ANALYSIS OF FLOW RESISTANCE IN BRAIDED RIVER - A CASE STUDY

A DISSERTATION

submitted in partial fulfillment of the
requirements for the award of the degree
of
MASTER OF ENGINEERING
in
WATER RESOURCES DEVELOPMENT

By
Christoforus M. T. Lasmono

WATER RESOURCES DEVELOPMENT TRAINING CENTRE
INDIAN INSTITUTE OF TECHNOLOGY, ROORKEE
ROORKEE - 247 667 (INDIA)

DECEMBER, 2001

CANDIDATE'S DECLARATION

I hereby certify that the work which is being presented in the dissertation entitled, " **ANALYSIS OF FLOW RESISTANCE IN BRAIDED RIVER - A CASE STUDY** " in partial fulfillment of the requirement for the award of the Degree of Master of Engineering in WRD (Civil) submitted in the Department of Water Resources Development Training Center, (WRDTC) Indian Institute of Technology Roorkee, is an authentic record of my own work carried out during the period from July 16, 2000 to the date of submission under the supervision of Dr. Nayan Sharma, Professor WRDTC, Indian Institute of Technology Roorkee.

The matter embodied in this dissertation has not been submitted by me for the award of any other degree.

Date : 8th December, 2001

Christoforus M.T Lasmono

This to certify that the above statement made by the candidate is correct to the best of my knowledge.

Dr. Nayan Sharma
Professor WRDTC
Indian Institute of Technology Roorkee
Roorkee – 247667 (U.A.) - India

ACKNOWLEDGEMENTS

It would always be in adequate to express my deep-felt gratitude to Dr. Nayan Sharma, Professor WRDTC, Indian Institute of Technology Roorkee. For constant guidance, help, advice, and genuine encouragement provided during preparation of this dissertation.

I am grateful to Prof. M.K Mittal, Professor Civil Engineering Department, Indian Institute of Technology Roorkee, for their invaluable advice at every stage of the preparation of this dissertation.

I would like to express my heartfelt gratitude to Prof. Devadutta Das, Director, WRDTC, Indian Institute of Technology Roorkee, for unflagging support they have provided. Thanks are due all other faculty members of WRDTC, who have imparted valuable knowledge in their respective fields. I would like to thánk to Mr. M. Abdullah for his support and co-operation. Thanks are also due to all other staffs of the WRDTC and the Indian Institute of Technology Roorkee, for their co-operation in pursuit of my course.

A word of sincere thanks and heartfelt indebtedness should also go to my family – parents, my wife **Ahnes Intan** and my son **Audric** who have constantly prayer, supported and encouraged me in every possible way.

(Christoforus M.T Lasmono)

SYNOPSIS

The problem of predicting the resistance to flow in the rivers is complicated by the configuration of the bed changes in flow condition, and it becomes a very difficult task to describe the resistance due to these bed forms by a constant resistance coefficient. A basic knowledge of these factors would be useful for understanding resistance to flow in the alluvial river. However, a lot of ground is yet to be covered for arriving at a generalization of the variation of roughness in the alluvial rivers.

The shape of the stream in plan is important in many design problems such as location of bridges. An alluvial channel stream seldom runs straight through a distance greater than about ten channel widths. Generally, it contains sinusoidal bends and it is often divided into several channels, which successively meet, and re-divide. Alluvial channels are categorized to possess straight, meandering, and braided pattern.

Generally, braiding is favoured by high-energy fluvial environments with step valley gradient, large and variable discharge, dominant bed load transport, and non-cohesive banks lacking stabilization by vegetation

The present study has been focused on to conduct experiments by constructing a model of the Padma river in the brick masonry (flume) in the River Engineering laboratory of WRDTC and to ascertain a suitable reference (datum) level for the measurement of depth and surface width with the comparative assessment of different alternatives.

A number of hypotheses, conjectures and suggestion are available for the roughness in alluvial river. During the study, the resistance relationships proposed by some investigators are evaluated with the available data from the field and laboratory data. Analysis was then carried out to arrive at the flow resistance model for braided river.

LIST OF SYMBOLS

A	=	cross sectional area of the channel;
B	=	channel width at bank level / over all width;
c	=	characteristic velocity of bed waves; total number entire segments;
C	=	Chezy's constant;
C_1, C_2	=	unknown constants in analytical solution;
d	=	diameter of bed material representative size of sediment;
D	=	mean depth of flow at the cross section, defined by A/W;
d_{50}	=	median grain size of bed material;
d_{65}	=	particle diameter of which 65% by weight are finer;
d_{84}	=	particle size at which 84% of bed material by weight are finer;'
d_p	=	Preston tube diameter;
F_r	=	Froude number of flow;
f	=	Darcy-Weishbach friction factor;
f'	=	friction factor due to bed form resistance;
f''	=	friction factor due to grain resistance;
g	=	acceleration due to gravity;
h	=	elevation above a common datum of water surface at the respective section; any vertical dimension;
h_f	=	head loss;
h_r	=	the boundary layer thickness; roughness height;
h_0	=	steady-state flow depth;
h_v	=	velocity head at respective section;
P#	=	section of Padma river where BWDB measuring cross section and water discharge
k	=	Von Karman's constant, usually equated to 0.40 for clear water;
k_s/d_{65}	=	$(67\ \tau_0/F_r^2)^\alpha$ in fps units and α, is a function of d_{65}
k_s	=	equivalent sand grain roughness of the boundary;
$k(\Delta h_v)$	=	energy loss due to acceleration of velocity or deceleration of velocity

K_u = 6.51 for ripples, 9.64 for dunes and 11.28 for transition regime respectively; coefficient that accounts for intensity of secondary cells; constant;

K_1 , K_2 = function of sediment size;

k_d = roughness height deflected;

K_i = proportionality constant;

L = length of flume or reach / stretch of river

m = k/d_{90};

n = Manning's roughness coefficient ;number of nodes.

P = wetted perimeter; total number of islands bisected by the bounding lines;

P_0 = static pressure head;

P' = density of any fluid;

P_t = total head pressure;

$P_t - P_0$ = differential manometer reading;

Q = discharge in m^3/sec;

q = water discharge per unit width;

Q_t = total discharge of stream'

R = hydraulic radius;

R' = hydraulics radii of the bed corresponding to grain resistances

R" = hydraulics radii of the bed corresponding to form resistances

R_b = hydraulic radius of the bed according to Vanoni-Brooks;

R_e = Reynolds number;

$R\omega$ = particles Reynolds number;

s = mass density of sediment relative to that of fluid;

S_f = slope of energy grade line;

S_0, S = bed slope of channel; water surface slope;

S' = slope due to grain resistance;

S" = slope due to form resistance;

u = velocity at a distance y from the boundary;

U = mean velocity of flow;

U_* = mean shear velocity;

u_* = shear velocity; friction velocity obtained with Clauser's method;

u'_* = shear velocity corresponding to grain roughness;

u_{*c} = critical shear velocity;

U_{cr} = critical average flow velocity at incipient motion;

V = average flow velocity based on continuity principle;

V_* = mean shear velocity in the section;

W = water width of stream channel;

y = depth of flow; distance from boundary

Y_*' = dimensionless shear stress due to grain resistance and bed features,

Y_* = dimensionless shear stress due to resistance on bed;

Y_{*c}' = critical Y_*' for lower limit and upper limit of transition regime, respectively;

y_b = bed-layer thickness;

Y_d = distance from boundary;

y_{top} = elevation of the dune peak relative the mean bed level;

σ = geometric standard deviation of sediment size distribution;

σ_I = σ of initial bed material;

ν = kinematic viscosity ;

δ = normal thickness of the boundary layer;

ω = sediment particle fall velocity in water;

θ = Shields parameter;

γ_s = unit weigth of sediment;

γ = unit weight of fluid;

$\Delta\gamma$ = submerged weight of sediment;

τ = Hydraulic shear stress.

τ_0 = shear stress;

τ_0' = shear stress for grain roughness;

τ_0'' = shear stress for form roughness;

Δh_v = upstream velocity head minus the downstream velocity head;

LIST OF TABLES

LIST OF FIGURES

CONTENT

DESCRIPTION		Page no.

INTRODUCTION

1.1 GENERAL

Alluvial channel may be defined as unconfined channel in alluvial deposits, and are classified as meandering, braided or straight. Straight channel occur when the banks are protected or consist of material, which is much, more erosion resistant than that of bed. Braided channel occurs after local deposition of coarser material that cannot be transported under local condition existing in the reach. This coarse material becomes a nucleus of a bar and subsequently grows into an island made up of coarse as well as fine material.

The problem of resistance to flow in alluvial streams has attracted the attention of hydraulic engineers for a long time in view of its importance in many problems associated with fluvial hydraulics such as design of stable channels, preparation of stage discharge curves, estimation of sediment transport rate etc. This statement implies the serious concern of the hydraulic engineers in the 70's in ascertaining the resistance to flow. However, many researches underwent in the case of sand bed rivers.

Flow resistance described the process by which the physical shape and bed roughness of a channel control depth, width and mean velocity of flow in the channel. The processes are accounted by a flow resistance coefficient. (Bathurst, 1985) The resistance characteristic of rigid boundary channel carrying clear water have been studied extensively and relationship such as Manning's and Chezy's equation are commonly used for these channels. The coefficient to be used in Manning's or Chezy's equations is well established for rigid bed channels. However, lot of uncertainty prevails over the choice of these coefficients for alluvial streams. This is because of two factors. Firstly, the bed of alluvial stream is movable and it can assume various bed configurations under different flow and sediment characteristics. Secondly, the presence of suspended load also modifies the flow and flood characteristics in alluvial streams. These factors have so far prevented the hydraulic engineer from obtaining an accurate relationship for the resistance of movable bed channels.

1.2 CHRACTERISTIC FEATURE OF BRAIDED RIVERS.

A braided river are characterized by having a number of alluvial channels with bars and islands between meeting and dividing again, and presenting form the air the intertwining effect of a braid (Lane 1957). Lane also used the term multiple channel stream to include both braided stream as defined above and anastomosing distributaries on deltas and alluvial fans. Leopold and Wolman (1957) defined a braided river as ' one which flows in two or more anastomosing channels around alluvial island. Schumm (1977) defined braided channels as single - channels bed load rivers, which at low water have islands of sediment or relatively permanent vegetated island, in contrast to multiple channels rivers (anastomosing or distributive) in which each branch may have its own individual pattern.

Braided channel pattern in alluvial systems reflected particular environmental conditions, and is no longer considered to represent disequilibria in aggrading systems. Braided streams are associated with high stream power and unstable sediments, often un-vegetated. Braiding is the division of a single channel into two or more anastomising channel ways. Actually, meandering starts with local bank erosion and then deposition, perhaps braiding begins in the same way. Braided rivers may be envisaged as a series of channel segments, which divide and rejoin around bars in a regular or repeatable pattern. Generally, braiding is favoured by high-energy fluvial environments with steep valley gradients, large and variable discharges, dominant bed load transport, and non-cohesive banks lacking stabilization by vegetation (Richards, 1982). The resultant wide, shallow cross-sections develop secondary circulation with multiple cells and bar formation occur where flow converges at the bed.

Braids may develop locally where chance bar emplacement or channel widening occurs. A braided stream is characterized by the general instability of the bars and channel ways and by caving of the channel walls.

Measures of degree of braiding (see table 1) generally fall into two categories; those that consider the mean number of active channels or braid bars per transect across the channel belt, and those that consider the ratio of the sum of channel lengths in a reach to a measure of reach length. The first type of braiding index is more desirable for two main reasons. First, it is related to the 'mode' of alternate bars. In order to express the degree of braiding of terms of 'mode' it is necessary to count point (side) bars as well as braid bars. Secondly, the total sinuosity is combined measure of channel segment sinuosity and degree of braiding. Thus, braided rivers with relatively large numbers of channel segments of low sinuosity can have a similar total sinuosity to those with fewer, higher sinuosity channel segment.

Table 1. Braiding indices

Author	Braiding index
Brice (1960, 1964)	$\frac{\text{2(sum of length of bars or island in a reach)}}{\text{Centerline reach length}}$
Howard, Keetch & Vincent (1970)	Average number of anabranches bisected by several transects perpendicular to flow direction
Engelund & Skovgard (1973) Parker (1976), Fujita (1989)	Mode = number of rows of alternate bars (and sinuosity flow pats) = 2 times the number of braid bars and number of side (point) bars per transect
Rust (1978)	Number of braids per mean curved channel wavelength = mode –1 (see above)
Hong & Davies (1979)	Total Sinuosity = $\frac{\text{Length of channels segments}}{\text{Channel belt length}}$ Number of braids or channel in cross-section
Mosley (1981)	Braiding index = $\frac{\text{Total length of bank full channels}}{\text{Distance along main channel}}$
Richards (1982), Robertson-Rintoul & Richards	Total sinuosity = $\frac{\text{Total active channels length}}{\text{Valley length}}$
Ashmore (1991)	Mean number of active channels per transect

	Mean number of active channel links in braided network
Friend & sinha (1993)	Braid Channel Ratio = $\frac{\text{Sum of mid-channel length of all channels in reach}}{\text{Length of mid-line of widest channel}}$

It is commonly held that channel geometry of alluvial rivers is dominated by flow and sedimentary processes operating over a range of high discharge. At seasonally low flows, sediment transport rates are relatively diminished and modification on the high stage adjusted channel is expected to be minimal. However, the increases in discharge, width/depth, and sediment transport associated with exceptional flood may precipitate a major degree of braiding (Schumm & Lichty, 1963). Discrimination between unbraided and braided rivers of the form $S = aQ^{-b}$ has been interpreted to represent a constant value of hydraulic property at the channel pattern thresholds. (See table 2)

Table 2 Hydraulic control of braided channel pattern: Discharge, Slope and Bed material.

Equation	Comments	Author
$S = 0.0007Qm^{-0.25}$	Meandering sand-bed channel	Lane (1957)
$S = 0.0041Qm^{-0.25}$	Braided sand-bed channel	
$S = 0.0125Qm^{-0.44}$	Meandering - Braided	Leopold &Wolman (1957)
$S = 0.000196D^{1.14}Q_{bf}{}^{0.44}$	Meandering - Braided	Henderson (1961, 1966)
$S = 1.4Q_{maf}{}^{-1}$	Meandering - Braided	Antropovsky (1972)
$S = 0.0009Q_{m}{}^{-0.25}$	Mainly meandering sand bed rivers in Kansas	Osterkamp (1978)
$S = 0.0017Q_{m}{}^{-0.25}$	Braided sand bed rivers in Kansas	
$S = aQ_{m}{}^{-0.23}$	Meandering – Braided	
$S = 0.0016Q_{m}{}^{-0.33}$	Meandering – Braided	Begin (1981)
$S = 0.07Q_{zf}{}^{-0.44}$	Sinuosity > 1.25 and meandering-Braided for gravel	Bray (1982)

	bed rivers	
$S = 0.042Q^{-0.49}D_{50}{}^{0.09}$	Meandering-braided for gravel bed Rivers	Ferguson (1984, 1987)
$S = 0.042Q^{-0.49}D_{90}{}^{0.27}$		
$S = 0.0049Q^{-0.21}D_{50}{}^{0.52}$	Meandering-braided using Parker's theory and hydraulic geometry	
$S \approx aQ^{-0.5}D^{0.5}$	Meandering - braided	Chang

1.3 OBJECTIVE OF THE STUDY

Study of the interaction between channel geometry, flow and sediment transport over a large discharge range for braided rivers are rare. It is also realized that available specific equations for the prediction of resistance equation in the braided rivers have limited applicability for several reason, such as small data base being used in all studies, lack of the consideration of the entire range of the flow condition and effect of the channel geometry. Unlike rigid boundary, which has been researched extensively over the last 35 years (e.g. Sellin, 1964; Knight and Demetriou, 1983; Knight and Shiono, 1996), mobile bed channels have received relatively little attention, despite their relevance to practical river engineering problems such as river training and morphology, sediment transport, dredging and design of flood alleviation works. With the above-mentioned information in view, the present study is mainly intended with the following objectives:

1. To review available published flow resistance equations in the alluvial stream
2. To analyse model equation proposed by, Limerinos, White – Collebrook, Leopold – Wolman & Miller,
3. To undertake physical flow simulation in a braided stream reach of an actual river and to compare the roughness coefficient from the

field and model simulation with some equations. (Field data from Padma river in Bangladesh are proposed to be used for the purpose)

1.4 Limitations of the Study

1. The experiment has done to collect hydraulic data of the model experiment such as top of water width, depth of channel, water discharge. Other parameters such as formation of bar, sinuosity, or meandering index are not considered.
2. Effect of sediment transport in the flow resistance is not considered during the study.

THEORETICAL CONCEPTS

2.1 GENERAL

There is a need to predict flow in un-gauged rivers and to estimate water depth and velocities. However, estimation methods may produce large errors especially where water depth is small relative to grain size. The traditional use of these methods has been prediction of flood levels in large rivers, or the flow in hydropower or irrigation canals. Today flow estimates for smaller and shallower rivers are needed for ecological assessment and stream restoration. Many of the traditional method were not developed for use in such conditions.

Where channel bed and banks are uniform, channels are wide and straight, there are no bed forms, no sediment movement or bank side vegetation, the flow resistance can confidently be predicted. For canals and larger river without over-bank flows, good estimate can usually be made. There is less confidence if there are significant over-bank flows. Flow resistance estimation for flood plains is very difficult because of the variation in the "bed" e.g. short grass, dense dwellings, and so on. There is low confidence in predicting velocities and depth for stream with low water depth to grain size ratios for these conditions there is much condition as the datum which water depth should be measured.

Factors affecting Flow resistance:

- Grain size; In alluvial streams where the material is fine, such as sand, clay, loam, or silt, the retarding effect is much less than where the material is coarse, such as gravels or boulder. When the material is fine, the value of n is low and relatively is unaffected by the change in flow stage. When the material consists of gravels and boulders, the value of n is generally high, particularly at low or high stage.

- Bed form such as ripples, dunes, bars, pools and riffles (bars have been shown to increase a resistance coefficient by 50% - 75%); In natural channels, such irregularities are usually introduced by the presence of ripples, dunes, bars, pools and riffles. These irregularities definitely introduce roughness in addition to that caused by surface roughness and other factors.
- River sinuosity; Smooth curvature with large radius will give a relatively low value of n, whereas sharp curvature with severe meandering will increase n. Based on flume test, Scobey suggested that the value of n be increased 0.001 for each 20 *degree of curvature in 100 ft of channels.*
- Sediment transport (sediment normally increases flow resistance, but when fine sediment covers a normally rough bed it may reduce the resistance coefficient by 50%-70%); the suspended material and the bed load, whether moving or not moving, would consume energy and cause head loss or increase the apparent channel roughness.
- Cross-section shape, the channel aspect ratio (width : depth) and ratio of bank roughness have a strong influence on overall flow resistance; There is no definite evidence about the size and shape of channel as an important factor affecting the values of n. An increase in hydraulic radius may either increase or decrease n, depending on the condition of the channel.
- Vegetation (encroaching vegetation increase flow resistance, especially if the section is less than 50 meters wide); Vegetation may be regarded as a kind of surface roughness, but it also markedly reduce the capacity of the channel and retards the flow. This effect depends mainly on height, density, distribution, and type of vegetation and its very important in designing small drainage channels.

2.2 THEORETICAL CONSIDERATION

2.2.1 Mixing Length Hypothesis

Prandtl (1904) considered mixing length l as the transverse distance between two layers such that the lump of fluid particles moving from one layer could reach the other layer and be embedded into it, thus retaining their momentum in the horizontal direction during their travel through the distance.

Prandtl (1904) further hypothesized that the fluctuating *velocity u' between the two layers has the same magnitude as* the difference in the time average velocities between the two layers.

Thus,

$$u' = l \frac{d\ U}{dy} \qquad (2.2.1)$$

Prandtl (1904) further assumed that v' is proportional to u' and thus

$$u'\,v' = -1^2\ \overline{\frac{du}{dy}} \qquad (2.2.2)$$

In turbulent flow, the total shear stress at any point is the sum of the viscous shear and the turbulent shear can be written as:

$$\bar{\tau} = \mu\ \overline{\frac{du}{dy}} + \rho\left(\frac{du}{dy}\right)^2 \qquad (2.2.3)$$

The viscous shear part is negligible small except near the boundary and therefore the shear is assumed to be due to turbulence alone.

Similar to the expression for the viscous shear, the turbulent shear can be expressed by Boussinesq (1877) as:

$$\bar{\tau} = \eta \frac{\overline{du}}{dy} \qquad (2.2.5)$$

Where u, τ, η, are the average velocity, shear stress and the eddy viscosity respectively. Since the dynamic viscosity μ depends upon the fluid property alone, the eddy viscosity depends upon the fluid as well as the flow characteristics.

Comparing and equating.

$$\eta = \rho l^2 \frac{\overline{du}}{dy} \qquad (2.2.6)$$

2.2.2 Boundary Layer Theory

The boundary layer theory is the key basis of understanding of flow resistance in the open channel flow. The Task Force (ASCE, 1963) states that "The present understanding of frictional resistance in open channel stems largely from the studies of boundary layer theory. It appears at this time that any advances in understanding will also come through the concept related to the boundary layer theory." The shear layer created in the open channel due to the friction at the boundary has similarity with boundary layer in the pipe flow. Although there are sufficient differences between the natural channel flows and simple boundary layer, these can be applied to the open channel condition also with some modifications. The success of the application of the boundary layer is satisfactory in idealized channels that are straight and uniform. But natural channels exhibit a variety of features-in boundary texture, in cross-sectional shape and in plan form. These make the evaluation of flow resistance truly complicated. However, the estimation of flow can well be relied upon this theory. For high velocity flow, provided the flow does not separate away from the boundary, the retardation of the fluid due to viscosity is limited to a thin layer near the boundary-giving rise to the frictional resistance to the flow. This is commonly known as the Boundary Layer. In the vicinity of the boundary, the velocity gradient is very large and hence even the fluid has small viscosity, the corresponding shear stress is of appreciable magnitude.

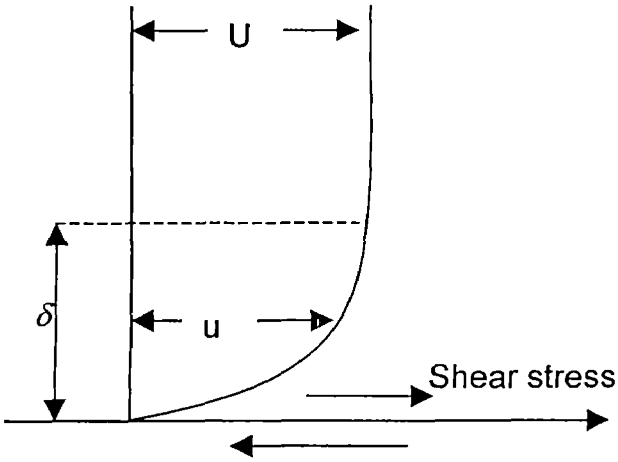


Fig. 2.1 Development of boundary layer theory
(Source; "Elementary fluid mechanics" by Garde and Mirajgaonkar)

Farther away from the wall, the velocity will be necessarily higher and as such:

$$\tau_o = \mu \left(\frac{\partial u}{\partial y} \right)_{y=o} \tag{2.2.7}$$

As a result, the fluid exerts a shear or tangential stress on the wall in the direction of motion. The force caused by this stress in the direction of motion is known as surface drag. The wall in turn exerts a force on the fluid which is equal in magnitude and opposite in direction giving rise to frictional resistance to flow thereby resulting in the retardation of flow near the boundary. Farther away from the boundary, this retardation due to the presence of the viscosity is negligible.

2.2.3 Concept of Surface Roughness

The effective height of the irregularities forming the roughness elements is called the roughness height k. The ratio of the roughness height, k to the hydraulic radius R is known as the relative roughness. As the velocity close to the channel surface is low, a very thin film of flow, i.e. laminar sub-layer will be developed on the surface.

The proper classification f the hydraulically smooth and rough condition will be obtained based on the comparative situation of the height of the roughness elements and the thickness of the laminar sub-layer. Within the laminar sub-layer, the flow will be kept laminar. A refined concept of laminar sub-layer will consider that there exists in the sub-layer a small amount of eddy, which decreases rapidly to zero at the boundary surface. Schilichting (1955) gave the critical height of the roughness element based on the following formula.

$$\frac{u_* \, k}{v} \leq 5 \qquad (2.2.8)$$

Where u* is the shear velocity, k is the height of roughness element and v is kinematic viscosity.

Also as,

$$u_* = \sqrt{gRS} \qquad (2.2.9)$$

In eq. (2.2.9) R is the hydraulic radius and S is the slope of the water surface.

The critical roughness height k_c is given by

$$K_c = \frac{5\,C}{\sqrt{g}} \frac{v}{U} \qquad (2.2.10)$$

Where C is Chezy's coefficient, v is the kinematic viscosity and U is the mean velocity if the roughness height is greater than the critical value defined by equation (2.2.10). The roughness elements will have sufficient magnitude and angularity to extend their effect beyond the laminar sub-layer and thus to disturb the flow in the channel. The surface will thus be termed as rough. In rough channels, the velocity distribution will depend on the form and size of the roughness projections and a stable laminar sub-layer can no longer be formed.

