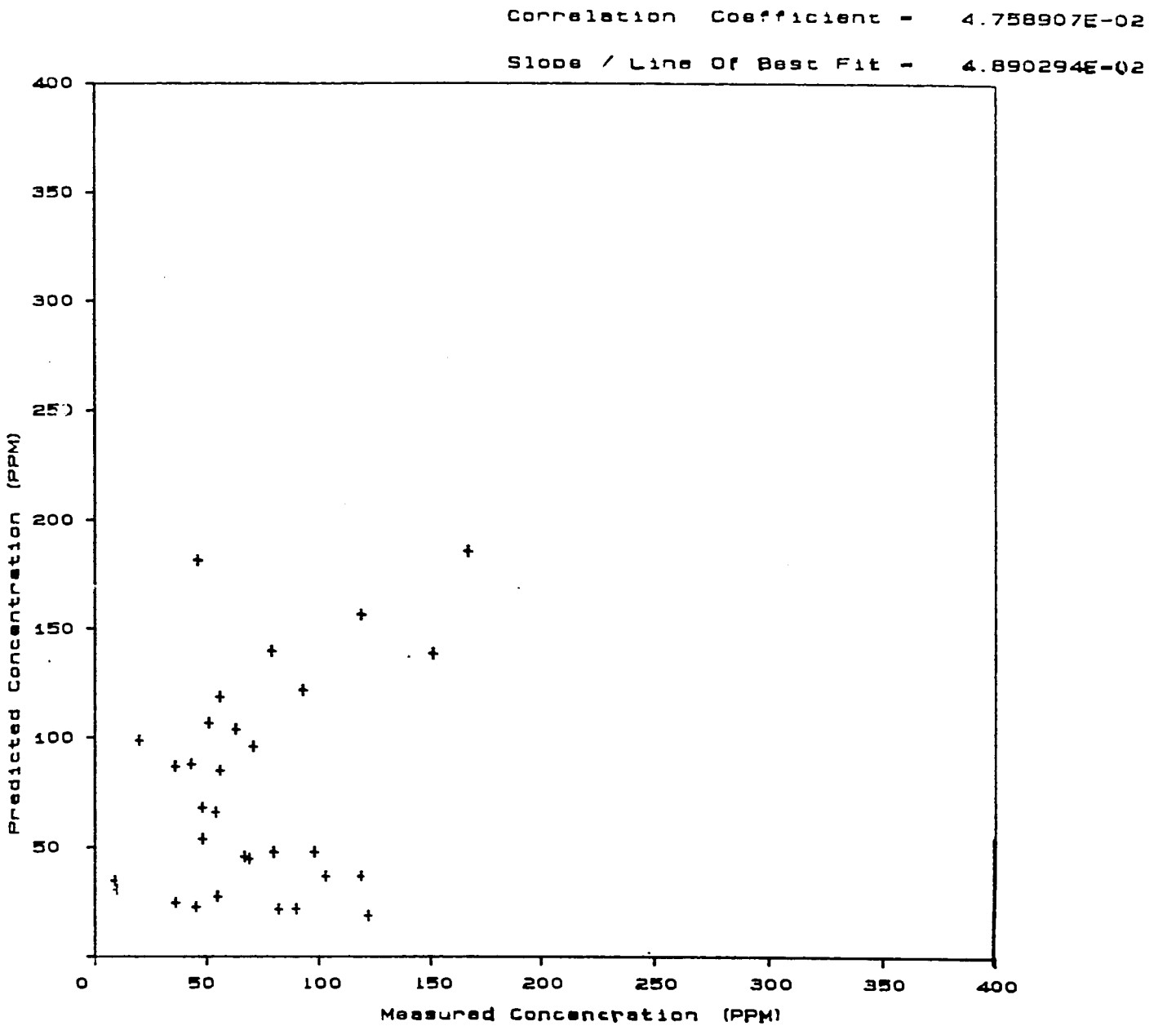
2/2



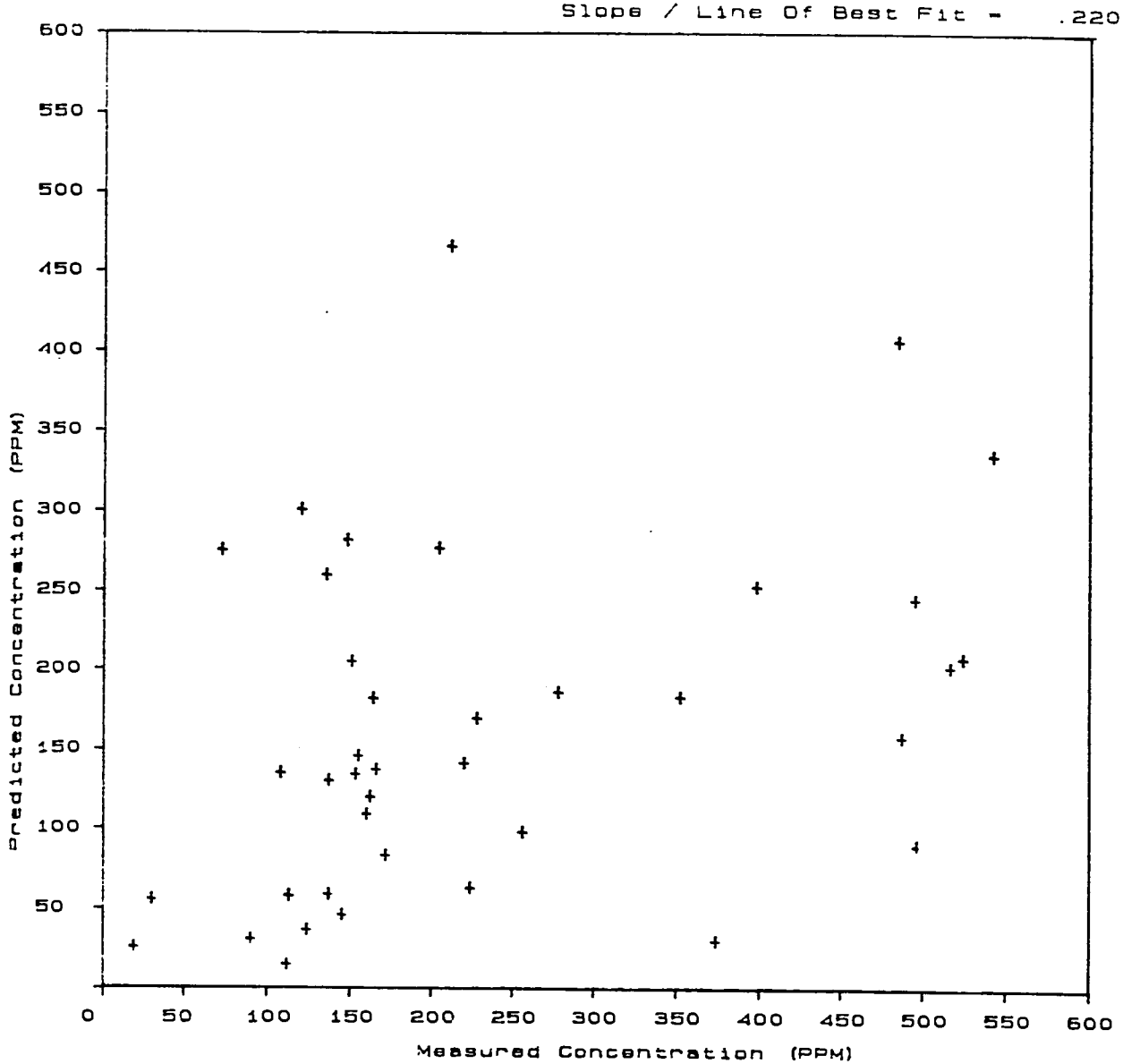
HYDRAULIC DESIGN CRITERIA	Depalpur Canal System
Measured Vs Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·26