The roughness height is merely a measure of the linear dimension of the roughness elements but is not necessarily equal to the actual or even an average height. In addition, the position from which the roughness height should be measured is a disputable matter. However, it is assumed that k is *measured from a datum that lies at a distance of 0.5 k below* the average bottom of the channel. (Chow, 1973).

2.2.4 Drag Force and The Resistance

If a body is placed in a fluid flowing at uniform velocity past it, it will experience a force in the direction of flow, which is termed as drag force. The total drag on the body is the sum of the (a) Deformation drag (b) Friction drag and (c) Form drag.

Deformation drag is due to wide spread deformation in flow and occurs only at low Reynolds number. Friction drag is the component of the tangential force in the flow direction due to the velocity gradient near the boundary and is proportional to the viscosity of the fluid i.e. it is a function of Reynolds number. Form drag is the result of separation of flow, which occurs in the case of bluff bodies even at moderate Reynolds number. As a consequence of separation, the pressure at the rear of the body is less than the pressure at the front and the difference in the pressure is equal to the form drag. In the case of the large-scale roughness where the Reynolds number exceeds 10^4, the entire drag will be the form drag and theoretical quantification of form drag will be difficult. (NM.kaka, 1974)

In addition, the estimation of frictional resistance through the theoretical approach is complicated because of the presence of separation zone and the ill-defined characteristics of the redeveloping boundary layer.

Due to the drag force acted upon the roughness elements, it exerts a force equal in magnitude but opposite in direction, which is known as resistance. The total resistance to flow in an open channel with artificial roughness elements on the bed is the sum of the frictional resistance on the plane boundary, the form resistance of the roughness elements and the resistance due to water surface waves.

The wave resistance in an open channel is a function of the Froude number of flow.

2.2.5 Velocity Distribution in Turbulent Boundary layers

The velocity distribution in a uniform channel flow will become stable when the turbulent boundary layer is fully developed. It is said to occur at Reynolds number 5×10^5 (Garde, 1983). On the turbulent boundary layer, the distribution can be shown approximately logarithmic. It may however be represented by power law also as:

$$(u/U) = (y/\delta)^m \qquad (2.2.11)$$

where u and U are the point velocity at a vertical distance from the datum and δ is the thickness of the boundary layer where the velocity is nearly equal to the ambient or free stream velocity.

Based on the mixing length hypothesis, and assuming the shear stress within the boundary layer to be constant and the value being equal to that on the bed Prandtl (1904) proposed the velocity distribution as:

$$u = 2.5\sqrt{\frac{\tau_o}{\rho}} \ln \frac{y}{y_o} \qquad (2.2.12)$$

or,

$$u = 2.5u_{*} \ln \frac{y}{y_o} \qquad (2.2.13)$$

This is known as Prandtl Von-Karman universal velocity distribution law. It is also expressed as:

$$\frac{u}{u_{*}} \quad \frac{1}{k} \ln \frac{y}{y_o} \qquad (2.2.14)$$

Where,

k is Von-Karman constant = 0.4

y_o is arbitrary roughness height

u is the velocity at a height y from the boundary

Changing the logarithm to the base 10, the equation can be written as

$$\frac{u}{u_{*}} = \frac{2.303}{k} \log_{10} \frac{y}{y_0} \qquad (2.2.15)$$

This equation is also known as the logarithmic law of the wall. The turbulent boundary layer is believed to consist of two principal regions namely the inner region and the outer region. In the inner region, nature of the wall is important in determining the form of the velocity profile. It is only in this layer that the bed shearing stress remains constant and equal to the mean boundary shear stress. The law applies to y/d<0.15 to rough and smooth boundaries. In the remaining outer layer, the profiles diverse from semi logarithmic depend on an undefined manner. The degree of divergence is independent of the boundary conditions and varies instead with the type of flow (boundary layer, pipe or free surface flow), the pressure gradient and secondary circulation. (Bathurst, 1982-b).

The outer region extends inward from the edge of the boundary layer until viscosity becomes important and overlaps the inner region except for the smaller Reynolds number usually encountered in practice. (For smaller Reynolds numbers, there may be no overlap). As consequences, the mathematical formulation of the velocity distribution in the overlap region of the boundary layer must be either of the logarithmic or the power law form. The logarithmic form has obtained considerable popular support because it fits experimental data over a wide range of Reynolds number and with the roughness. In addition, the power law formulation does not take into account the mixing length parameter or mixing co-efficient.

From the above discussions, a resistance law for boundary layer over rough surfaces can be given as:

$$\left(\frac{8}{f}\right)^{1/2} = \frac{\bar{u}}{u_*} = \frac{2.303}{k}\log\frac{d}{k_s} + C1 - C2 - \frac{\Delta}{d} \qquad (2.2.16)$$

Where k_s = the equivalent uniform sand roughness height of the boundary roughness, f is the Darcy-Weisbach friction factor, C_1 is a constant for fully developed roughness flow. C_2 is the divergence of the outer layer of the velocity profile from the semi logarithmic dependency at the edge of the boundary layer and Δ is clauser defect thickness, which relates the mean and the free stream or surface velocities.

The above equation applies to boundary layer where:

(I) The flow is turbulent and the Shear Reynolds number u^*d/v exceed about 2000.

(II) The flow is two-dimensional

(III) The boundary to the flow is longitudinally uniform and

(IV) The top of the layer is not a free surface. (Bathurst, 1982-b)

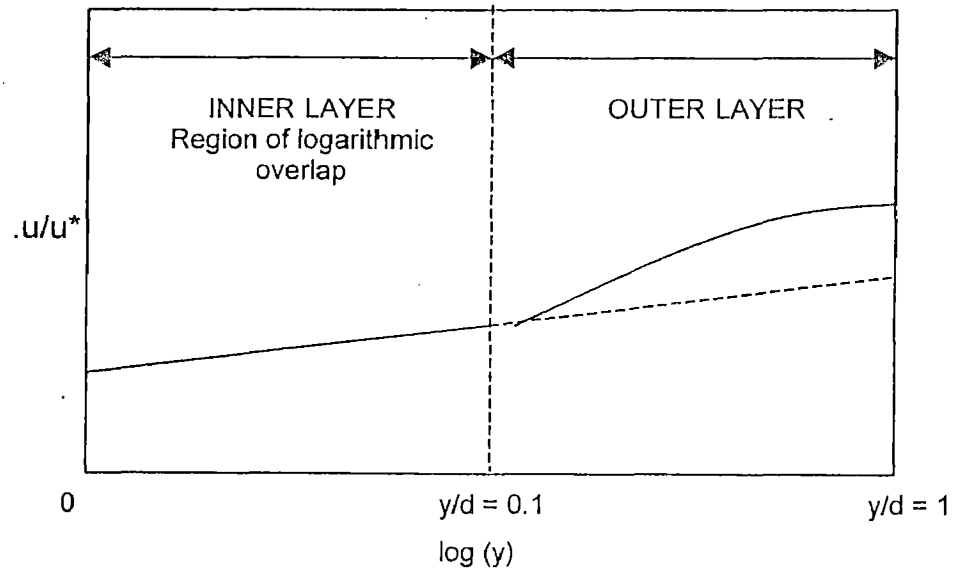


Fig. 2.2 Idealized velocity profile in a simple two dimensional boundary layer over a rough surface

(Source; "Gravel bed river" edited by Hey, Bathurst, Thorne 1982)

In addition, the terms concerning boundary roughness have generally been derived from studies with closely packed, uniform roughness elements or with a regular spatial distribution of elements that can be defined by the single length scale K_s.

The application of aforesaid equation is not valid in open channels as the assumption laid for the equation is not fully satisfied in natural channels because of the presence of 3 dimensional effects channel shape and plan form.

(1) the longitudinal variation in plan form and

(2) The presence of free surface.

These factors contribute in affecting the outer layer of the velocity profile and so far the researches have undergone on the resistance of bed material which has its main effect on the inner layer. Also the theoretical quantification of the co-efficient/terms C_1, C_2 has not been achieved. These are therefore evaluated only empirically.

The channel resistance depends on the alteration of the divergence of the outer velocity profile from the base value C_2 and on the creation of laterally non-uniform distribution.

2.2.6 Longitudinal Non Uniform Flow

Even with a uniform channel profile, there can be longitudinal non-uniformity of flow such as acceleration and deceleration, which alter the shape of the velocity profile. The non-uniformity is apparent in the change of water surface slope S_w, so the profile shape can be quantified as some function of the quantity B – where

$$B = (g\ R\ S_w)/\ \tau o$$

Here, B equals unity for uniform flow.

Bathurst (1982-b) quoting Finley's unpublished data stated that the measurement of velocity profiles over smooth, non-uniform bed at supercritical flow with Froude number equal to or greater than 4 revealed that as B increases or the flow becomes more accelerative, divergence of velocity profile gradually decreases. Similar is the case with the deeper sub-critical flows. It is not certain that the findings can be applied to riffle sequences has a much greater effect on depth and velocity than the changes in water surface slope over a uniform bed profile. Consequently, in natural channels, it is likely that the effect of non-uniform flow described by the function of B is relatively small.

2.3 Existing relationship

By understanding, the condition under which the various equations were developed and comparing them to conditions of the channel for which a value is required it may become apparent that some methods may be more appropriate than others. Many equation have been developed under some conditions such as uniform flow, straight rectangular or trapezoidal channels, fully developed turbulent flow, negligible sediment transport, low bank roughness, large H/d, which implies deep water and/or small grain size and shallow slopes.

2.3.1 Regime Equation

Regime equations calculate velocities or flow from channel dimensions and slope without an explicit resistance parameter. They are usually non dimensionless, i.e. the coefficient depend on the measurement system used. The following regime equations are given in S.I units and predicted flow (Q) directly using channel slope (S), hydraulic radius (R) and cross section area (A).

Lacey's (1946) equation was derived for the channel forming discharge of regime channels in relatively fine sediment. They should be most appropriate for relatively high in-bank flows.

$$Q = 10.8\,AR^{2/3}S^{1/3} \qquad \text{(SI units)} \qquad (2.3.1)$$

2.3.2 Resistance Coefficient

During the past two hundred years several formulae have been suggested for channel resistance in steady uniform flows. As early as 1769 the French engineer Antoine Chezy was developing probably the first uniform flow formula, which is usually expressed as follows:

$$U = C\sqrt{RS} \qquad (2.3.2)$$

Where U is the mean velocity, R is the hydraulic radius, S is the slope of the energy line, and C is a factor of flow resistance, called

Chezy's C. Three important formula for determination of Chezy's C are given below:

a. The G. K. Formula. Gangguillet and Kutter published a formula expressing the value of C in terms of the slope S, hydraulic radius R, and the coefficient of roughness n, in the English units, the formula is

$$C = \frac{41.65 + \dfrac{0.00281}{S} + \dfrac{1.811}{n}}{1 + \left(41.65 + \dfrac{0.00281}{S}\right)\dfrac{n}{\sqrt{R}}} \qquad (2.3.3)$$

b. The Bazin formula. H Bazin proposed a formula according to which Chezy's C is considered a function of R but not of S. Expressed in English units, this formula is

$$C = \frac{157.6}{1 + m/\sqrt{R}} \qquad (2.3.4)$$

c. The Powell Formula, Powell suggested a logarithmic formula for the roughness of the artificial channels. This formula, an implicit function of C, is

$$C = -42 \log\left(\frac{C}{4R}\right) + \frac{\varepsilon}{R} \qquad (2.3.5)$$

In 1889, the Irish engineer Robert Manning presented a formula, which was later modified to its present well-known form

$$U = \frac{1}{n} R^{2/3} S^{1/2} \qquad (2.3.6)$$

Where U is the mean velocity in m/s, R is the hydraulic radius in m, S is the slope of energy line, and n is the coefficient of roughness, specially known as Manning's n.

For better understanding of the problem in resistance to flow first we must understand about velocity distribution of the flow. The velocity distribution law for turbulent flow past a smooth a rough boundary, which can be derived from the equation of shear stress in turbulent flows, is

$$\frac{U}{U_*} = \frac{1}{K}\ln\left(\frac{y}{y'}\right) \qquad (2.3.7)$$

Where U is the velocity at distance y from the boundary, K is the Karman constant, u* is the shear velocity = $\sqrt{\tau_0/\rho_f}$ and y' is the distance such that u = 0 at y = y'. For hydro dynamically, smooth and rough boundaries in equations (2.3.7) one gets the well-known Prandtl-Karman velocity distribution equation, viz.

$$\frac{U}{U_*} = 5.75\log\left(\frac{U_* y}{v}\right) + 5.5 \text{ for smooth boundaries} \qquad (2.3.8)$$

And $$\frac{U}{U_*} = 5.75\log\left(\frac{y}{K_s}\right) + 8.5 \text{ for rough boundaries} \qquad (2.3.9)$$

where K_s is the equivalent sandgrain roughness of the boundary. Keulegan obtained the following logarithmic resistance laws

$$\frac{U}{U_*} = 5.75\log\left(\frac{u_* R}{v}\right) + 3.25 \quad \text{for smooth boundaries} \qquad (2.3.10)$$

$$\frac{U}{U_*} = 5.75\log\left(\frac{R}{K_s}\right) + 6.25 \quad \text{for rough boundaries} \qquad (2.3.11)$$

By comparing Chezy's equation with Manning's equation, the following dimensionless relationship can be obtained:

$$\frac{U}{U_*} = \frac{C}{\sqrt{g}} = \frac{R^{1/6}}{n\sqrt{g}} \qquad (2.3.12)$$

The above equations, shows that Chezy's and Manning's equations can be dependable only when viscous effects are negligible or when the boundary is hydro dynamically rough.

Strickler (1923) and Keulegan (1938) presented techniques for estimating flow resistance based on bed particle size:

$$n = 0.039\, d_{50}^{1/6} \qquad \text{(S.I unit) (2.3.13)}$$

$$n = 0.035\, d_{90}^{1/6} \qquad \text{(S.I unit) (2.3.14)}$$

These techniques provide reasonable estimates of roughness in relatively low gradient streams with sediment of gravel size or smaller and where bed material is the primary source of resistance to flow. Equation such as this does not account for the resistance of bed forms if they exist in the channel. In steeper mountain streams with high relative roughness, these equations are often inaccurate and underestimate.

2.3.3 Friction Factor Equations

This equation is based on evaluating the Darcy-Weisbach friction factor *f, which* is then used to calculate velocity.

$$V = \sqrt{\frac{8\,gRS}{f}} \qquad (2.3.15)$$

Most equation relates the friction factor to channel dimension(s) and grain size. Where comparisons between measured and predicted friction factors have been made, many investigations show reaches where the friction factor is more than 25% in error. This investigation would be more representative if measured velocities were compared with those predicted using the friction factor formula because the friction factor is not measured directly and spurious correlation could be introduced.

2.4 HYDRAULICS OF FLOW IN ALLUVIAL RIVER

2.4.1 Nature of Bed Material

The nature of the bed material has a considerable influence on the hydraulics of alluvial streams. The size distribution of the material at a station as well as the variation in size and character along the length are important from a geomorphologic viewpoint.

2.4.1.1 Size Distribution

Bed material characteristics are generally expressed in terms of the median size and standard deviation. Sediment sampled at one station is often found to follow a lognormal distribution. From analysis of data, for natural sediments from alluvial streams bed the geometric standard deviation σ_g increases with increase in sediment size. Similarly, Kramer Uniformity coefficient M can be correlated with σ_g as shown in fig.2.3 Swamee and Ojha found that equation (Garde – Ranga Raju, 2000)

$$M = (0.1769.\ln.\sigma_g + 1.0)^{-10} \qquad (2.4.1)$$

fits the data in fig 2.3 well and satisfies the boundary condition that M = 1.0 when σ_g = 1.0. Information from this figure should be useful in selection of bed material for movable bed models

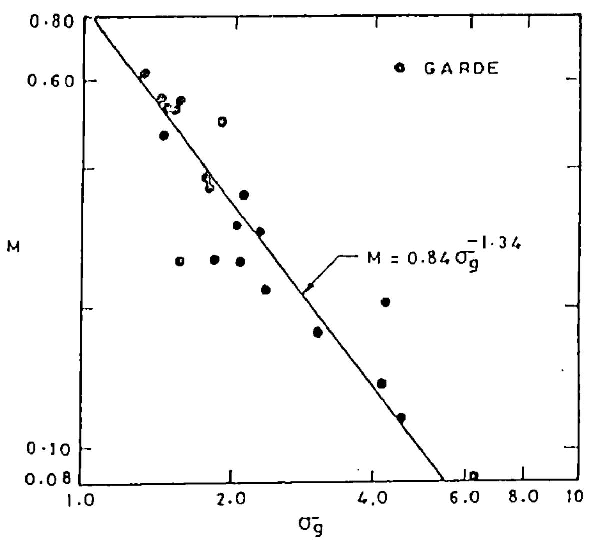


Fig. 2.3 Variation of M with σ_g

(Source; Mechanich of sediment transportation and aluuvial stream problem, R.J Garde & K.G Ranga Raju)

2.4.1.2 Variation of Sediment Size Along the Length of The Stream

The median size of the bed material in a natural stream is found to decrease continually along the length of the stream. This reduction is partly due to sorting action and partly due to abrasion.

As the stream comes down from mountainous regions to the plains, the slope decreases and the stream width increase gradually. Such a decrease in slope reduces the capacity of the stream to transport the coarser particle brought from upstream and the coarser particles are thus deposited on the stream bed. Sorting takes place depending on the variation of sediment transport capacity along the length of the stream. Abrasion is the reduction in the size of particles due to rubbing, grinding and crushing of the sediment particles against each other or against the bed. It is evident that if abrasion has to be major factor in reducing the sediment size, majority of the transported material must travel along or near the bottom, i.e. as bed load. On the other hand, sorting can be the more important factor in the reduction of sediment size if the material is transported as suspended load.

2.4.1.3 Hydraulic Sorting

The sorting of bed sediment taking in an alluvial stream can be divided into local sorting and progressive sorting.

Local sorting occurs over the width or over longitudinal distances smaller than the bed-form length. A typical example of local sorting is at a bend, where bars of fine gravel are formed on the inner side of the bend whereas coarse gravel accumulates in the deeper portions. Local sorting also takes place over the length of a dune.

Progressive sorting takes places in the downstream direction due to reduction in the transport capacity of the stream because of change in discharge and energy gradient. However, progressive sorting is not easy to analyze because of inflow from the tributaries carrying varying discharges and sediment of varying size.

2.4.2 Stream Slope

In general, the longitudinal slope of a stream shows a continual decrease along its length. Examination of stream profile would show that the slope is greatest near the source, decreasing more or less regularly as the river follows its course. Such reduction in slope will correspond to a longitudinal profile, which is concave upwards. Several factors are responsible for this.

Firstly, the size of bed material in transport decreases in the downstream direction due to abrasion. Secondly, in humid regions the discharge in a stream increases in downstream direction due to inflow from the tributaries. Unless there is a corresponding increase in the sediment inflow, the stream would necessarily flatten to the extent required by the increased sediment and water discharge. Thirdly, the upper part of the drainage basin is the main source of sediment even though the run off from this part of the catchment may be small; the run off from the rest of the basin is large but the sediment supply from this region is relatively small. This leads to decrease in concentration in the downstream direction, necessitating a smaller slope. Fourthly, because of the bed materials being finer streams usually have relatively narrow channels in the downstream direction. As a result the stream has a greater hydraulic efficiency and flows with a flatter slope.

2.4.3 Shape of Stream

2.4.3.1 Shape in Cross-section

Alluvial stream transport predominantly the same type of material as the material forming the channel in the lower reaches. These rivers are called rivers in flood plains. Streams in flood plain exhibit great freedom in meandering within their permanent banks. A typical cross section of river with flood plain is shown in fig. 2.4 to a greatly exaggerated vertical scale.

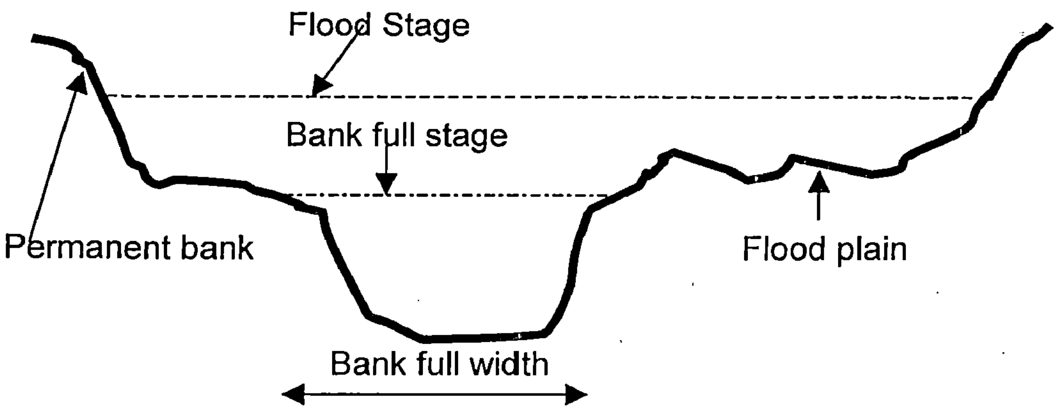


Fig.2.4. Typical cross section of river with flood plain.

The width of the flood plain between the permanent banks, i.e. width of valley, varies considerably depending on the size of the stream and other factors; the width of the valley in large stream can be as much as few kilometer.

2.4.3.2 Shape in Plan

The plan form of alluvial streams can be classified into the following three categories:

(1) Braided

Braided stream can be defined as one, which flow in two or more channels around alluvial island. Figure 2.5 shows a typical braided reach of Padma River (model study). Field observation and laboratory investigations by Leopold and Wolman throw some light on the sequence of events leading to braiding and the hydraulic relationship between divided and undivided reaches of stream. Their study shows that a braided pattern develops after local deposition of coarser material, which cannot be transported under local condition existing in the reach. This coarse material becomes the nucleus of a bar and subsequently grows into an island made of coarse as well as fine material. The formation of the bar deflects the main stream towards the bank and causes erosion. Study of the hydraulic characteristic of divided and undivided channels indicated that for divided stream (i) the slope is steeper, (ii) width is larger, and (iii) depth is smaller than that for an undivided stream. The ratio of slope of divided stream to the slope of undivided stream varies from 1.3 to 2.3, while the ratio of the corresponding widths ranges from 1.05 to 2.0

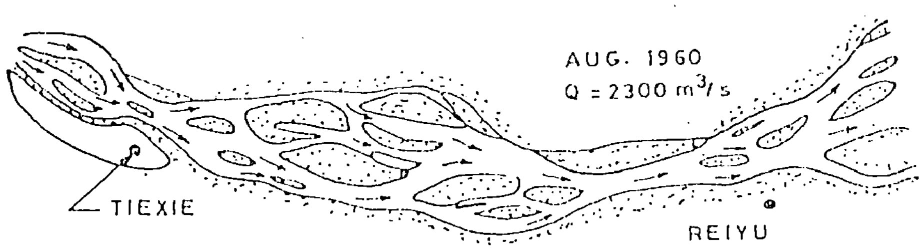


Fig. 2.5 Typical braided reach of the Yellow river

(2) Straight

It is extremely difficult to find straight reaches of streams over large lengths. Fig. 2.6 shows a typical straight reach of a stream. It can be seen that even though the channel is straight, the line of maximum depth moves back and forth from one bank to another. Sometimes deposits of sediment are also found adjacent to the banks in alternating position. In addition, natural streams with straight reaches are also characterized by pools and riffles. Riffles are the bars over which depth are small.

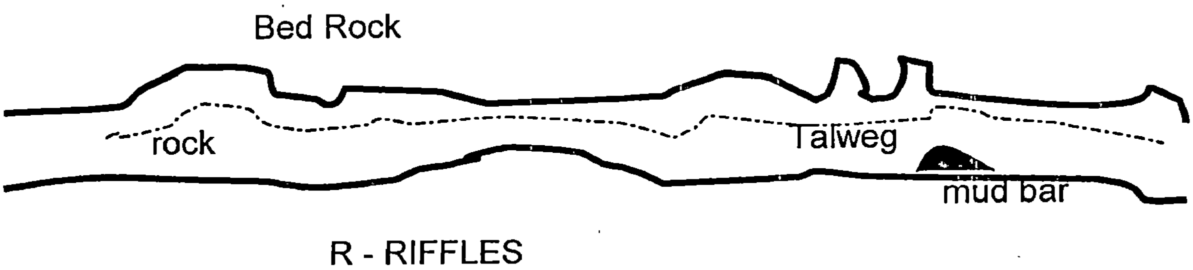


Fig. 2.6 Straight reaches of Valley creek at Sugar Ridge farm

(3) Meandering

The word meander comes from the name of the river Maiandrose in Turkey, which is characterized by a sinuous path. It is difficult to demarcate clearly between straight channels and sinuous channels which can be called meandering channels. Terms like sinuosity and turtuosity have been introduced to provide a quantitative basis for the classification of streams into straight and meandering streams. Sinuosity of a stream is defined as the ratio of talweg length to the valley length.

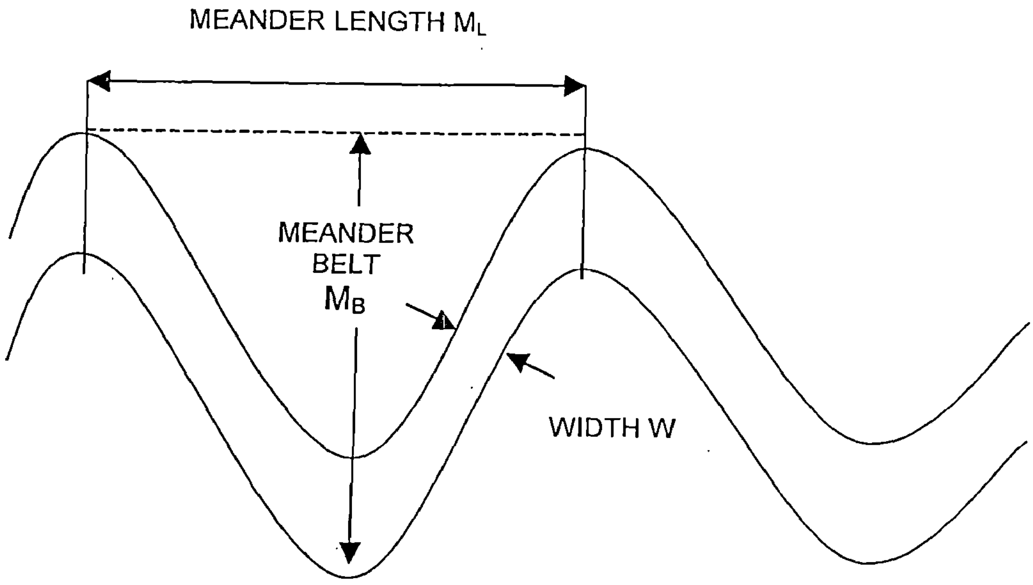


Fig. 2.7 Definition sketch for meandering stream

REVIEW OF MODELLING OF FLOW RESISTANCE IN ALLUVIAL RIVER

3.1 GENERAL

This chapter in essence is a part of the literature review. However, due to importance of this topic and its relevance to the present work, the chapter is exclusively devoted to the modeling of flow resistance in alluvial streams.

The present study considers a typical stretch of river Padma in Bangladesh. The length of this river stretch is approximately 160 km. and width of the river varies around from 5 to 22 km within the reach. Based on the data spanning nearly a decade, the study considers use of Manning's rugosity co-efficient. Based on such an evaluation, it is found that Manning's 'n' is not a constant and it depends on the flow and channel characteristics. Subsequently, several alternate expressions for Manning's rugosity coefficient have been either derived or used as reported in the literature.

In the present chapter, it is envisaged to present the models for predicting the resistance in alluvial streams by various investigators and also the conditions in which these data sets were available.

3.2 RESISTANCE RELATIONSHIP BASED ON TOTAL RESISTANCE APPROACH.

Garde and Ranga Raju analyzed from flume studies and natural streams, and proposed an empirical equation for the mean velocity. Using the principles of dimensional analysis, the functional relationship was written as

$$\frac{U}{\sqrt{\Delta\gamma_s / \rho_f}} = \phi\left(\frac{R}{d}, \frac{S}{\Delta\gamma_s / \gamma_f}, \frac{g^{1/2} d^{3/2}}{v}\right) \tag{3.2.1}$$

The parameter $g^{1/2}d^{3/2}/v$ was considered insignificant as a first approximation and the following relationship was obtained by plotting of data:

$$\frac{U}{\sqrt{\Delta\gamma_S d / \rho_f}} = K\left(\frac{R}{d}\right)^{2/3}\left(\frac{S}{\Delta\gamma_S / \gamma_f}\right)^{1/2} \tag{3.2.2}$$

Initially the values of the constant K for plane bed with no motion, ripple-dune, and transition regimes were found to be 7.66, 3.20, and 6.0 respectively, K was found to be 6.0 for the anti-dune regime.

Engineers in Japan use the formula

$$\frac{U}{U_*} = 5.75\log\left(\frac{R}{K_s}\right) + 6.0 \tag{3.2.3}$$

as the basic equation for resistance. Based on the analysis of Japanese river data, Tsubaki and Furuya obtained the following expression for K_s in the ripple and dune regime:

$$\log\left(\frac{K_s}{d}\right) = 3.48(1 - 0.225\tau_*^{-1/2}) \tag{3.2.4}$$

Ishihara, Iwagaki and Sueshi proposed the following equation for K_s in the plane bed regime with motion:

$$\frac{Ks}{d} = 10\,\tau_*^{0.769} \tag{3.2.5}$$

Liu-Hwang performed a dimensional analysis of the resistance problem and obtained the following functional relationship:

$$\phi\left(\frac{U}{u_*}, S, \frac{u_* d}{v}, \frac{d}{R}, \tau_*, \frac{\omega_0 d}{v}\right) = 0 \tag{3.2.6}$$

Using a large volume of flume data they found that the above relationship can be expressed in terms of empirical equation

$$U = C_a R^x S^y \tag{3.2.7}$$

Sugio has used river data from Japan and obtained the following equation for different regimes:

$$U = KR^{0.54} S^{0.27} \quad \text{in SI units} \tag{3.2.8}$$

where K=6.51 for ripples, 9.64 for dunes and 11.28 for transition regime respectively.

Paris using a flume and field data, and presented the following formula for sub critical flow in alluvial streams.

$$\frac{C}{Co} = 1 - 0.47\log\left(\frac{\tau_*}{\tau_{*c}}\right) + 0.12\left\{\log\left(\frac{\tau_*}{\tau_{*c}}\right)\right\}^2 \tag{3.2.9}$$

in which τ_{*c} is the dimensionless critical shear stress as per Shields, C is the Chezy's coefficient for the depth under consideration and C_o is the Chezy's coefficient for the depth under critical condition calculated from the following equations:

$$\frac{Co}{\sqrt{g}} = \sqrt{32}\log\left(10\frac{Dcr}{d35}\right) \tag{3.2.10}$$

in which Dcr the depth under critical condition for the given slope S computed as

$$Dcr = \frac{\tau_{cr} d_{35} (\gamma s - \gamma f)}{\gamma_f S} \tag{3.2.11}$$

Brownlie's obtained the following equation for unit discharge. q

For ripple and dune regime:

$$\frac{q}{\sqrt{gd^3}} = 4.57\left(\frac{R}{d}\right)^{1.529} \frac{S^{0.389}}{\sigma_g^{0.161}} \tag{3.2.12}$$

For plane bed, standing waves and anti-dunes:

$$\frac{q}{\sqrt{gd^3}} = 4.57\left(\frac{R}{d}\right)^{1.60} \frac{S^{0.46}}{\sigma_g^{0.128}} \tag{3.2.13}$$

where σ_g is the geometric standard deviation of the sediment.

White et al used the parameters employed by Ackers and White in their resistance analysis. They use the sediment mobility parameter F_1 defined as

$$F_1 = \frac{u_*^{C1}}{\sqrt{\frac{\Delta\gamma_s}{\rho_f} d_{35}}} \left[\frac{U}{\sqrt{32} \log 10 \frac{D}{d_{35}}} \right]^{1-C1} \qquad (3.2.14)$$

Bharat Singh proposes the use of the following equations for the resistance of ripple and dune beds.

$$\frac{U}{U_*} = 6.25 + 5.75 \log\left(\frac{R}{K_s}\right) \qquad (3.2.15)$$

where

$$\frac{K_s}{d_{65}} = \left(\frac{67\tau_0}{F^2{}_r}\right)^a \text{ in fps units} \qquad (3.2.16)$$

Here $Fr = U/\sqrt{gR}$ and α is a function of d_{65}

3.3 RESISTANCE RELATIONSHIP BASED ON DIVISION OF RESISTANCE

Einstein and Barbarossa were the first to suggest a resistance relationship considering total resistance to be the sum of grain resistance and form resistance due to bed formation, i.e.

$$\tau_0 = \tau'_0 + \tau''_0 \qquad (3.3.1)$$

where τ'_0 and τ''_0 are the shear stresses corresponding to the grain resistance and the form resistance of the undulation respectively. Equation (3.3.1) was written as

$$\gamma_f R_b S = \gamma_f R'_b S + \gamma_f R''_b S$$

i.e. $R_b = R'_b + R''_b$ (3.3.2)

For hydro-dynamically rough plane boundary, the Manning's roughness coefficient n' is given by Strickler's equation, namely,

$$n' = \frac{d_{65}^{1/6}}{25.6} \quad \text{in SI units} \qquad (3.3.3)$$

Combining this with the Manning's equation, one can write

$$\frac{U}{U'_*} = 7.66\left(\frac{R'_b}{d_{65}}\right)^{1/6} \qquad (3.3.4)$$

where $u'_* = \sqrt{gR'_b s}$ The foregoing equation can be replaced by the following logarithmic relation.

$$\frac{U}{u'_*} = 5.75\log\left(\frac{12.27R'_*}{d_{65}}\right) \qquad (3.3.5)$$

Engelund proposed the splitting up of the shear stress and the hydraulic radius and he proposed following equation to describe the grain resistance.

$$\frac{U}{u'_*} = 5.75\log\left(\frac{R'}{2d_{65}}\right) + 6.0 \qquad (3.3.6)$$

Alam and Kennedy also used the splitting up of resistance to predict resistance in the alluvial channel.

$$f = \frac{8gRS}{U^2} \qquad (3.3.7)$$

and $f = f' + f''$

where $f' = \frac{8gRS'}{U^2}$, $f'' = \frac{8gRS''}{U^2}$

Van Rijn used the resistance equation

$$\frac{U}{u'_*} = 5.75\log\left(\frac{12R_b}{k_s}\right) \qquad (2.51)$$

Yalin – Scheuerlein proposed equation similar with Engelund with the difference due to "sudden expansion" downstream of the equation of the crest of the undulations. The equation is as follows

$$\frac{U}{u'_*} = f\left(\frac{\tau_0}{\tau_{0C}}, \frac{D}{d}, \bar{d}*\right) \qquad (3.3.8)$$

in which $\bar{d}* = \left(\frac{\Delta \gamma_s d^3}{\rho_f \nu^2}\right)^{1/3}$

3.4 OTHER EQUATIONS

Jarrett's (1984) equation is recommended for steep streams with low H/d ratios.

$$Q = 3.17\,AR^{0.83}S^{0.12} \qquad \text{(SI units)} \qquad (3.4.1)$$

Riggs (1976) equation is:

$$Q = 1.55A^{1.33}S^{0.05-0.056\log S} \qquad \text{(SI units)} \qquad (3.4.2)$$

This relationship was developed from relatively small sample (62 data points) and not thoroughly validated. According to Dingman and Sharma (1997), the equation gives unreliable predictions when both discharges and Froude numbers (F) are small (Q < 3 m^3/s and F < 0.2). Dingman and Sharma (1997) developed an equation using 520 data points and validated it with a further 100 points. It is recommended for use where flows are > 3 m^3/s and F > 0,2

$$Q = 1.564\,A^{1.173}R^{0.400}S^{-0.0543\log S} \qquad \text{(SI units)} \qquad (3.4.3)$$

Limerinos (1970), using 50 measurements of discharge and appropriate field survey at 11 sites in California, related Manning's n to hydraulic radius and particle size as follows:

$$n = \frac{0.113R^{0.16}}{1.16 + 2.0\log\left(\frac{R}{d_{84}}\right)} \qquad \text{(SI unit)} \qquad (3.4.4)$$

Jarrett's (1984,1990) equation is recommended for steep streams with slopes up to 0.09 and for those with low h/d. His equation for n is:

$$n = 0.32S^{0.38}R^{-0.16} \qquad \text{(SI unit)} \qquad (3.4.5)$$

Sauer's (1990) equation applies to channels with slope between 0.0003 and 0.018 with R up to 5.8 m. This equation is limited to specific applications, such as estimating n values on narrow channels with dense stream bank vegetation (Coon 1998).

$$n = 0.11S^{0.18}R^{0.08} \qquad \text{(R in feet)} \qquad (3.4.6)$$

The investigation showed that the following equation of Hey (1979) performs as well as any other equations tested for riffles and dunes:

$$\frac{1}{\sqrt{f}} = 2.03\log\left(\frac{aR}{3.5d_{84}}\right) \qquad (3.4.7)$$

The coefficient 'a' varies between 11.1 and 13.46 and reflects the cross-sectional shape.

Karim and Kennedy (1990) recommended different equations depending on Shields dimensionless shear stress $\theta = \frac{RS}{\left(\left(\gamma s/\gamma - 1\right)d\right)}$, where γ_s and γ are the specific weight of the grains and water respectively. Their equations are:

$$\frac{f}{fo} = 1.2 + 8.92\left\{0.08 + 2.24\left(\frac{\theta}{3}\right) - 18.13\left(\frac{\theta}{3}\right)^2 + 70.9\left(\frac{\theta}{3}\right)^3 - 88.33\left(\frac{\theta}{3}\right)^4\right\}$$

for 0< 1.5 .

$$\frac{f}{fo} = 1.2 \qquad \text{for } \theta > 1.5 \qquad (3.4.8)$$

where the grain roughness factor $fo = \frac{8}{\left(6.25 + 2.5\ln\left(\frac{H}{2.5d50}\right)\right)^2}$ and d_{50} is the median bed particle size.

Equation which use the Froude number, F should be treated with caution because the definition of **f** and F are closely related from the same data. Close correlation can be found even though the predicted velocities may contain large errors.

An example containing F is that Afzalimehr and Ancil (1998):

$$\sqrt{\left(\tfrac{1}{f}\right)} = 2.03\log\left(\psi\, {}^{y}\!/_{d}\right) + 2.96F - 0.18\, {}^{\tau s}\!/_{\tau c} - 0.83 \qquad (3.4.9)$$

where $\psi = (p/w)^{1/2}$ is a cross sectional form factor, w is channel width, p is the channel wetted perimeter and $\tau_c = 0.03$ in SI units.

Another equation, given by Colosimo (1988), may avoid the spurious correlation problem, as it is designed to be solving iteratively.

$$\frac{1}{\sqrt{f}} = 2.03\log\left(\alpha y_m / m d_{84}\right) + \left(2.54F - 1.65\right) + \left(0.75 - 0.68\, Y/Y_c\right) \qquad (3.4.10)$$

α is cross-section shape factor, m is calculated from the grain size distribution, y_m is the mean depth, $Y = V_*^2/gd_0((\gamma_s/\gamma)-1)$ is a sediment mobility factor .γ_s and γ are the specific weight of the grains and the liquid respectively. Y_c is the critical value of Y. V_* is the mean shear velocity and d is the particle size for which percent of the particles are finer.

Chi Emeka G.Ilo (1975), obtained the exponential form of the equation for Manning's 'n', friction factor ('*f*) as below:

$$n = 0.012.R^{1/6}.\exp\left(0.2\frac{\tau''o}{\tau'o}\right)$$

$$f = 0.017.\exp\left(0.4\frac{\tau''0}{\tau'0}\right)$$

was found for a best fit for both laboratory and field data.

He found that the resistance factor increase slowly for low values of $\tau''o/\tau'o$ but very rapidly for higher value. It therefore indicates the relative influences of the bed forms and grains at different flow regimes.

EXPERIMENTAL SCHEME

4. 1 GENERAL

The interaction between the floodplains and an alluvial river channel is considerably more complex than that for non-erodible river channel, since the bed forms of the alluvial channel and hence roughness, change with discharge or stage. Unlike rigid boundary channels, which have been researched extensively over the last 35 years (e.g. Sellin, 1964; Knight & Demetriou, 1983, Knight & Shiono, 1996), mobile bed channels have received relatively less attention, despite their relevance to practical river engineering problems such as river training and morphology, sediment transport, dredging and design flood alleviation works.

In the present study it is proposed to analyse the field data of the Padma River in Bangladesh and for that purpose all fluvial data of the channel like water discharge, sediment discharge, velocity, slope, etc. have been collected from Bangladesh Water Development Board. It is also necessary to conduct experimental study, and for that purpose a model flume set-up has been constructed at the River Engineering laboratory of WRDTC. The geometrical and fluvial data of the experimental model runs have been measured. The plan form of the study river reach has been shown in fig. 4.1

4.2 EXPERIMENTAL APPARATUS AND PROCEDURES

4.2.1 Equipment

The experimental installations are composed a masonry re-circulating flume, which is constructed in the River Engineering laboratory of WRDTC Indian Institute of Technology Roorkee, Roorkee. The flume is 25 m long, 2.6 m wide and 1.4 m high (see fig. 4.2). The flume has two walls along its length. Two rails are fitted on that wall. A steel bridge/ trolley spans fitted at the width of the flume and is mounted on rails on the walls. The bridge or trolley is moved manually and it is equipped with a pointer gauge for measuring elevations of the sand surface and water surface with an accuracy of .001m vertically and .001m horizontally.

Scales are installed along the length of the flume and on the bridge, these are used to establish a co-ordinate system, and channel morphology is measured in relation to it. The flume is composed of a poorly sorted medium sand having d_{50} around 0.20 mm to 0.25 mm with depth of 40 cm. The initial channels having various shapes and sizes, are moulded by means of template mounted on a moving carriage. Water was supplied through a two pumps; 4-inch diameter and 6-inch diameter axial flow pump and these are used for re-circulating the water. Direct discharge meter is connected to the delivery pipe. From the meter or delivery pipe, water flows into a stilling basin and thence through three honeycombed walls / structures for suppressing the turbulence and after flowing through the model channel both water and sediment enter the tail box or sediment collector and it is re-circulated. Discharges are used in the range two (2) l/s, three (3) l/s, four (4) l/s, five (5) l/s, and six (6) l/s. At the down stream of the sand channel there is a trapezoidal weir, which is made by brick, the elevation of which is kept approximately level with the sand bed of the stream. Tailgate was provided at the down stream end of the flume to regulate the depth of the flow.

Velocity of the flowing water and bed shear stresses are measured by Preston tube and Acoustic Doppler velocimeter. During experiment, bed elevations of the channel and water surfaces are measured by using the pointer gauge.

At the end of each experiment a series of channel bed profile are measured. (AppendixII)

4.2.2 Acoustic Doppler Velocimeter

The Acoustic Doppler Velocimeter (ADV) is a versatile, high-precision instrument that measures all three-flow velocity components. The measurements are insensitive to water quality, which allows for a wide range of applications. ADVs are used in laboratories, wave basins, rivers, estuaries and for oceanographic research.

The ADV uses acoustic sensing techniques to measure flow in a remote sampling volume. The measured flow is practically undisturbed by the presence of the probe. Data are available at an output rate of 25 Hz. The 3-D velocity range is ±2.5 m/s, and the velocity output has no zero-offset.

The instrument consists of three modules: the measuring probe, the conditioning module and the processing module. The measurement probe is attached to the waterproof conditioning module, which contains low-noise electronics. The housing and cable attachment are rugged and can be deployed to 30 m in the standard configuration.

The acoustic sensor consists of one transmit transducer and three receive transducers. The receive transducers are mounted on short arms around the transmit transducer at 120 azimuth intervals. The acoustic beams are oriented so that the receive beams intercept the transmit beam at a point located at 50 mm or 100 mm below the sensor. The interception of these four beams, together with the width of the transmit pulse define the sampling volume. This volume is 3-9 mm long and approximately 6 mm in diameter. All three receivers must be submerged to ensure correct velocity measurements.

ADV calibration factors are determined by the speed of sound and by the angles between the transmitters and receive transducers. To ensure that the correct speed of sound is used, the water temperature and salinity must be entered in the data acquisition software.

ADVLab

The ADVLab is designed for use with a desktop PC in laboratory settings. It is very simple to set up and operate, the data are stored directly to hard disk, and the power is supplied from the PC. The standard unit is delivered with a 5 cm down-looking sensor mounted on a rigid 40 cm stem. The standard cable length to the PC is 10 meters. An analogy output for use with a secondary data acquisition system is optional.

Probe orientation

The down-looking probe (standard for all systems) cannot measure the velocity in the upper 5 cm of the water column. If the main interest is to measure the surface layer or to measure under structures, an up-looking probe may be very useful. The side-looking probe is primarily used in wave flumes.

In very shallow water, (minimum 2 cm) a 2D side-looking probe measures the two horizontal components.

Software

A full set of data collection, data conversion and diagnostic software is included with all ADVs. The software displays the real time and time filtered velocity, echo amplitude, the standard deviation of velocity, and correlation - a quality parameter.

4.2.3 Experimental Procedure Adopted

Before starting the experiment, model study was, prepared with the help of dresser from IRI Bahadarabad (see Fig.4.3). Discharge meter was installed in the supply pipe to record volume of water flow in the channel. Tailgate at the end of channel has been arranged to regulate depth of the flow and water surface slope. For each discharge, water surface level and water width has been measured at each cross section using scale and pointer gauge. Discharge has to change for each $1^1/_2$, $1^1/_2$, 1, 1, 1 hours time intervals.

For measuring velocity, the Pitot tube was lowered into the water after mounting it on the graduated rod fitted with the base plate, rested on the movable trolley. Velocity profiles are located at the middle of each channel for each cross section. The manometer was calibrated and this calibration was checked several times during the experiment. At each measurement, the proper levelling of the manometer was ensured. It was confirmed that there is no air entrapped in the Pitot tube connecting the manometer all the time.

4.2.3.1 Flow condition

Velocity distribution in alluvial stream has several complications, such as (i) change in bed configuration, (ii) change in the character of fluid due to suspension of material, and (iii) effect of sediment transport on flow characteristics. It should also be appreciated that the velocity profiles at different stations with respect to crest of a dune are not identical making even definition of an average velocity profile difficult.

For the experimental purpose, it was tried to dampen the flow disturbances in the flow. It was done by the honeycombed walls / structures at the upstream of the flume

4.2.3.2 Slope of the Bed Channel

The bed channel slope is depending here on elevation of the cross section concerned to other cross section (for initial plan form). Analysis was done using slope of the water surface, which was measured in each discharge by measured distinction between elevations at the upstream cross section with downstream cross section.

4.2.3.3 Depth of flow.

Alluvial streams are often contracted to increase the flow depth and thereby make them navigable. An alluvial flow may also have natural constriction.

For the experimental purpose the depth of the flow has been taken to be similar with the field condition as per model experiment, with the result that other measurement can be done.

For analysis, depth of flow was calculated from distinction between water surface level at each discharge and channel bed level at the end of the experiment.