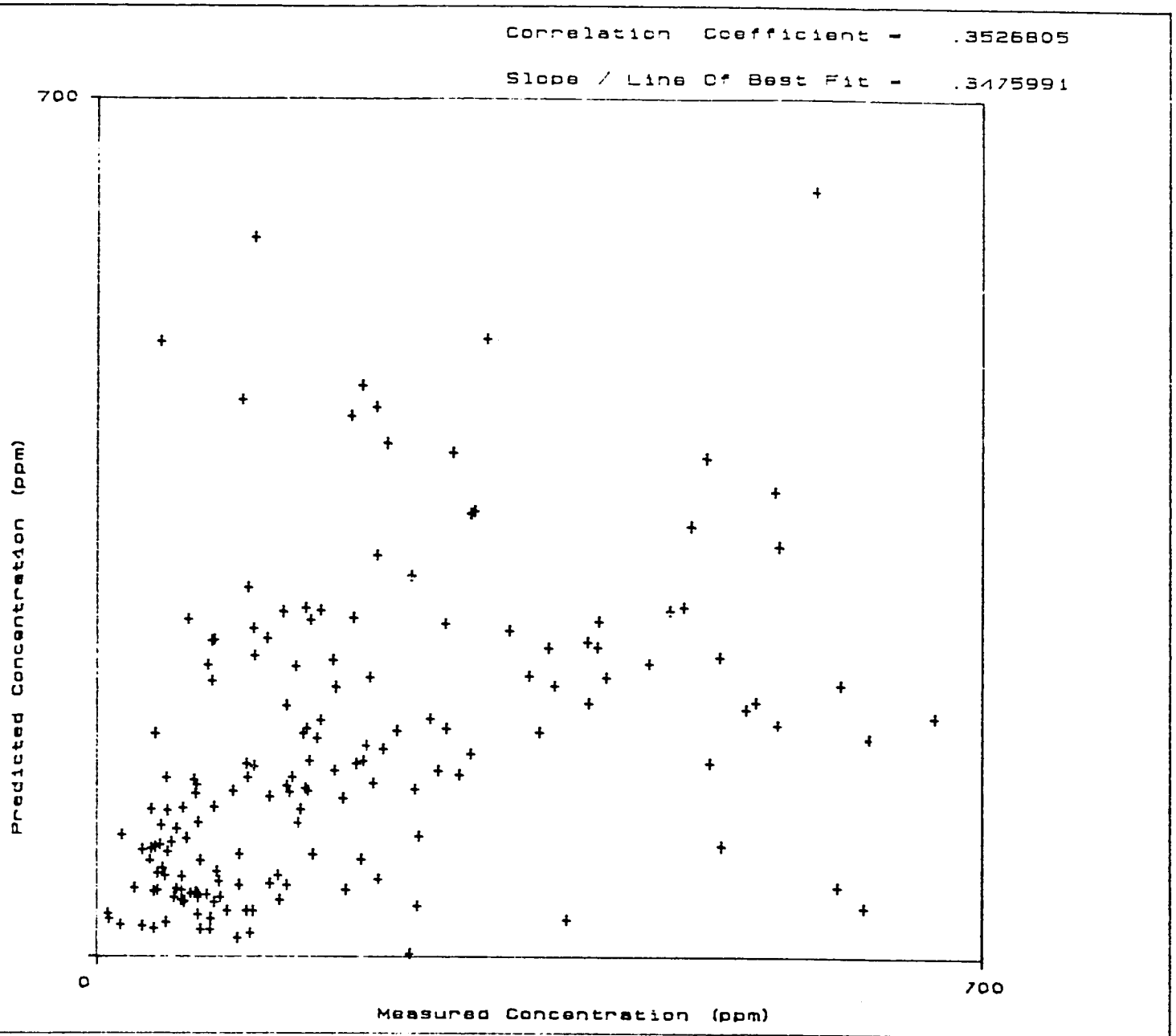
HYDRAULIC DESIGN CRITERIA	Upper Gugera Branch
Measured VS Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHFCCHI	FIG . 6·27



HYDRAULIC DESIGN CRITERIA	Upper Gugera Disties
Measurec VS Predicted Concentration	Punjab Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·28



HYDRAULIC DESIGN CRITERIA	Sind Canal Systems
Measured VS Predicted Concentration	Sind Province
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·29



HYDRA'LIC DESIGN CRITERIA	Canal Systems
Measured Vs Predicted Concentration	Punjab & Sind Provinces
IRRIGATION SYSTEMS MANAGEMENT PRC/CHECCHI	FIG . 6·30