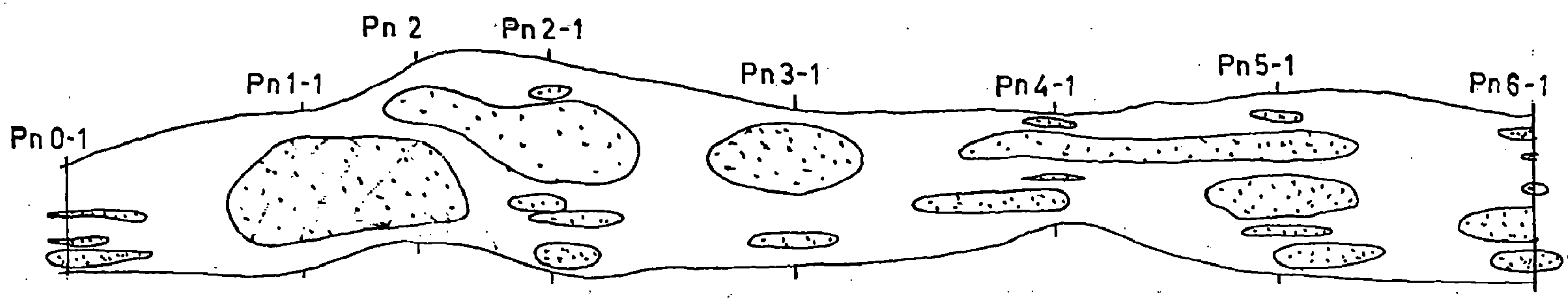
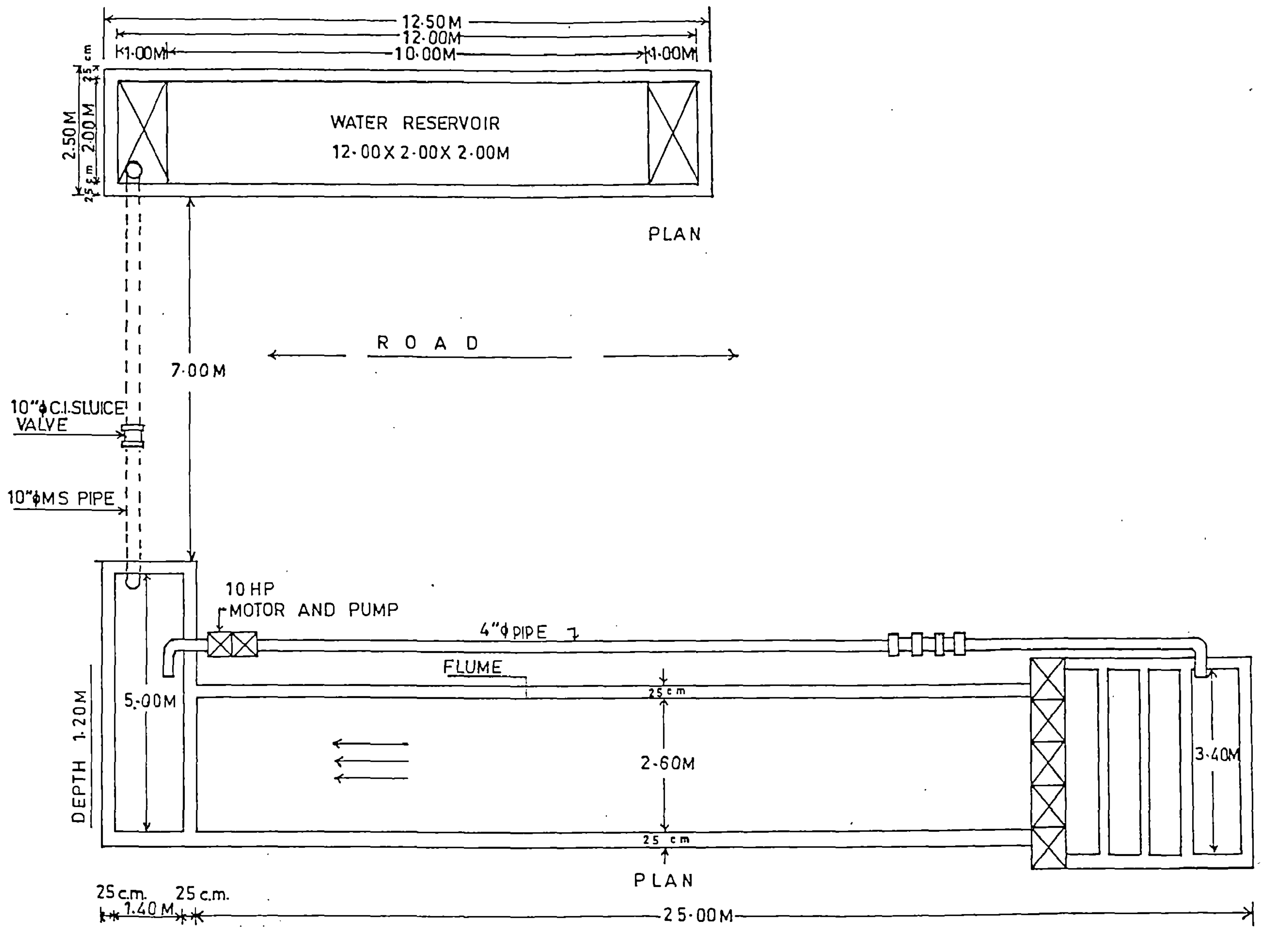


Fig. 4.1 PLAN FROM OF PADMA RIVER IN BANGLADESH
(SOURCE :- BANGLADESH WATER RESOURCES BOARD 1995)



SCALE:- NOT TO SCALE

Fig. 42 SCHEMATIC DIAGRAM OF EXPERIMENTAL SET UP

ANALYSIS OF DATA AND MODEL DEVELOPMENT

5.1 INTRODUCTION

In this chapter, the collected data from flume studies and field data are compiled and analyzed in order to get more information about resistance to flow in braided river.

Analysis has been carried out to obtain the resistance relationship based on the regression analysis of the available field and experimental data. The resistance coefficient in the braided river can be expressed as a function of the ratio of the velocity and bed shear velocity with the ratio of depth and grain size diameter of the bed channel, for any anticipated discharge and the friction factor can be obtained from Darcy-Weisbach relationship. Another parameter of the resistance coefficient also has been carried out such as a function of the ratio of velocity and bed shear velocity with ratio of width and depth of the channel. In addition, these parameters can be predicted from the initial known flow characteristics and sediment properties. The study has also been devoted to compare a number of equations given by many investigators such as those given by Limerinos, White – Collebrook, Leopold - Wolman & Miller. The present study was also envisages to propose suitable resistance model for the braided alluvial river.

5.2 PARAMETERS FOR THE ANALYSIS

5.2.1 Depth of flow

In the discussions, the datum is defined as the imaginary plane from which the vertical distances are measured. There are different conclusions derived by different investigators regarding the reference level (datum).

The depth of flow was calculated as below:

Depth = water surface elevation – channel bed elevation at the end of the experiment.

5.2.2 Hydraulic radius

Hydraulic radius of the channel was calculated with assumption that the channel is trapezoidal in form, so the hydraulic radius can be obtained from the equation below:

$$R = \frac{A}{(B + 2.D)}$$

where, A is area of the channel, B is water width surface, and D is average depth of the channel.

5.2.3 Velocity of flow

The mean velocity of flow was calculated from available discharge data. This is given by:

$$U = Q / A$$

Where Q is the discharge, U is the mean velocity, A is the area which can be obtained from equation below:

$$A = \frac{(h1 + h2).x.distance}{2}$$

5.2.4 Width depth (B/D) ratio

As mentioned earlier, it is convenient to express the roughness in terms of dimensionless number. This parameter has been used by many investigators in terms of B/D. In the present analysis B/D have been used as function of the roughness coefficient or friction factor.

5.2.5 Shear velocity

The shear velocity is given by:

$$u^* = \sqrt{g.R.S}$$

where R is the wetted perimeter of the channel, S is the water surface slope and g the acceleration due to gravity.

5.2.6 Darcy – Weisbach friction factor (*f*)

The friction factor is given by;

$$f = \frac{8.g.R.S}{U^2} = 8\left(\frac{u^*}{U}\right)^2$$

5.2.7 Reynolds number (Re)

The parameter Reynolds number Re is the ratio of the inertial force and the viscous force and is given by:

$$Re = U.\ R/v$$

Where v is the kinematic viscosity and adopted as 10^{-6} m^2/s (Garde and Ranga Raju, 2000). This factor however depends upon the temperature; correction due to temperature has not been applied. Re will indicate the behavior of the flow and when Re > 10^4, there will not be any viscous effect and only form drag will be dominant in the flow characteristic.

5.2.8 Ratio of Hydraulic radius and grain size (R/d ratio)

This parameter has been used by many investigators in terms R/D_x. In the present analysis, R/d has been tried to use as function of the roughness coefficient or friction factor.

5.3 DEVELOPMENT OF THE RESISTANCE MODEL

Regression analysis is the process of constructing and analyzing functional relationship between responses, the dependant variable Y, and important factors, the independent variables X_1, X_2, ..., X_k , that affect of the response. The word 'independent' means that variable can be set or observed at specific values.

In order to construct a functional relationship for resistance coefficient and friction factor for braided river, parameter R/d ratio and B/D ratio was proposed.. The resistance relationship will be calculated with the following equation:

$$y = c.\ln(x) + b \qquad (5.1)$$

where x is the parameter of the roughness coefficient, y is roughness coefficient, c and b are constant, and ln is the natural logarithmic function. Coefficient b and c can be determined from the equations below:

$$c = \frac{\sum\left(xi - \bar{x}\right).\left(yi - \bar{y}\right)}{\sum\left(xi - \bar{x}\right)^2} \qquad (5.2)$$

$$b = \bar{y}. - c.\bar{x} \qquad (5.3)$$

where

$$\bar{x} = \frac{\sum xi}{n}$$

$$\bar{y} = \frac{\sum yi}{n}$$

The degree of association between the two phenomena is computed by a correlation coefficient R^2 where:

$$R^2 = 1 - \frac{\sum\left(yi - \bar{yi}\right)^2}{\left[\left(\sum yi\right)^2 - \left(\frac{\left(\sum yi\right)^2}{n}\right)\right]} \qquad (5.4)$$

The value of R^2, shall be equal to 1, and relation between the variable x and variable y is of functional type rather than of associative type. Various names have been given to the association between the variables as follow:

0.6	<	R	<	1	good direct correlation
0	<	R	<	0.6	insufficient direct correlation

5.3.1 Resistance relations using R/d_x ratio as a parameter

Regression of roughness coefficient U/u* vs. R/d with all the 42 available field data sets was carried out both in the logarithmic as well as the power fit equations. The power fit gave the correlation of R^2 =0.0848(Fig. 5.1.1) with the standard error of estimate was 0.808

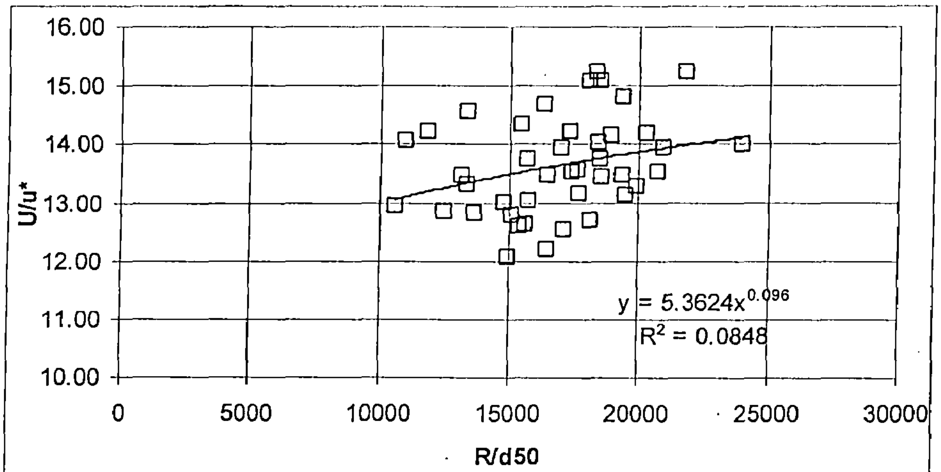


Fig. 5.1.1 U/u* vs R/d50 (Power form)

(Table A-4.2) while the correlation of the logarithmic fit improved slightly with R^2 =0.0851 (Fig.5.1.2) with the standard error estimate 0.808 (Table A - 4.2)

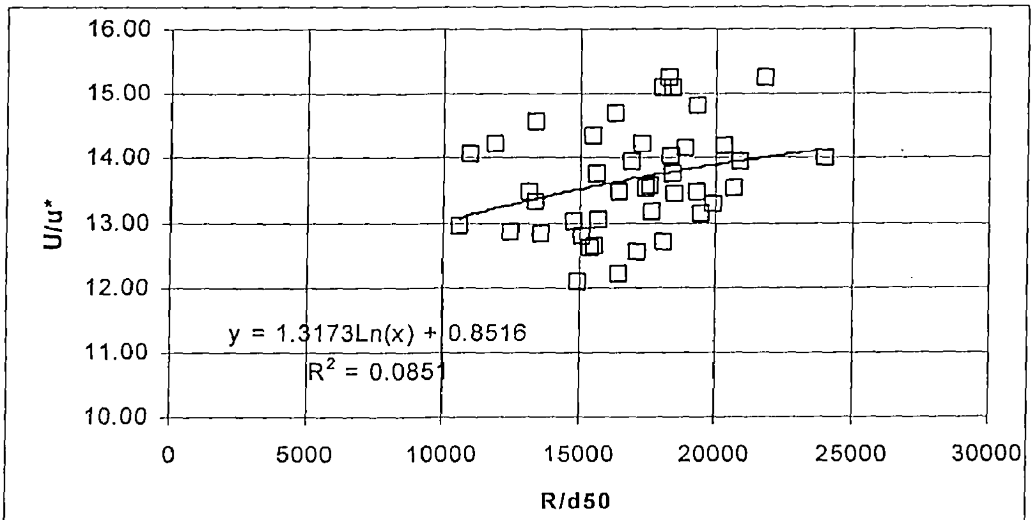


Fig. 5.1.2 U/u* vs R/d50 (Logaritmic form)

The Field data comprised of R/d50 ranging from 10,595.92 to 23,971.24.

Logarithmic form:

$$\frac{U}{u^*} = 1.3173.\ln(R/d50) + 0.851 \qquad (5.5)$$

with the R^2 value of 0.0851 and the standard error 0.808

Power form:

$$\frac{U}{u^*} = 5.3624(R/d50)^{0.096} \qquad (5.6)$$

with the R^2 value of 0.0848 and the standard error 0.808

Fig. 5.2 RELATION BETWEEN U/u* AND R/d50 RATIO AT DIFFERENT SLOPE (FIELD DATA)

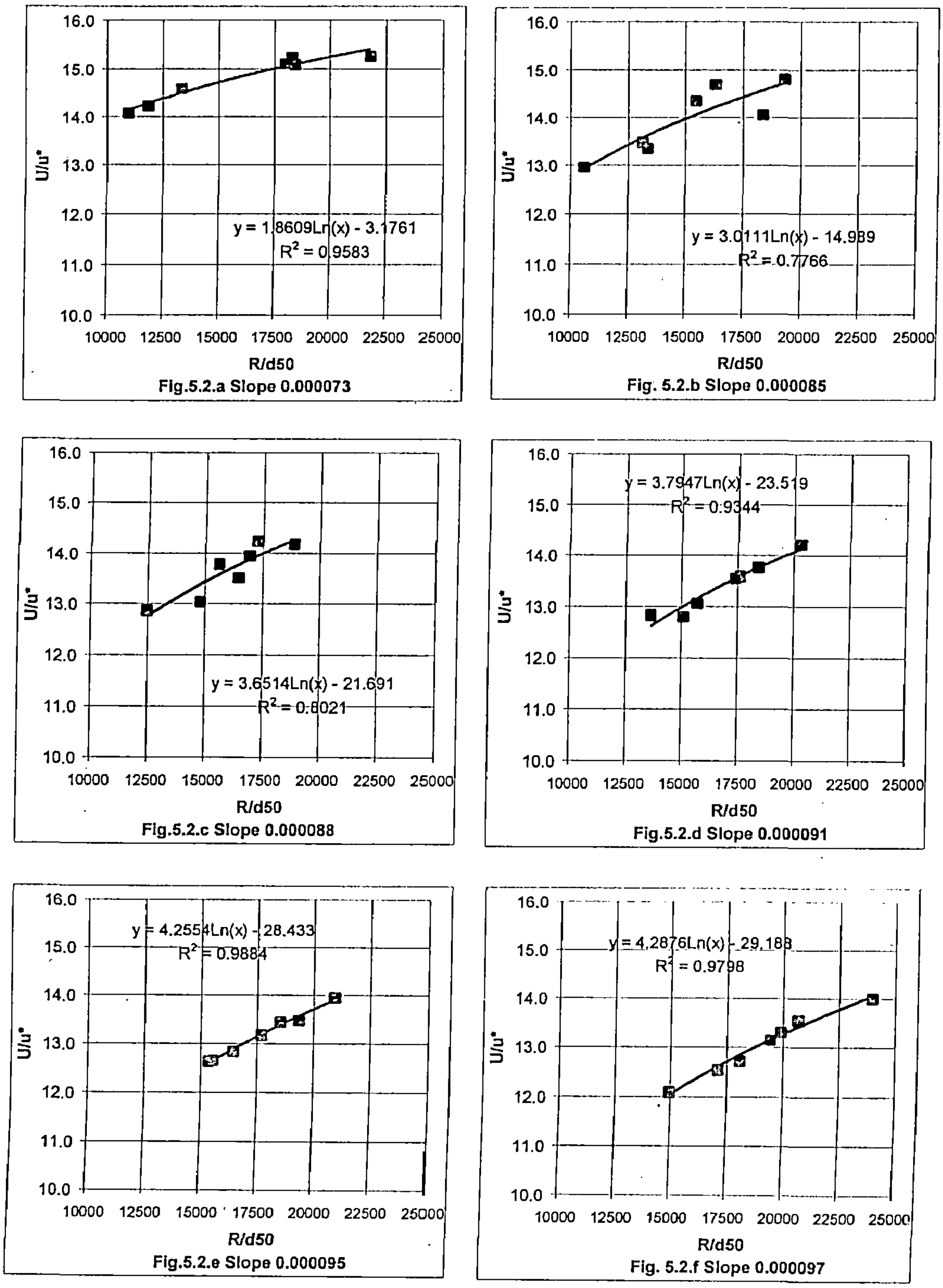


Fig.5.2.a Slope 0.000073

Fig. 5.2.b Slope 0.000085

Fig.5.2.c Slope 0.000088

Fig.5.2.d Slope 0.000091

Fig.5.2.e Slope 0.000095

Fig. 5.2.f Slope 0.000097

From the family of curves, it could be observed that although the semi-logarithmic equation could be empirically fitted, a significant scatter has been observed in the estimation of the friction roughness coefficient U/u*. As indicated, the scatter may be affected by the slope (S).

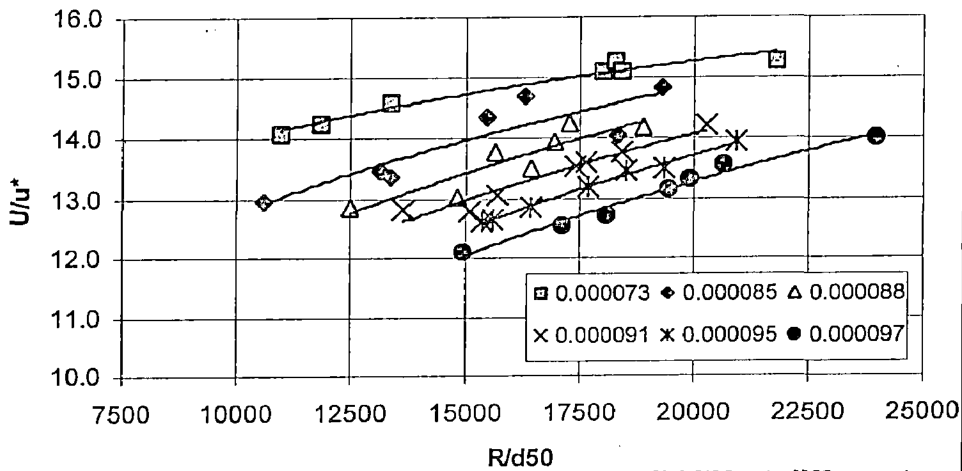


Fig. 5.3 Relation Between U/u* vs R/d50 at different slope (Field data)

Figure (5.3), showed that was needed to provide factor correction for the above relations. (TableA-4.4). Factor correction (K1) has been calculated base from the curve, which placed in the middle between all the family curves and has good fit association.

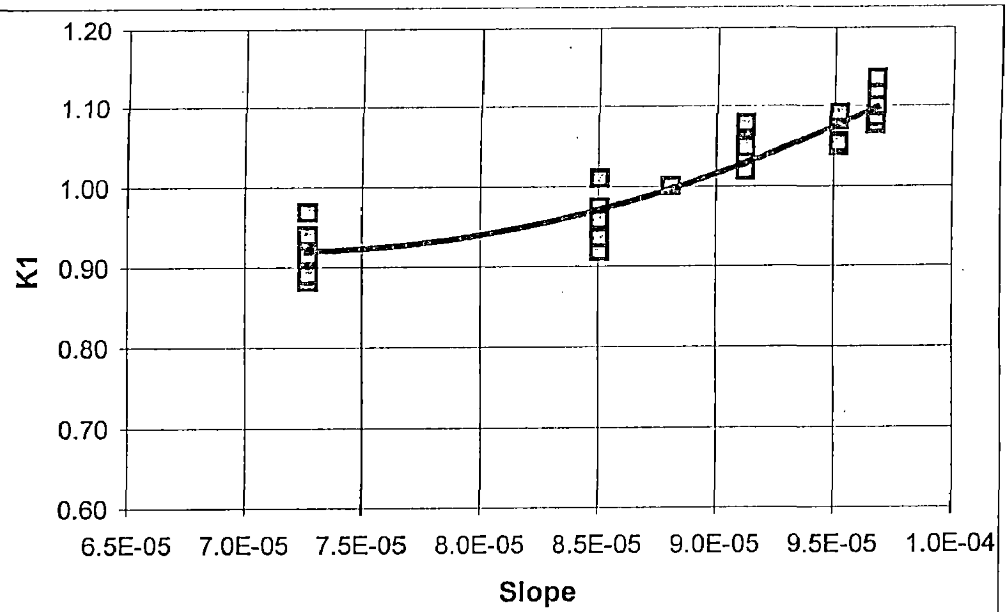


Fig.5.4 Relations between factor correction (K1) and Slope(field data)

After applied factor correction, it has given improvement for the degree of association R^2 and equation (5.5) became:

$$\frac{U}{u*} = 3.1474.\ln(R/d50) - 16.743 \qquad (5.7)$$

with the R^2 value of 0.8205 and the standard error 0.876

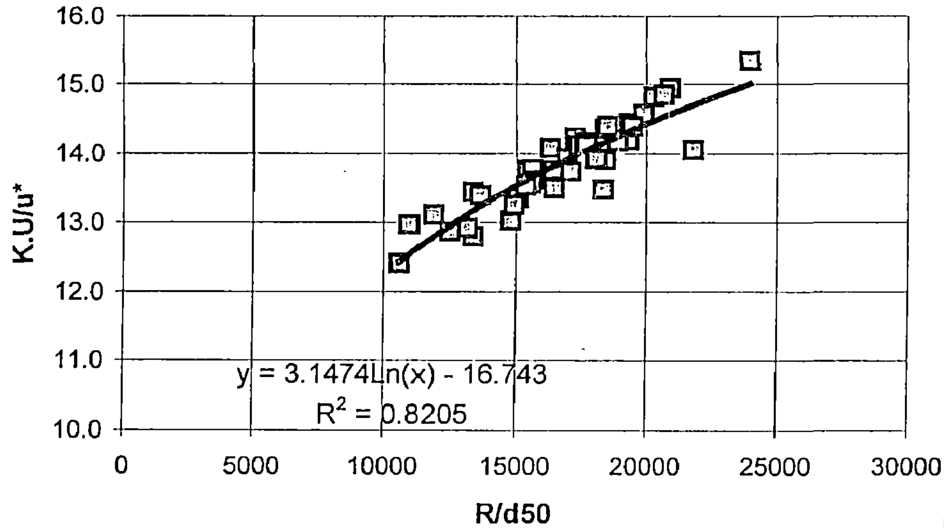


Fig.5.5 Relation between K1.U/u* and R/d50 (Field data)

Darcy-Weisbach has given relation between roughness coefficient and friction factor as below:

$$\frac{1}{\sqrt{f}} = \frac{1}{\sqrt{8}}\left(\frac{U}{u*}\right) \qquad (5.8)$$

Substitute equation (5.7) to equation (5.8)

$$\frac{1}{\sqrt{f1}} = 1.113.\ln\left(\frac{R}{d50}\right) - 5.92 \qquad (5.9)$$

Similarly from the experimental data relation between roughness coefficient and parameter R/d50, the equation could be obtained below:

$$\frac{U}{u*} = -1.6464.\ln\left(\frac{R}{d50}\right) + 13.603 \qquad (5.10)$$

and the friction factor equation:

$$\frac{1}{\sqrt{f2}} = 0.582.\ln\left(\frac{R}{d50}\right) + 4.80 \qquad (5.11)$$

5.3.2 Resistance relations using B/D ratio as a parameter

Taizo Hayashi (march, 1980) proposed parameter Fr. vs. B/D ratio for channel pattern criteria. Base from this parameter friction factor relationship will be tried to obtain.

Similar method with the parameter R/d_x has been done to obtained the equation for roughness equation and friction factor.
The equation obtained from analysis are given below:

1. Field data

- **Roughness coefficient**

$$\frac{U}{u*} = -1.338\ln(B/D) + 22.758 \qquad (5.12)$$

- **Friction factor**

$$\frac{1}{\sqrt{f3}} = 7.99 - 0.467.\text{In}\left(\frac{B}{D}\right) \qquad (5.13)$$

2. Experimnetal data

- **Roughness coefficient**

$$\frac{U}{u*} = -1.4.8095.\ln(B/D) + 24.461 \qquad (5.14)$$

- **Friction factor**

$$\frac{1}{\sqrt{f4}} = 8.648 - 1.70.\ln\left(\frac{B}{D}\right) \qquad (5.15)$$

FIGURE 5.6 RELATIONSHIP BETWEEN RESISTANCE COEFFICIENT AND R/d50 RATIO (EXPERIMENTAL DATA)

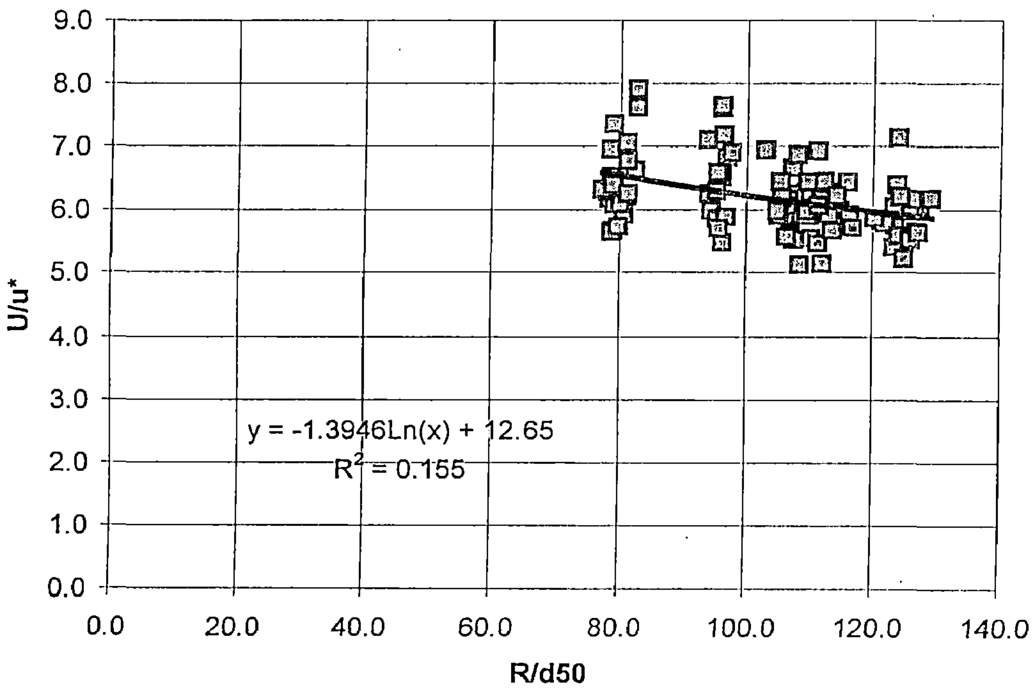


Fig 5.6.1 Logaritmic form

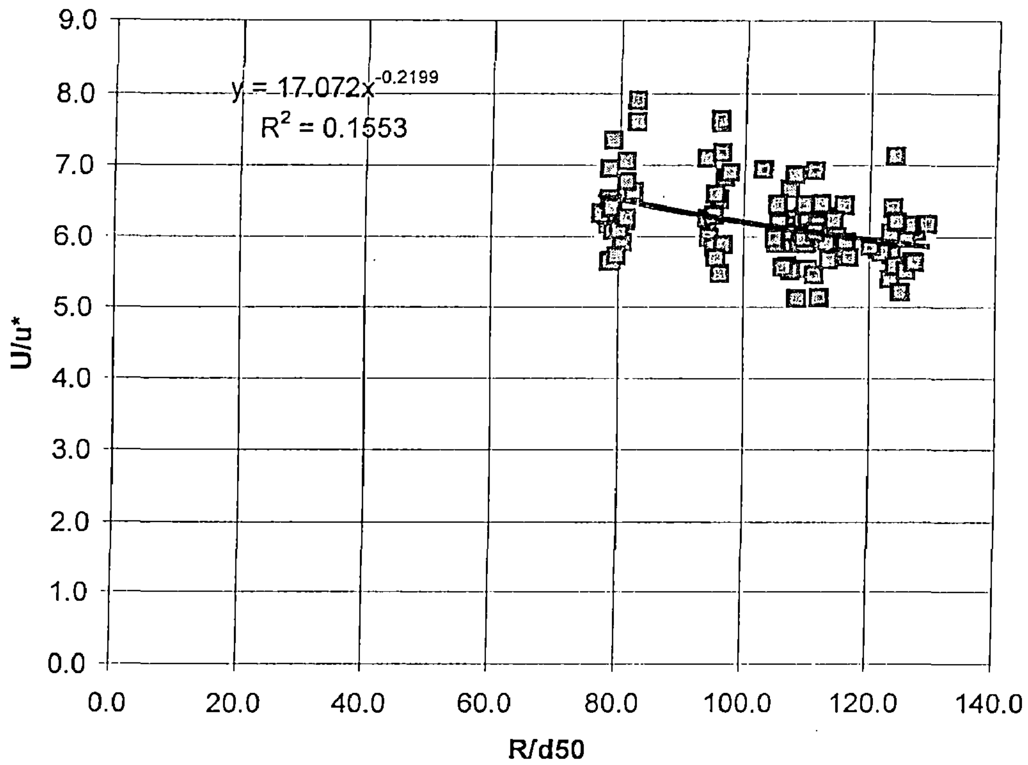


Fig. 5.6.2 Power form

FIGURE 5.7 RELATION BETWEEN U/u* AND R/d50 RATIO AT DIFFERENT SLOPE (EXPERIMENTAL DATA)

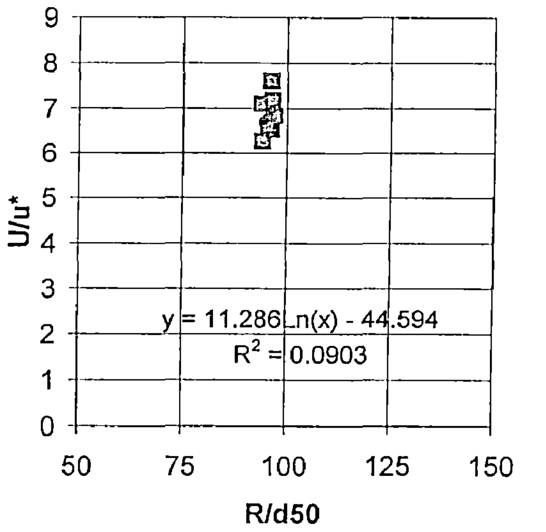


Fig 5.7.a Slope 0.00020

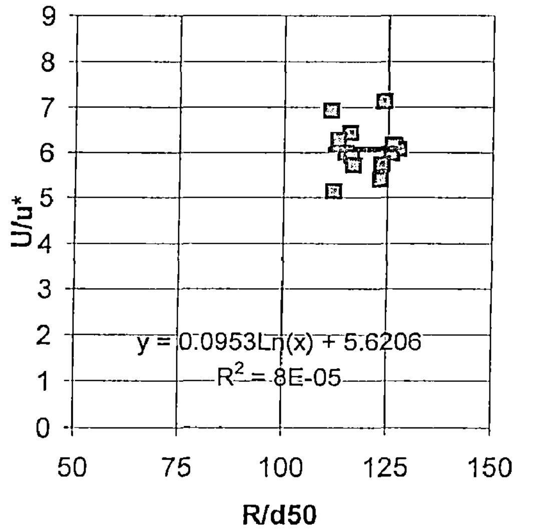


Fig 5.7.b Slope 0.00023

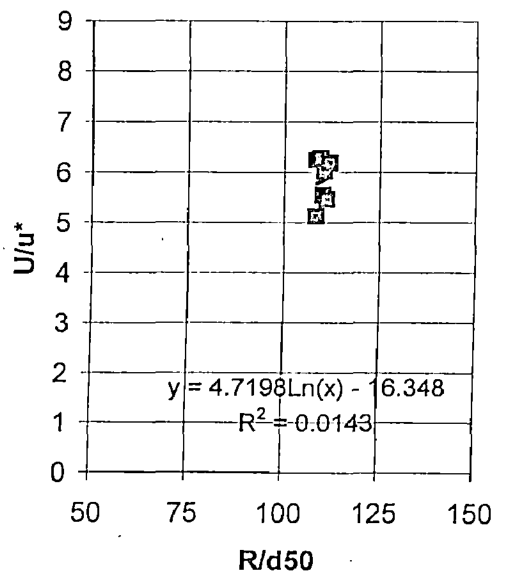


Fig 5.7.c Slope 0.00024

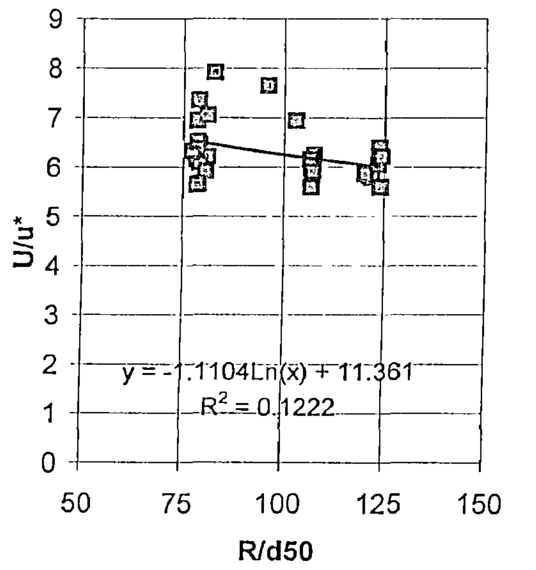


Fig 5.7.d Slope 0.00025

FIGURE 5.7 RELATION BETWEEN U/u* AND R/d50 RATIO AT DIFFERENT SLOPE (EXPERIMENTAL DATA)

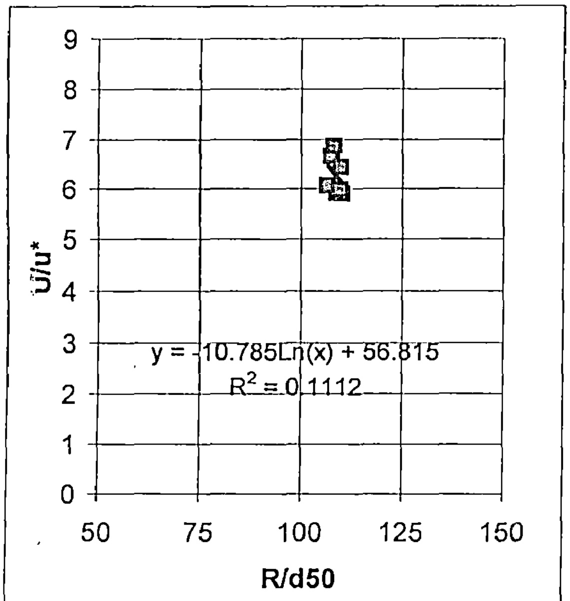


Fig 5.7.e Slope 0.00026

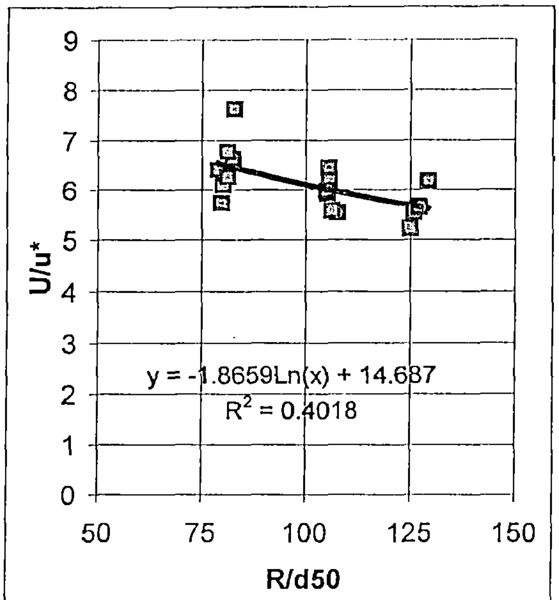


Fig 5.7.f Slope 0.00027

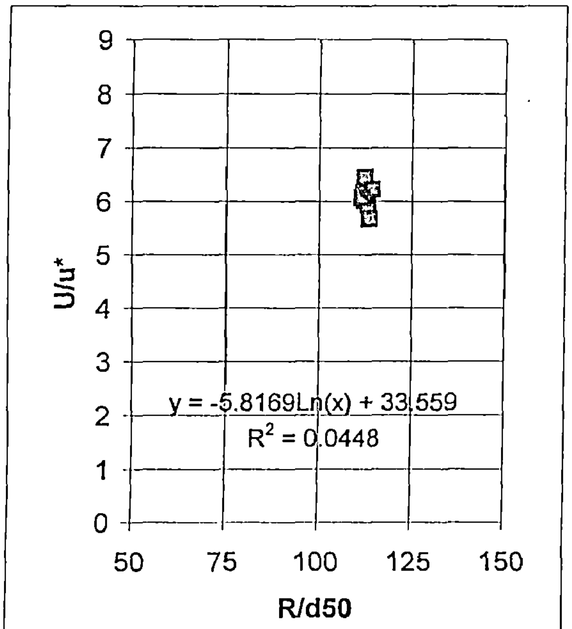


Fig 5.7.g Slope 0.00028

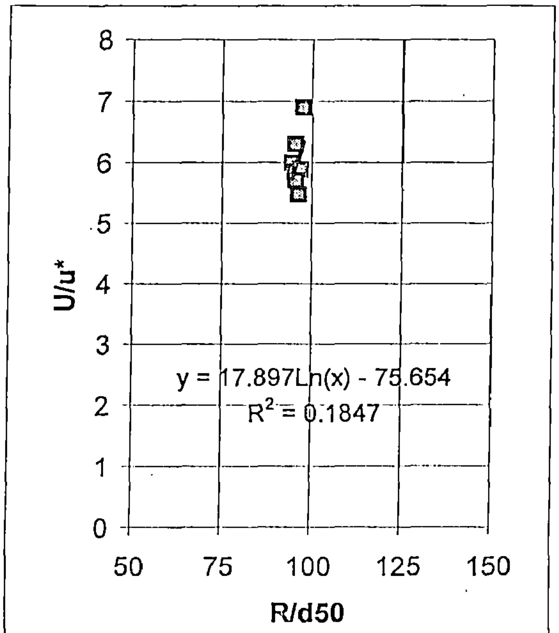


Fig 5.7.h Slope 0.00029

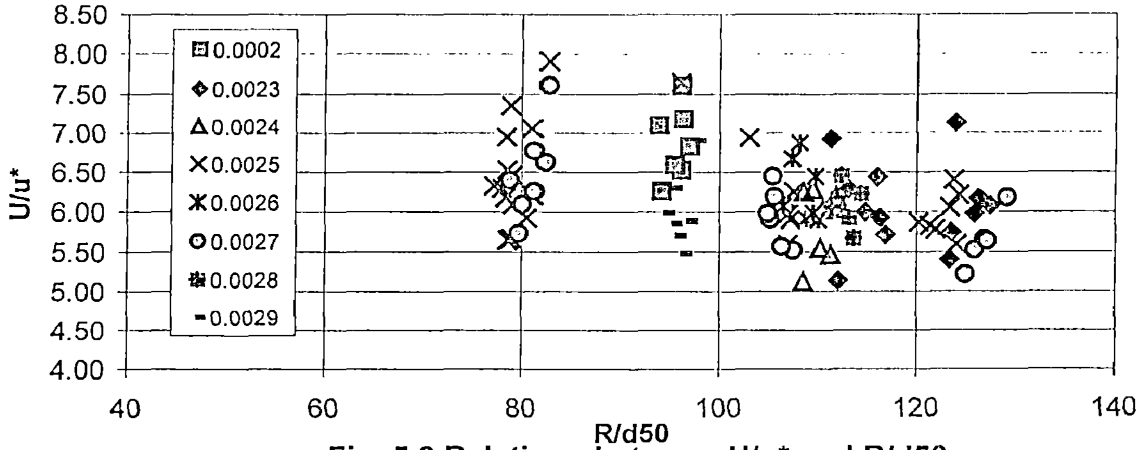


Fig. 5.8 Relations between U/u* and R/d50 (Experimental data)

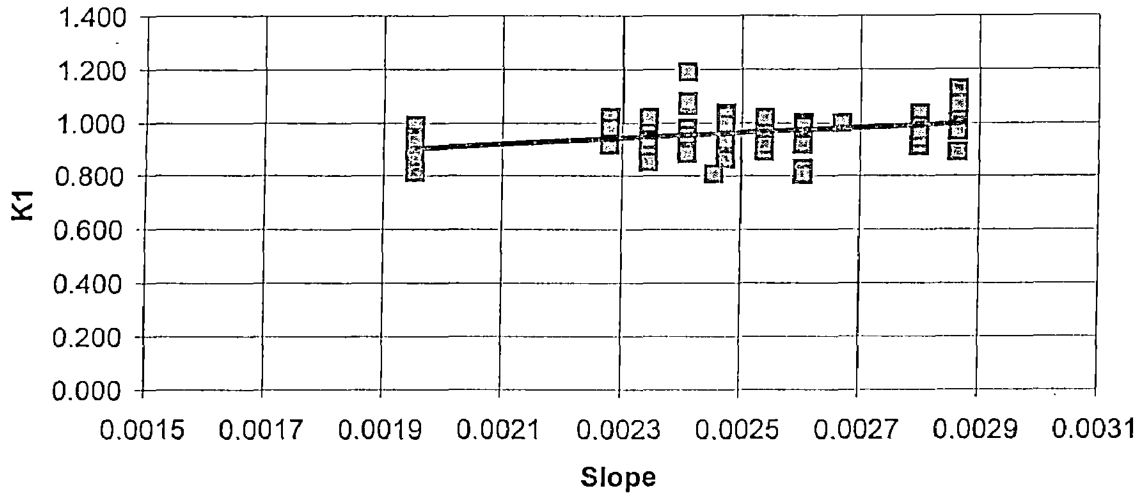


Fig 5.9 Relation between factor correction K1 and Slope (experimental data)

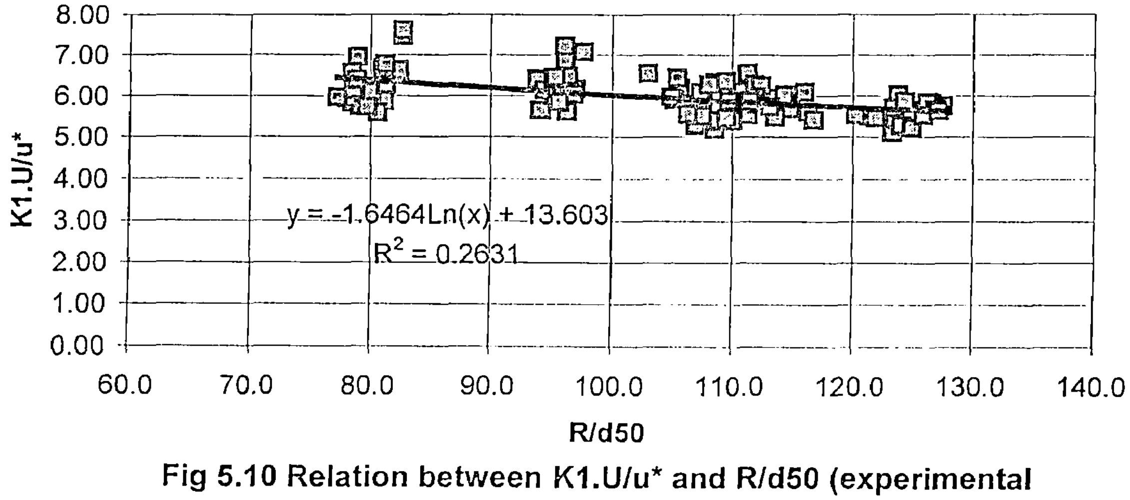


Fig 5.10 Relation between K1.U/u* and R/d50 (experimental data)

FIGURE 5.11 RELATIONSHIP BETWEEN RESISTANCE COEFFICIENT AND B/D RATIO (EXPERIMENTAL DATA)

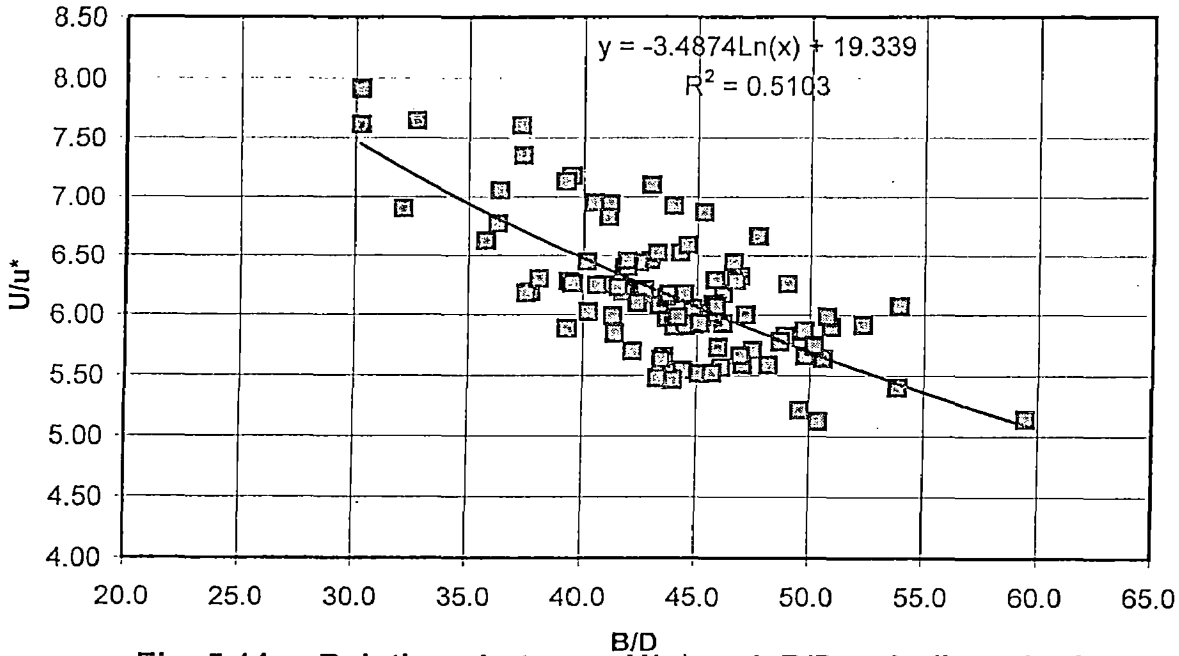


Fig. 5.11.a Relations between U/u* and B/D ratio (logaritmic form)

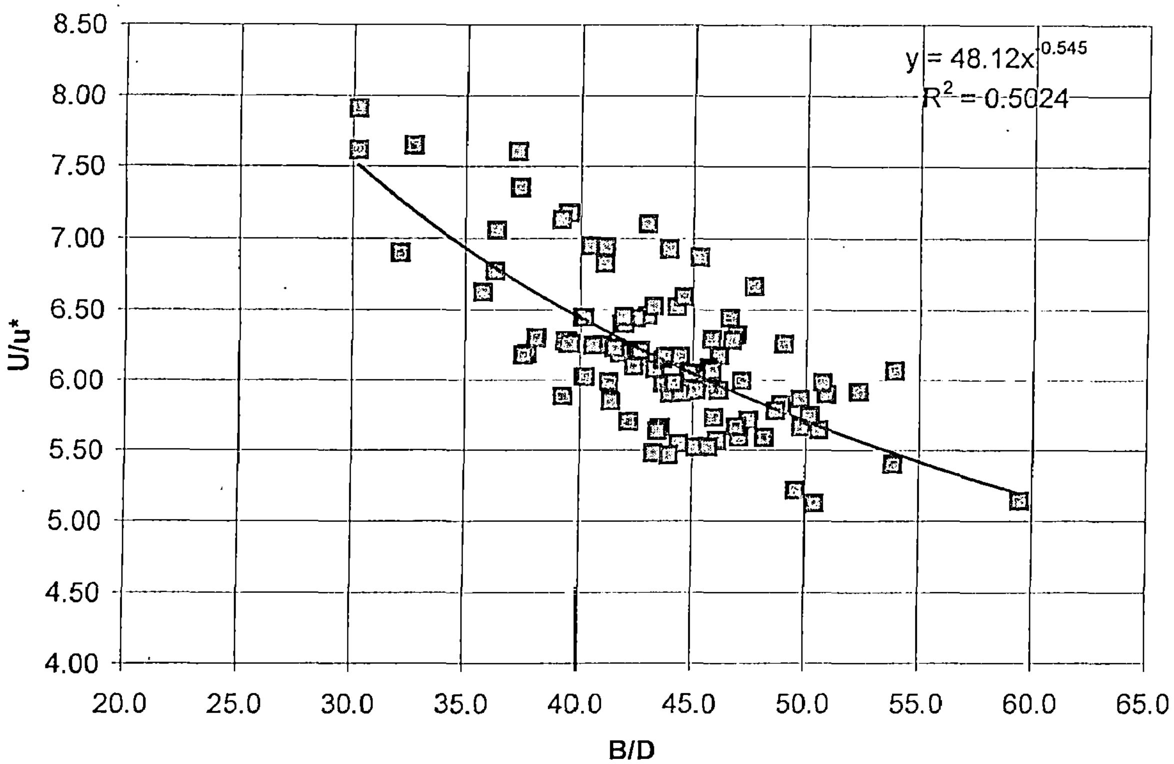


Fig.5.11.b Relations between U/u* and B/D ratio (power form)

Fig. 5.12 RELATIONS BETWEEN U/u* AND B/D RATIO AT DIFFERENT SLOPE (Experimental data)

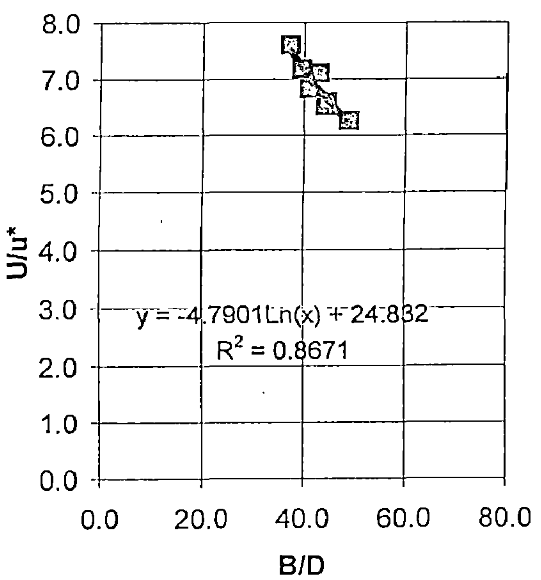


Fig.5.12.a Slope 0.0020

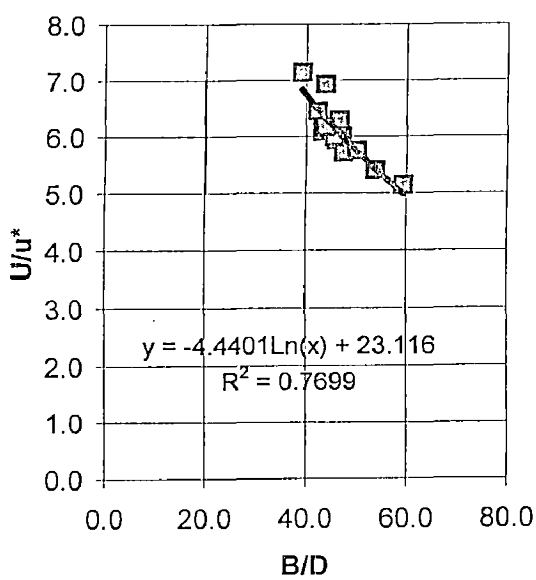


Fig.5.12.b Slope 0.0023

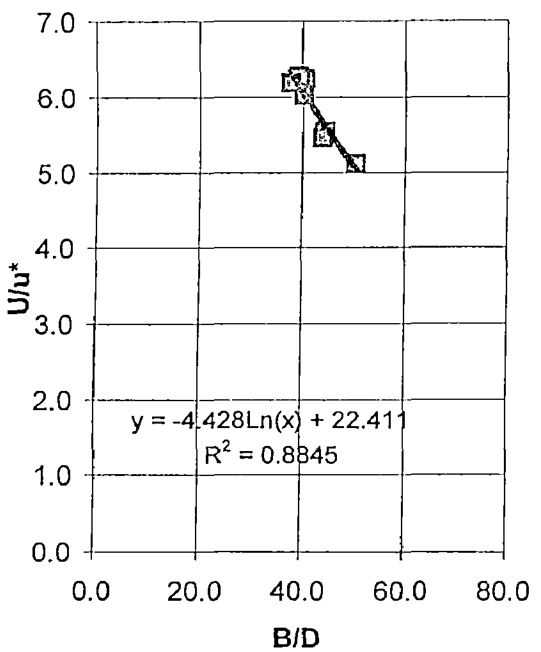


Fig.5.12.c Slope 0.0024

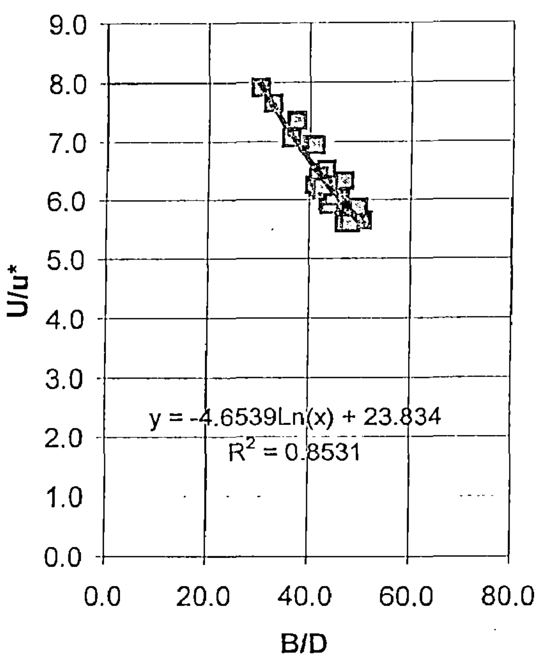


Fig.5.12.d Slope 0.0025

Fig. 5.12 RELATIONS BETWEEN U/u* AND B/D RATIO AT DIFFERENT SLOPE (Experimental data)

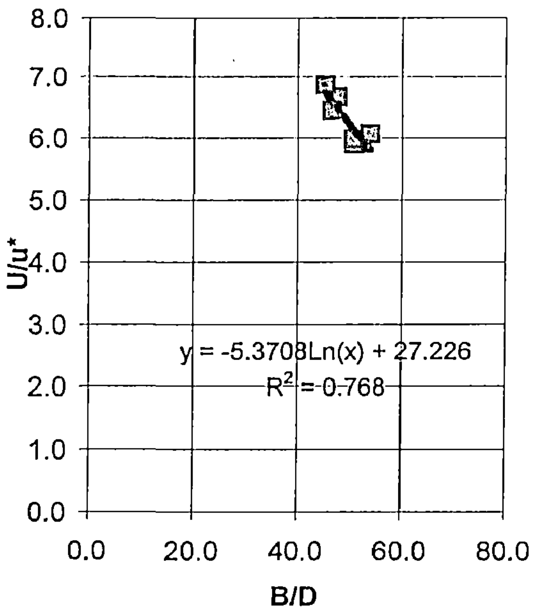


Fig.5.12.e Slope 0.0026

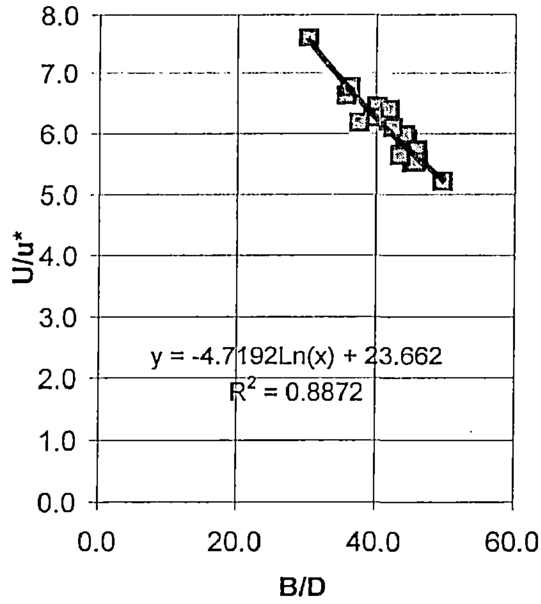


Fig.5.12.f Slope 0.0027

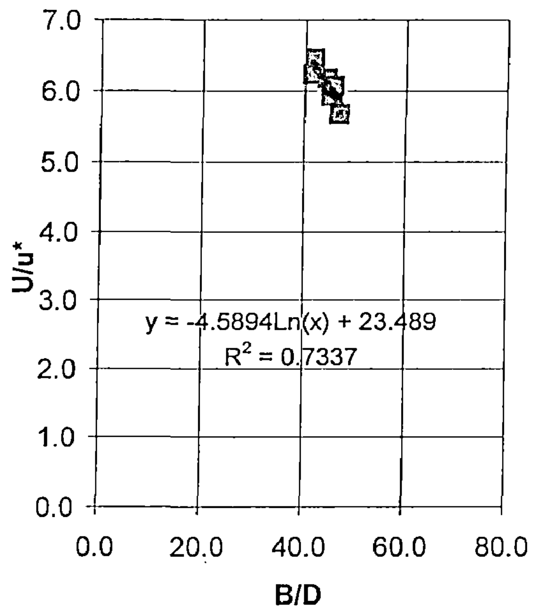


Fig. 5.12.g Slope 0.0028

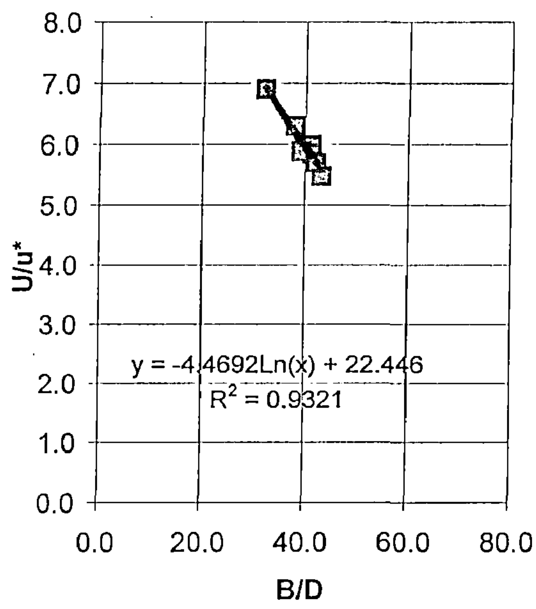


Fig. 5.12.h Slope 0.0029

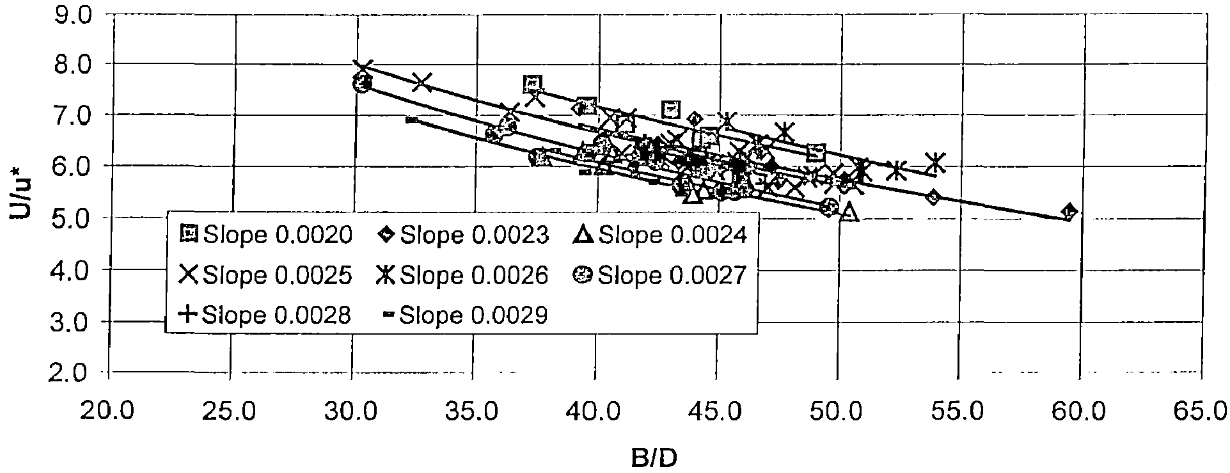


Fig. 5.13 Relations between U/u* and B/D with different slope

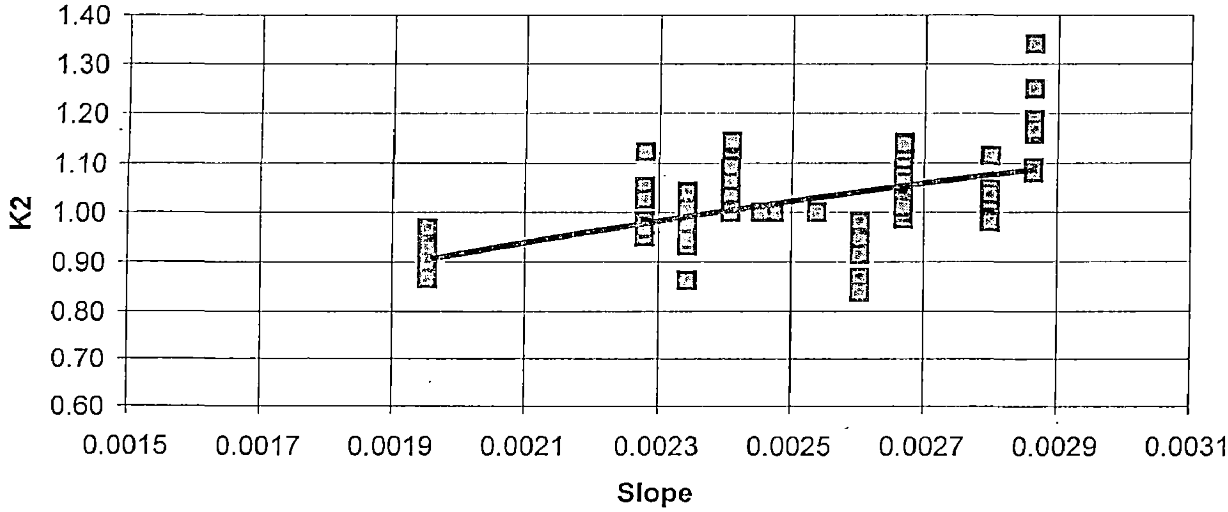


Fig.5.14 Relations between correction factor (K2) and slope

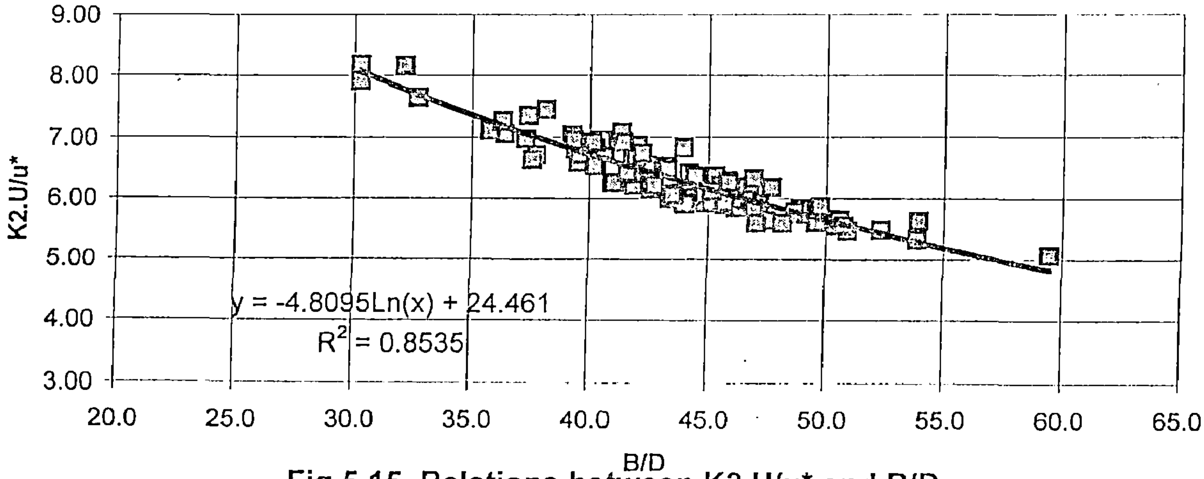


Fig.5.15 Relations between K2.U/u* and B/D
(Experimental data)

FIGURE 5.16 RELATIONSHIP BETWEEN RESISTANCE COEFFICIENT AND B/D RATIO (FIELD DATA)

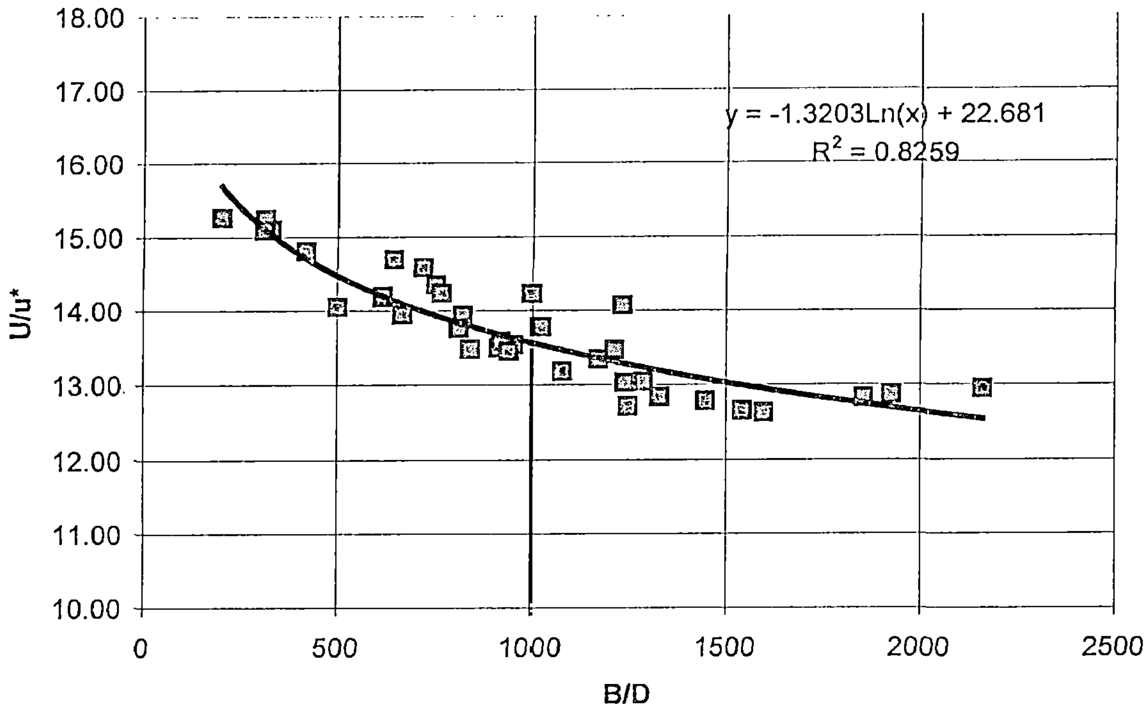


Fig. 5.16.a Relations between U/u* and B/D (Logaritmic form)

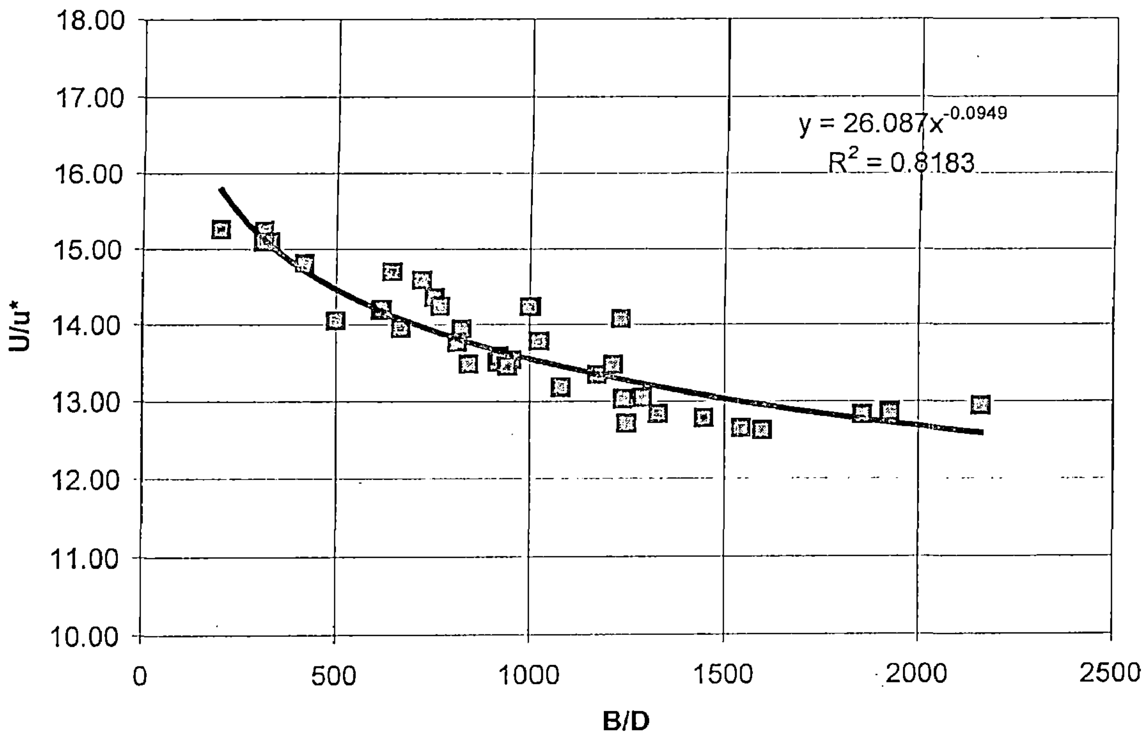


Fig. 5.16.b Relations between U/u* vs B/D (Power form)

Fig. 5.17 RELATIONS BETWEEN U/u* AND B/D RATIO AT DIFFERENT SLOPE

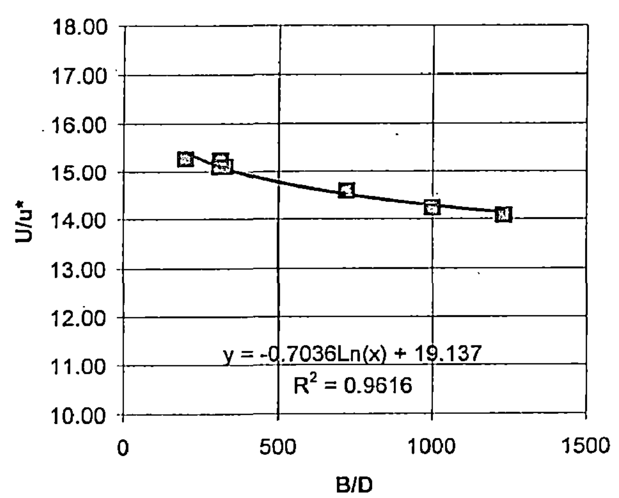


Fig. 5.17.a Slope 0.000073

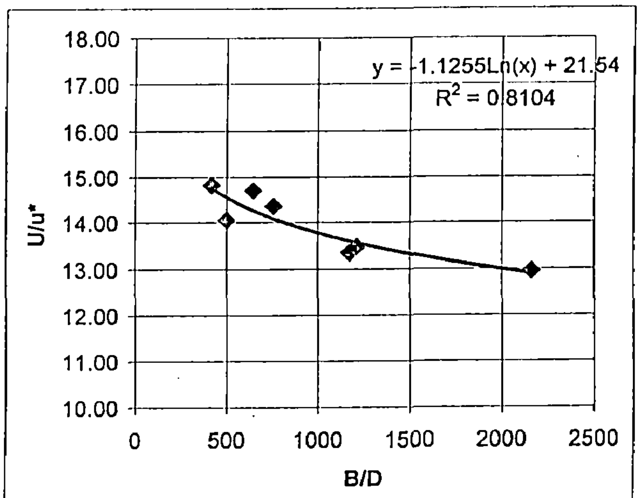


Fig. 5.17.b Slope 0.000085

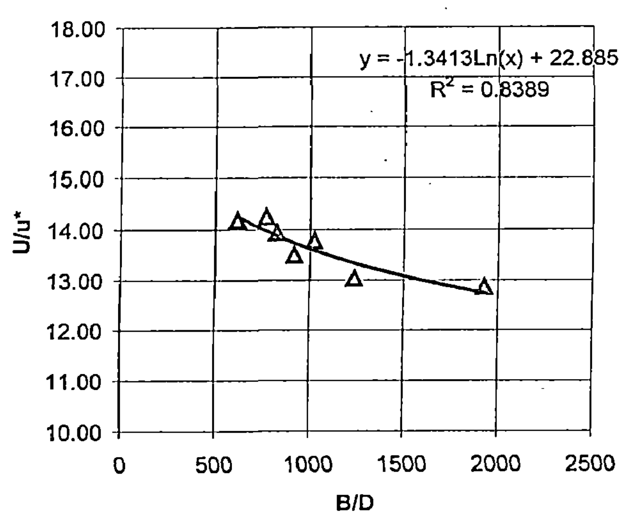


Fig. 5.17.c Slope 0.000088

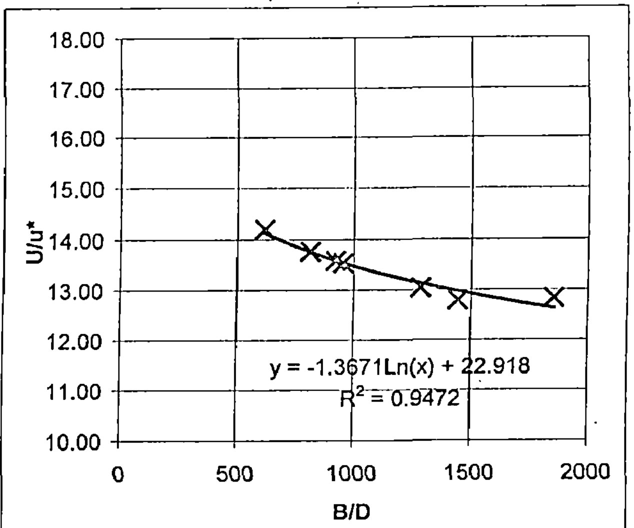


Fig. 5.17.d Slope 0.000091

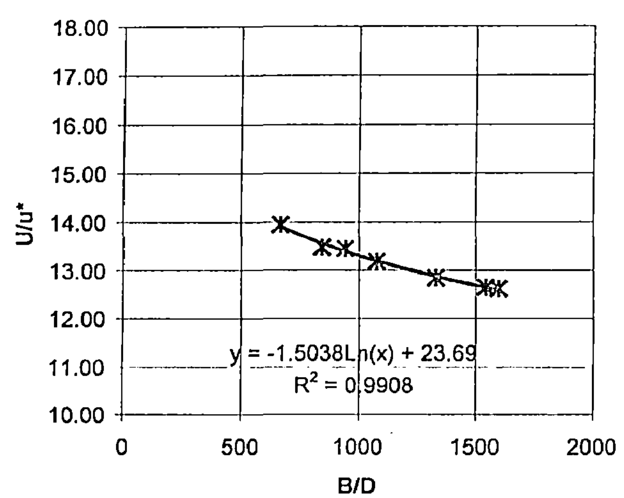


Fig. 5.17.e Slope 0.000095

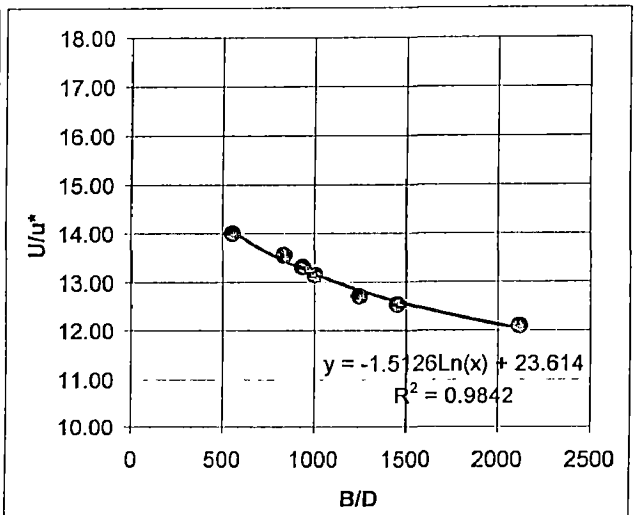


Fig. 5.17.f Slope 0.000097

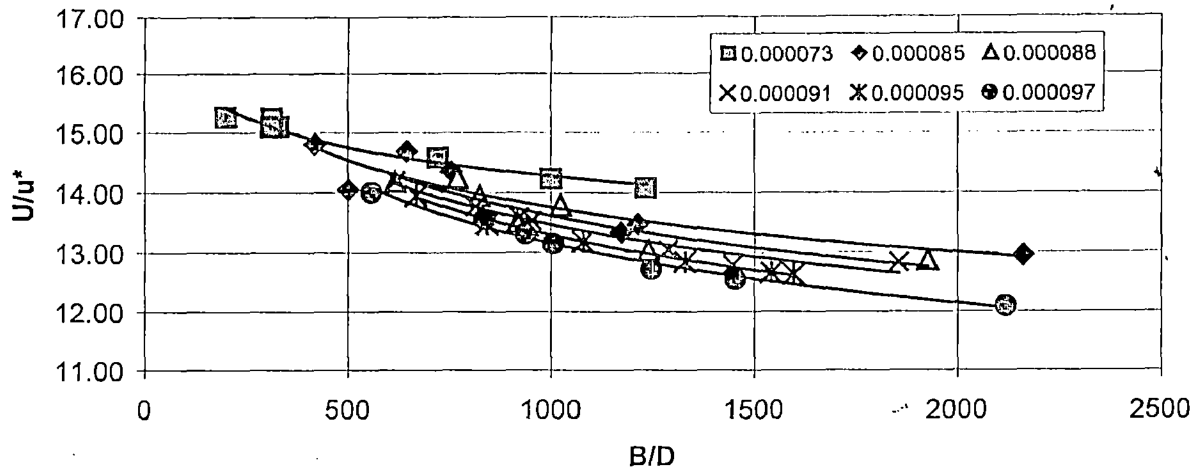


Fig.5.18 Relations between U/u* vs B/D with different slope

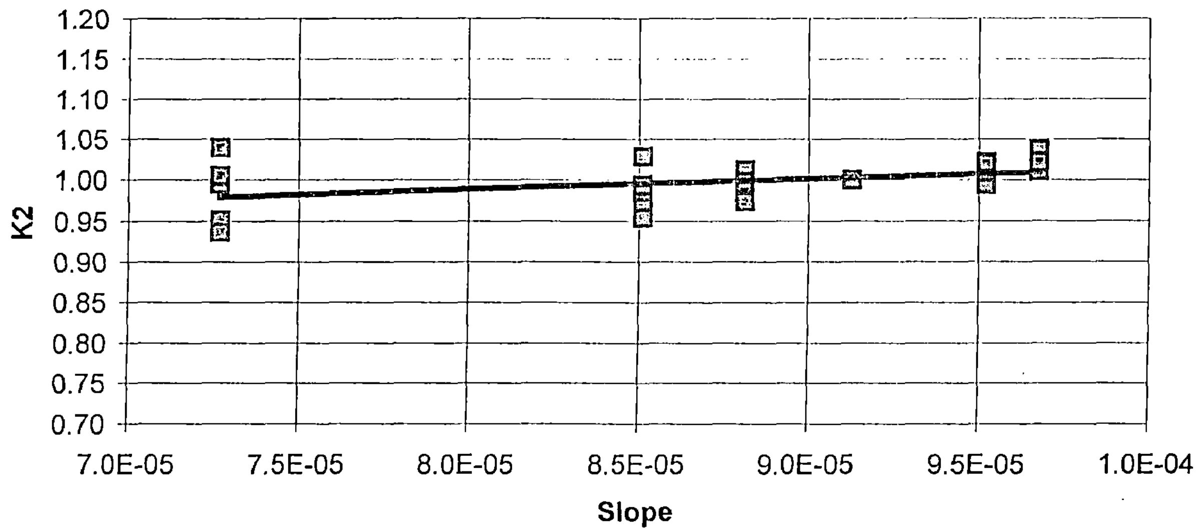


Fig.5.19 Relations between factor corection (K2) and slope

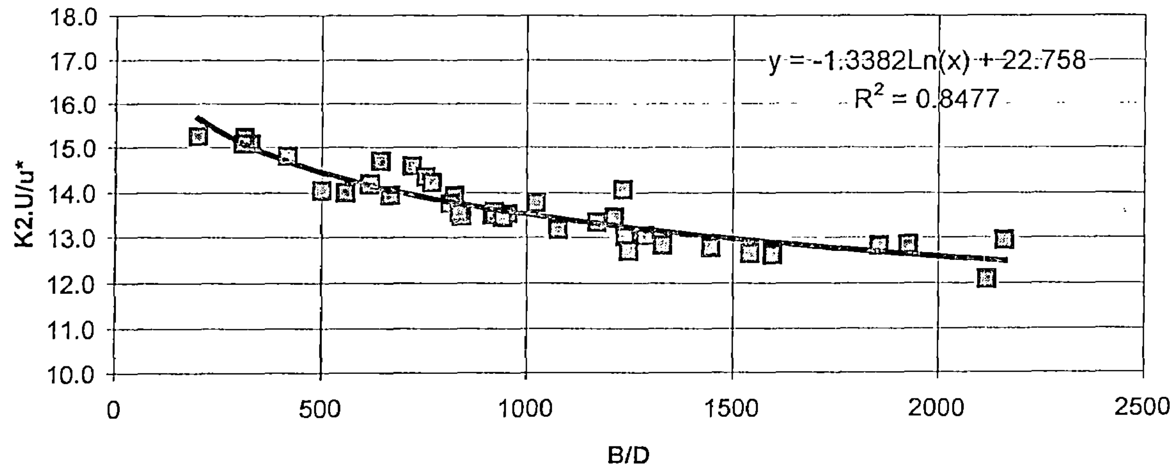


Fig.5.20 Relation between K2.U/u* and B/D (Field data)

5.4 TEST OF DIFFERENT EQUATIONS

During the analysis, the equations given by Limerinos, Leopold-Miller & Wolman, White & Collebrook, were tested.

5.4.1 Method of evaluation

A conventional method such as the graphical one is on many occasions used when results from mathematical model are to be compared against observed data. Previous study on alluvial rivers also based their conclusions on graphical comparison, despite the largely subjective nature of such a method. Comparison is made between the computed (f study) and the observed values of U/u*, f. The line of perfect agreement or a set of envelops defining a certain error margin is then used as the guideline in the assessment. The major drawback of this method is that when the performance of the two models are tend to be similar, any difference in the degree of variance is hardly perceptible from the plots and the superiority of the one or the other cannot be spelled out in concrete terms.

The standard error of estimate has often been used as a statistical tool for comparative assessment of different models. It provides a quantitative measure of scatter of observed data relative to the curve defined by the model. If Y_0 and Y_c be the observed and computed values of the variables and if there is n such points in a series, then the standard error of estimate is given by:

$$\textit{Standard error of estimate} = \sqrt{\sum_{i=1}^{n} \frac{(yo - yc)^2}{n-2}} \quad (5.22)$$

As the quality of the model increases, the parameter approaches to zero. The fact remains, however that the tool is purely statistical and has been criticized on many occasions for giving over-simplified picture of a complex problem.

a. Friction factor equation version of White – Colebrook

Friction factor version of White – Colebrook has been used to compute the friction factor of both experimental and field data. Comparing the equation of the present study with this equation yielded standard error of estimate for each value of the f study as 0.0285 for f1, 0.188 for f2, 0.0174 for f3 and 0.0337 for f4.

The plot of the f1 study and f of White - Collebrook equation (fig.5.21), showed the group data relation between f1 study and f of White-Colebrook. Most of data point were found to lie between the 25 % and 50 % error margin, and about 6 data points on the were found to lie with in the + 50 % error margin.

For equation f2, f3 & f4 study (fig.5.27), (fig.5.30), (fig.5.37) showed, that all data points lie in the + 50 % error margin thus the equation was found to underestimate the value of friction factor.

b. Friction factor equation version of Leopold – Wolman & Miller

Computation of friction factor version of Leopold - Wolman & Miller was carried out for both experimental and field data. Comparing the present study equation with Leopold – Wolman & Miller equation yielded standard error of estimate for each value of the f study as 0.0241 for f1, 0.334 for f2, 0.0095 for f3 and 0.0255 for f4.

The plot of the f1 study, f4 study and Leoplod et,al equation (fig.5.24), (fig.5.34) showed all of data points were found to lie between the 25 % and 50 % error margin.

For f2 study, (fig.5.28) showed about 6 data points lie below 25 % error and most of data point were found to lie between the 25 % and 50 % error margin, plotting f3 study (fig.5.29) showed about 6 data point lie nearly perfect agreement line, around 30 % of data were found to lie between the perfect agreement and 25 % error margin. Around 70 % of data were found to lie between the 25 % and 50 % error margin and only one data were found to lie with in the + 50 % error margin.

c. Friction factor equation version of Limerinos (d84)

Computation of friction factor for version of Limerinos (d84) was carried out for both experimental and field data. Comparing the present study equation with Limerinos (d84) equation yielded standard error of estimate for each value of the f study as 0.0232 for f1, 0.098 for f2, 0.0080 for f3 and 0.0246 for f4.

The plot of the f1 study, f4 study and Limerinos (d84) equation (fig.5.23), (fig.5.36) showed all of data points were found to lie between the 25 % and 50 % error margin.

For f2 study, (fig.5.28) showed about 6 data points lie below 25 % error and most of data point were found to lie between the 25 % and 50 % error margin, plotting f3 study (fig.5.29) showed about 6 data point lie in the perfect agreement line, around 60 % of data were found to lie between the perfect agreement and 25 % error margin. Around 40 % of data were found to lie between the 25 % and 50 % error margin

d. Friction factor equation version of Limerinos (d50)

Similarly, for friction factor version of Limerinos(d50) comparing the present study equation with Limerinos d50) equation yielded standard error estimate for each value of the f study as 0.0284 for f1, 0.160 for f2, 0.0140 for f3 and 0.0296 for f4.

The plot of the f1 study and Limerinos (d50) equation (fig.5.24), showed all of data points were found to lie in the + 50 % error margin.

For f2, f3 and f4 study (fig.5.25), (fig.5.31) and (fig.5.35) showed some of data points lie between 25 % error and 50 %

error and most of data point were found to lie in the +50 % error margin.

5.4.2 Test of the equation used with different data.

Computation of friction factor study using different data has been carried out to show, which one of the equation can be reliably to calculate friction factor for the other data.

For friction factor equation using parameter (R/d50) ratio f1 and f2 study as a parameter (Table A-6.1831) showed that the computation using eq.(5.9) and eq.(5.11) equation has highly underestimated the value of the friction factor, and also the standard error estimate in computing the friction factor using eq.(5.9) and eq.(5.11) equation was 1.5159.

Similarly for friction factor with (B/D) ratio as parameter also has been tested with different data. Friction factor f3 (Fig.5.33) showed most of data points lie between 25 % and 50 % error margin and some of data points lie with in +50 % data point. And friction factor f4 (Fig.5.38) showed 15 % of data point lie between perfect agreement line and 25 % error margin, 35 % data points lie between 25% error margin and 50 % error margin and 50 % of data points.

Beside that, present study also tried to obtain relation ship between experimental data and field data, and from that relation we can obtain best-fit equation for braided river.

Fig.5.39 did not produce a clear trend but the corresponding trend of the best-fit lines for U/u* vs. B/D in Fig.5.40, for experimental and field data depicted a similarity in character.

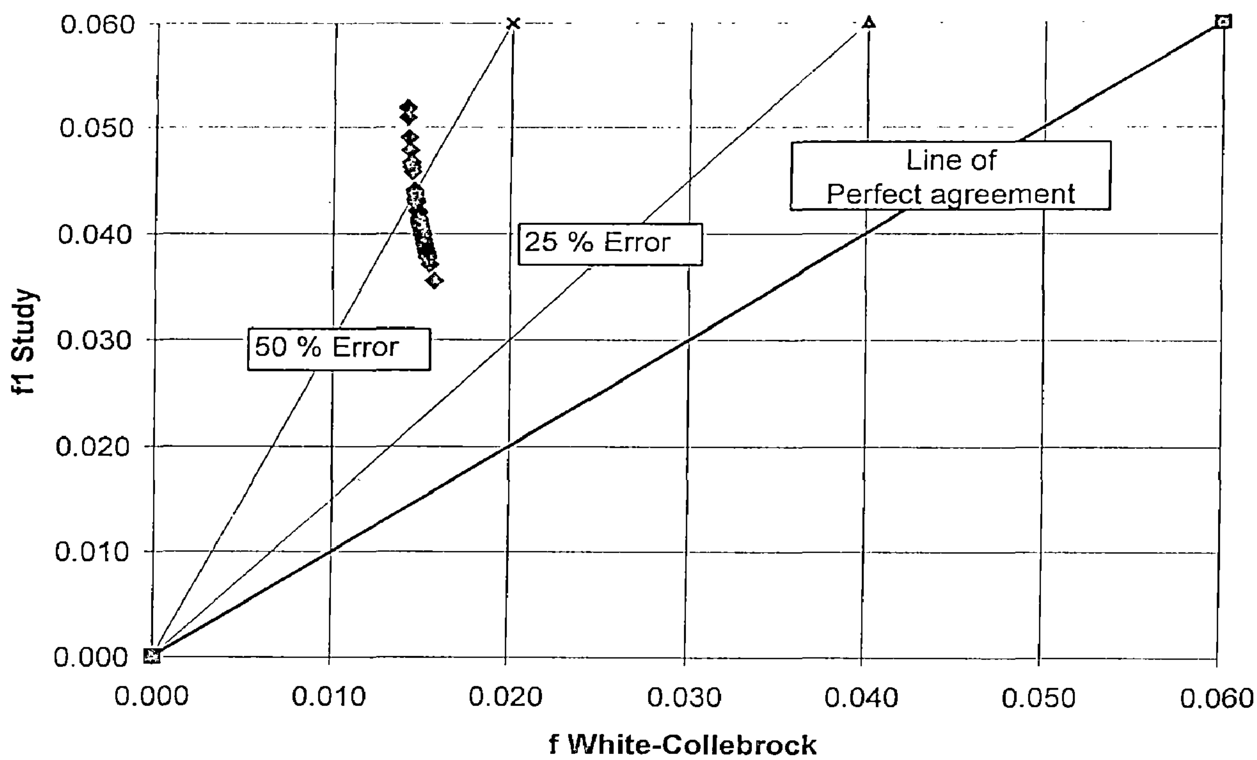


Fig. 5.21 Comparison between f1 study and f White - Collebrock

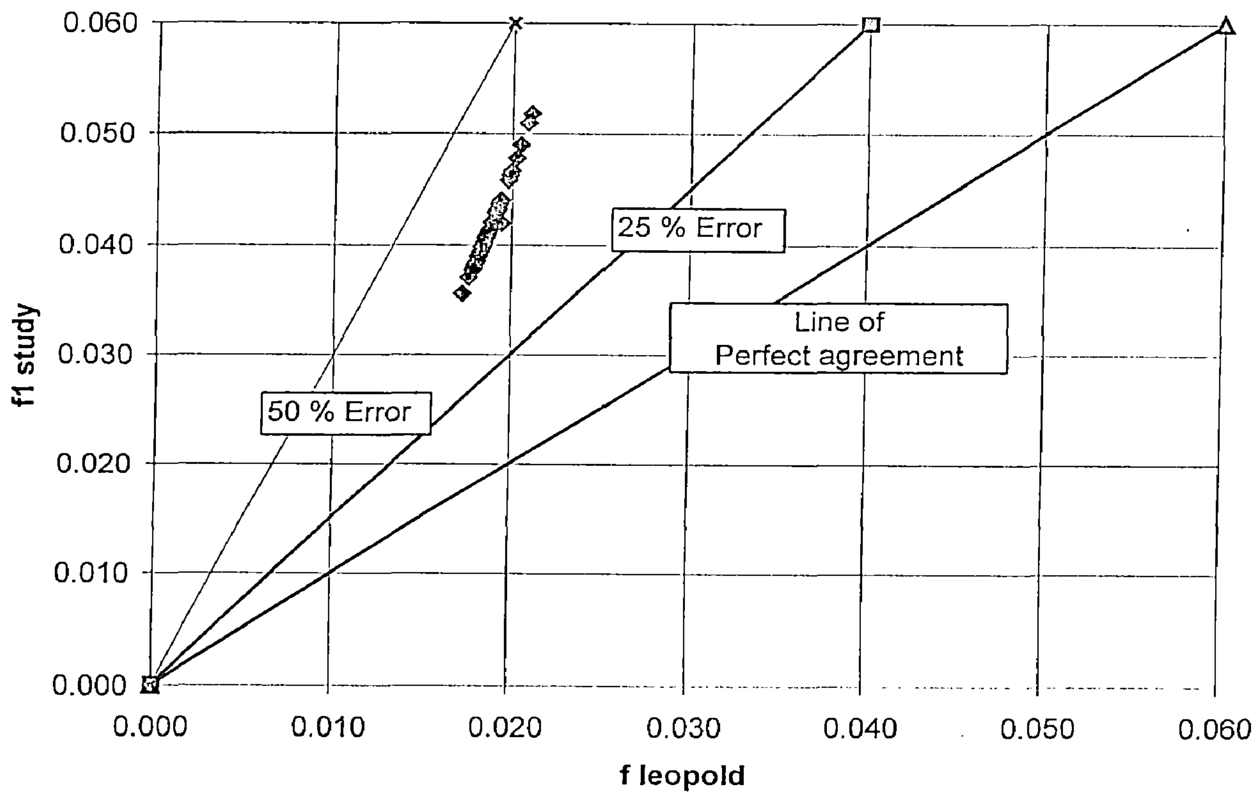


Fig. 5.22 Comparison between f1 study and f leopold,et al

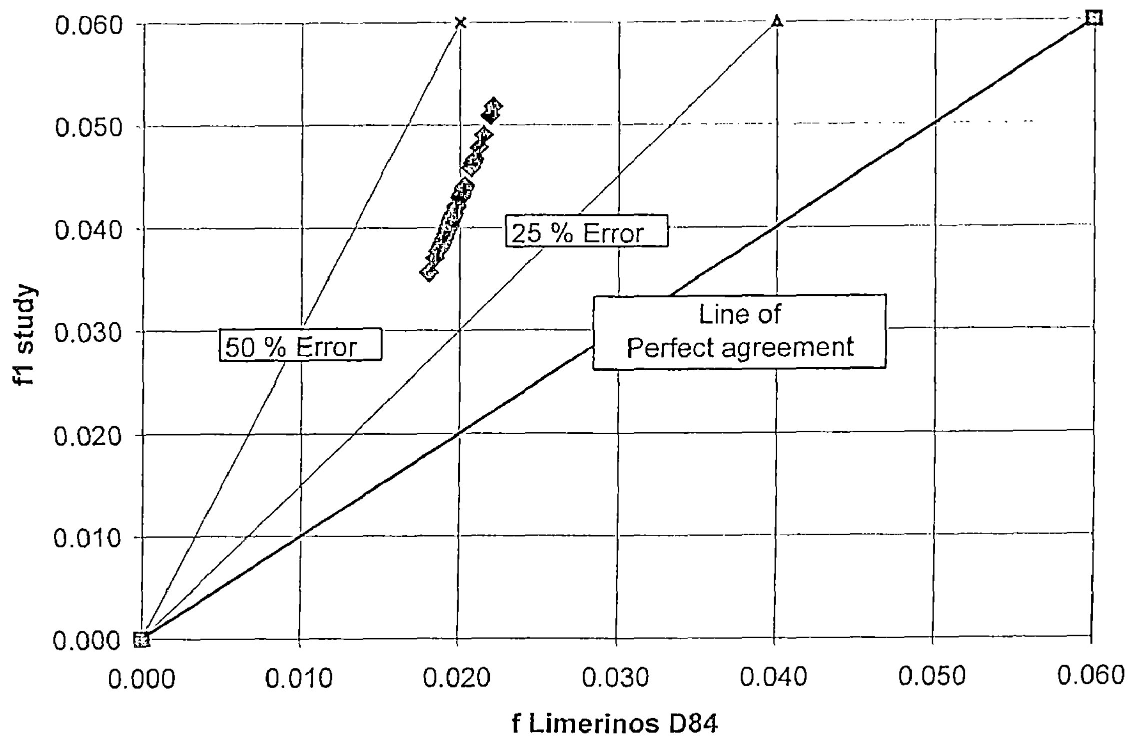


Fig. 5.23 Comparison between f1 study and and f Limerinos d84

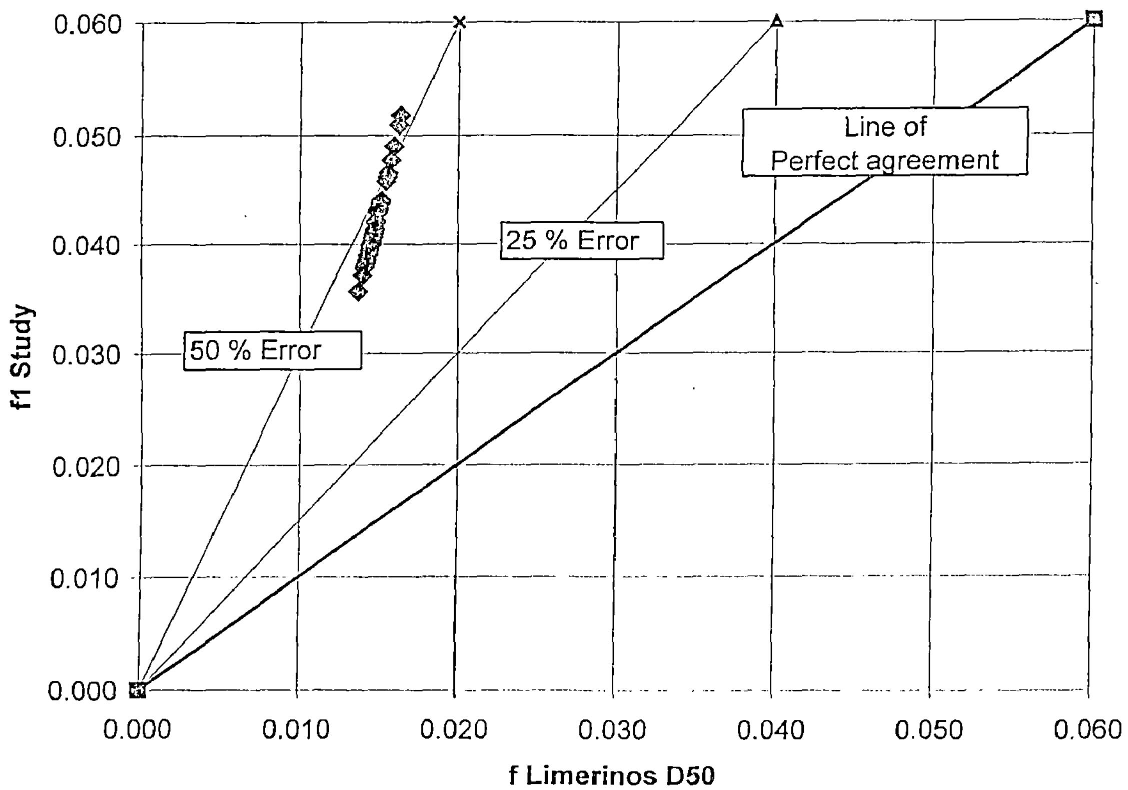


Fig. 5.24 Comparison between f1 study and and f Limerinos (d50)

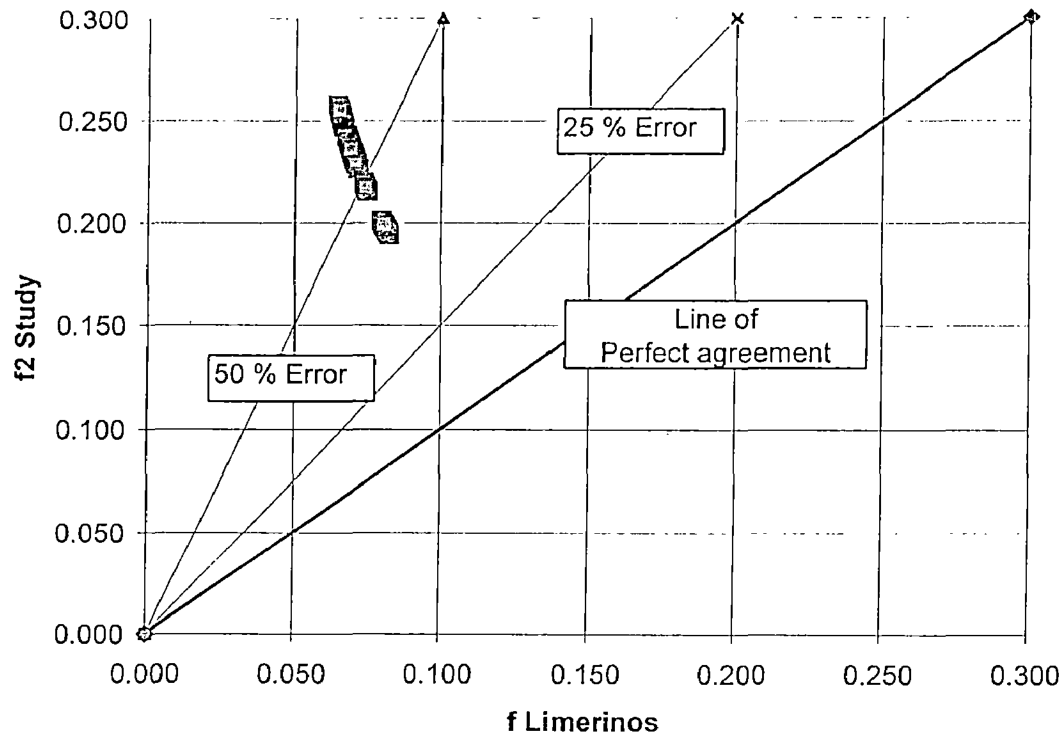


Fig.5.25 Comparison between f2 Study and f limerinos(d50)

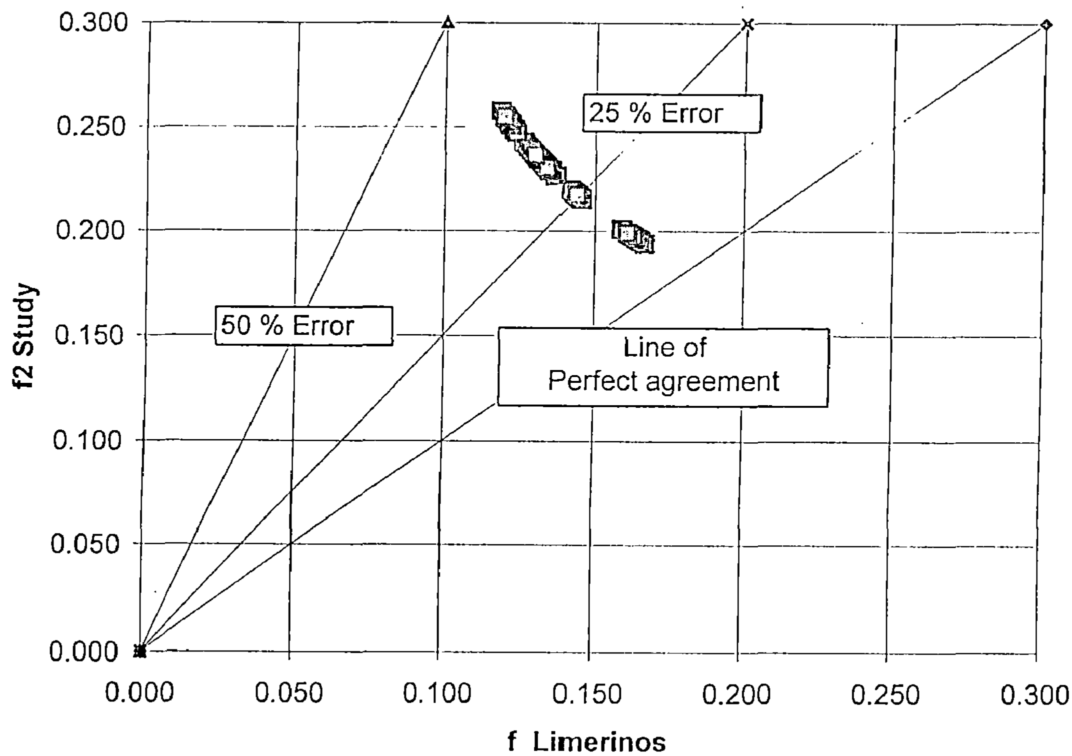


Fig.5.26 Comparison between f2 Study and f limerinos(d84)

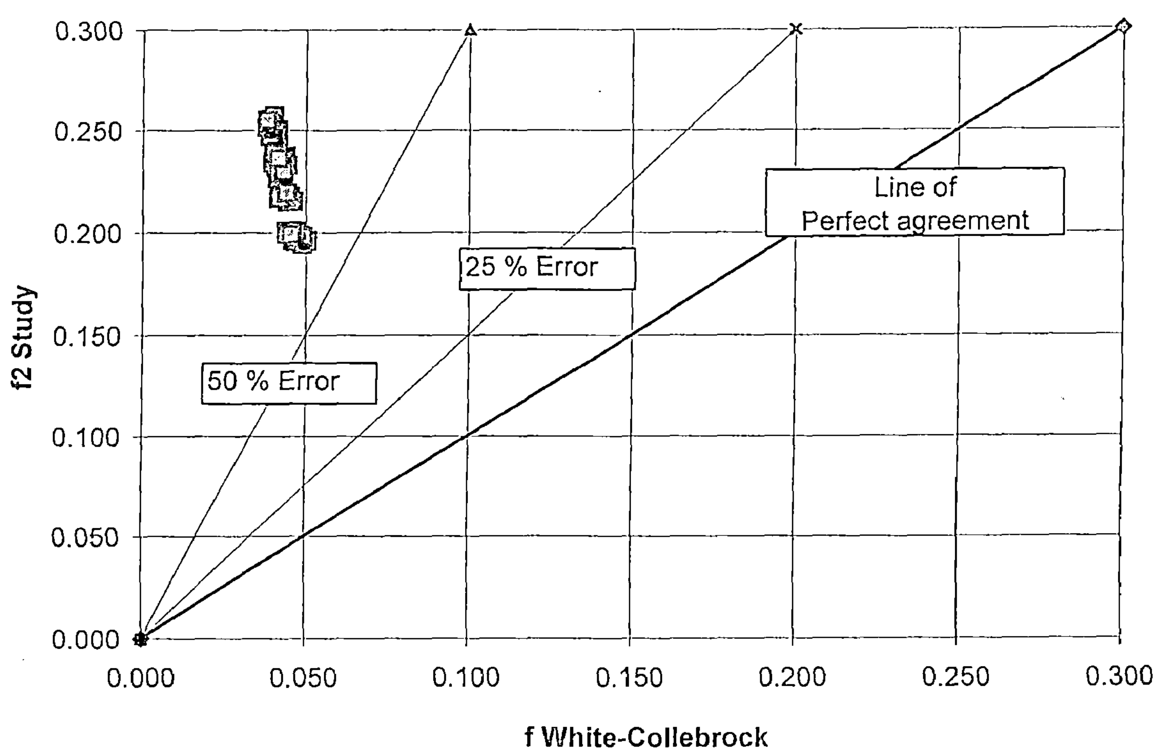


Fig.5.27 Comparison between f2 Study and f White-Collebrock

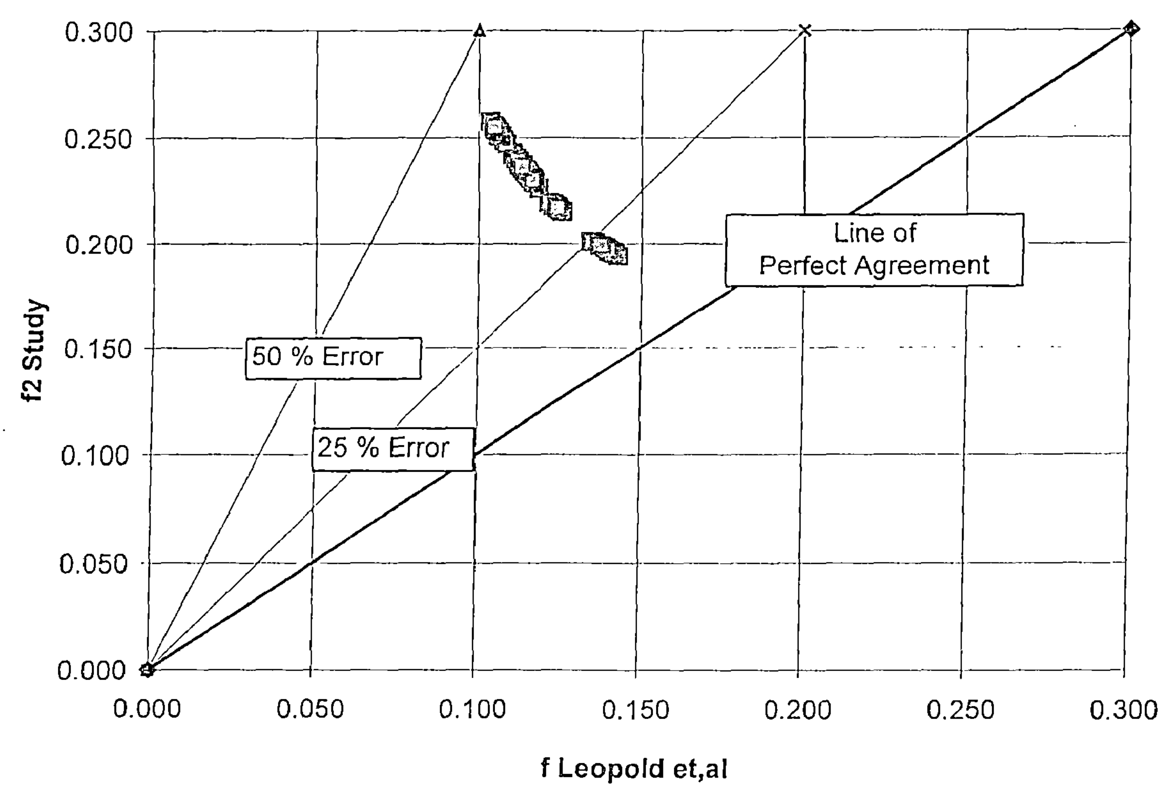


Fig.5.28 Comparison between f2 Study and f Leopold,et.al

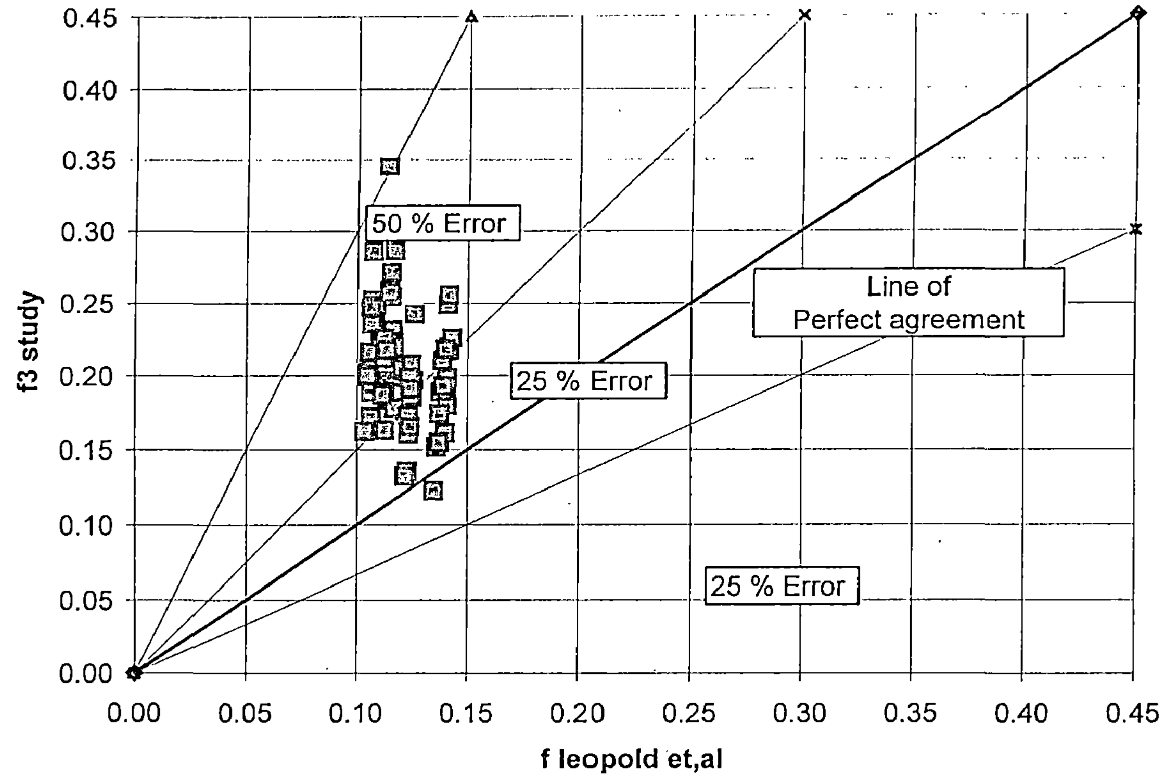


Fig.5.29 Comparison between f3 study and f Leopold et.al

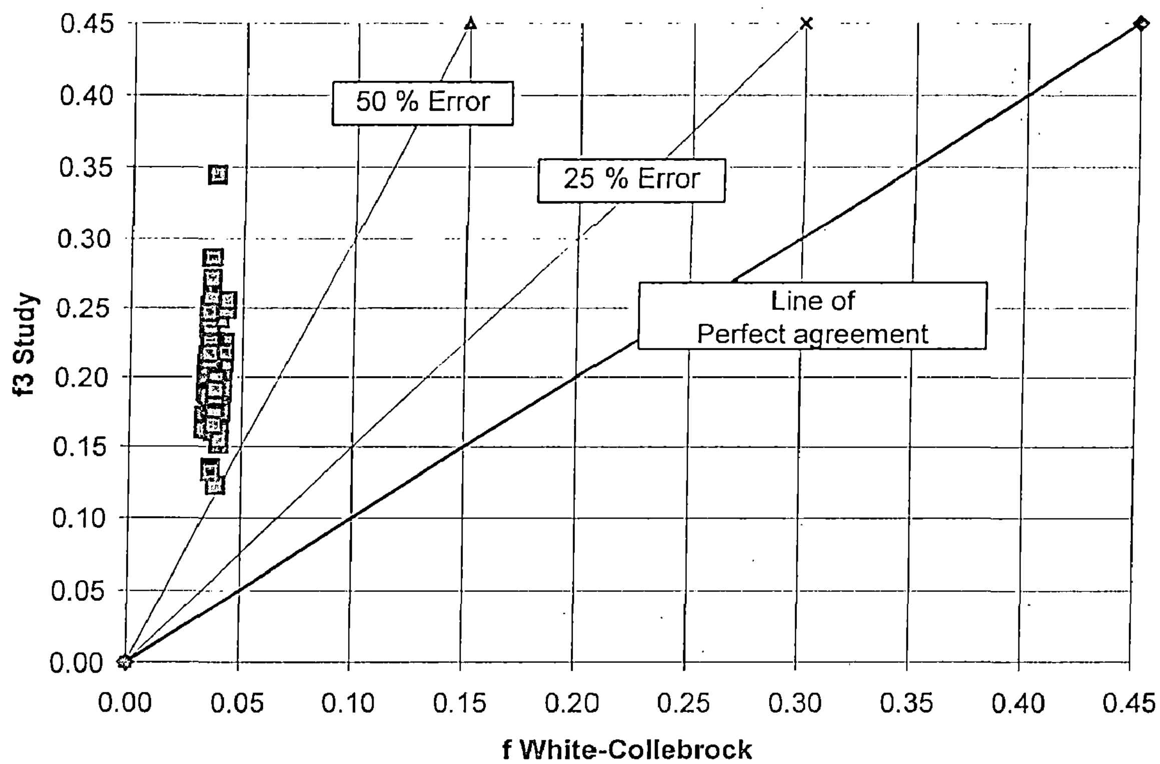


Fig. 5.30 Comparison between f3 study and f white-Collebrock

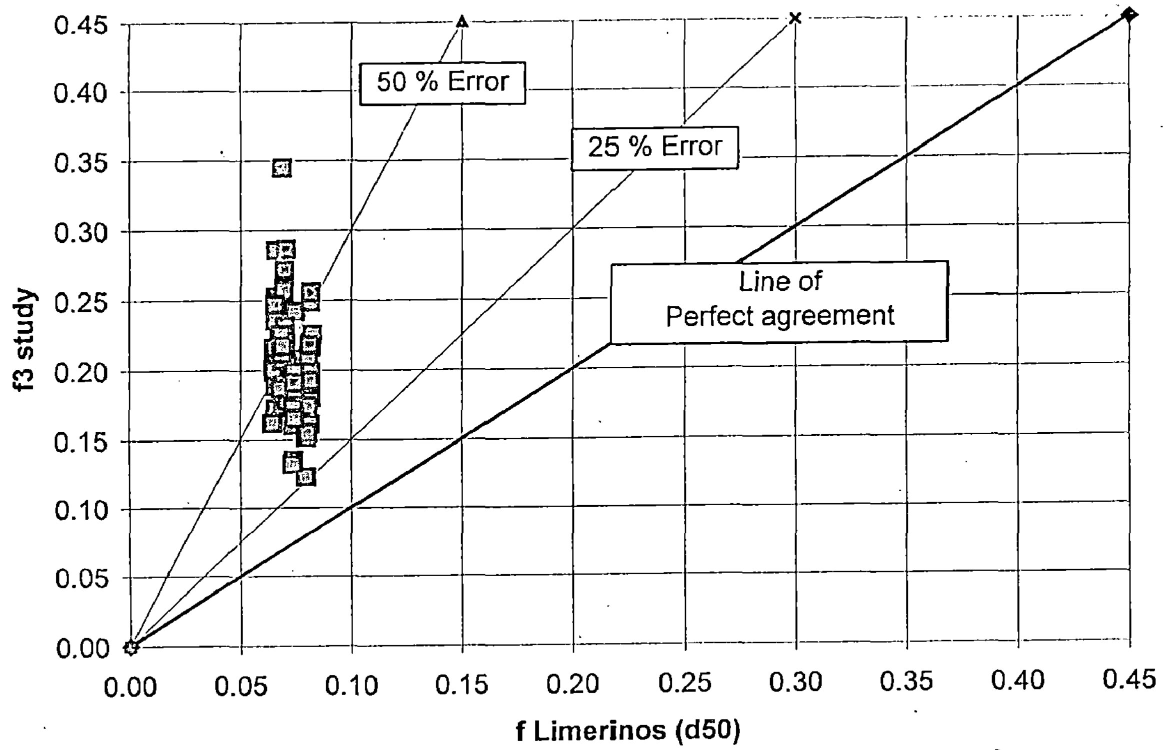


Fig.5.31 Comparisson between f3 study and f Limerinos(d50)

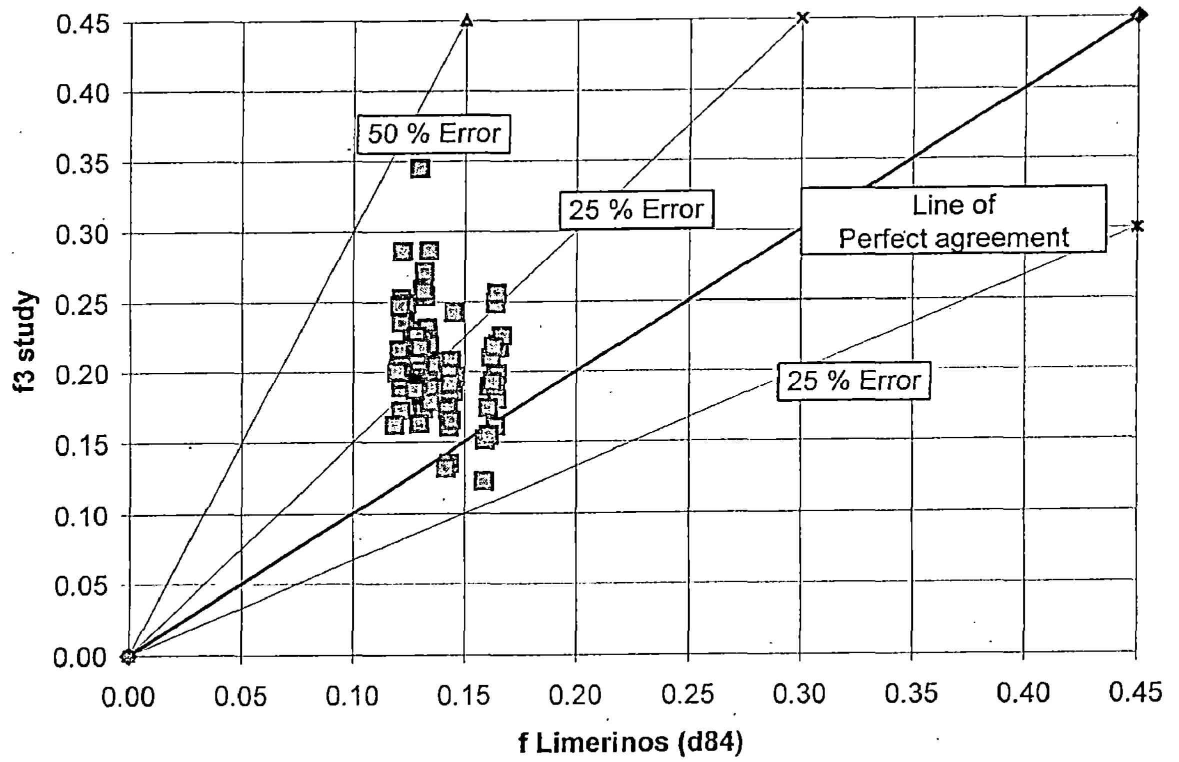


Fig.5.32 Comparisson between f3 study and f Limerinos(d84)

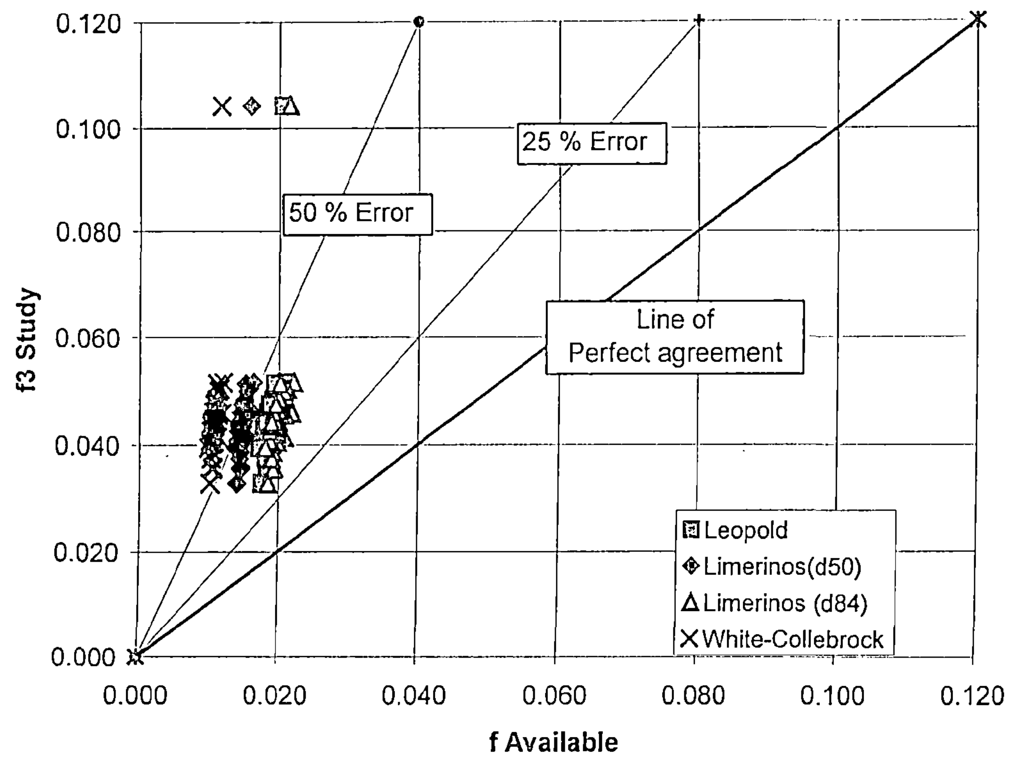


Fig.5.33 Comparison between f3 study and f available used field data

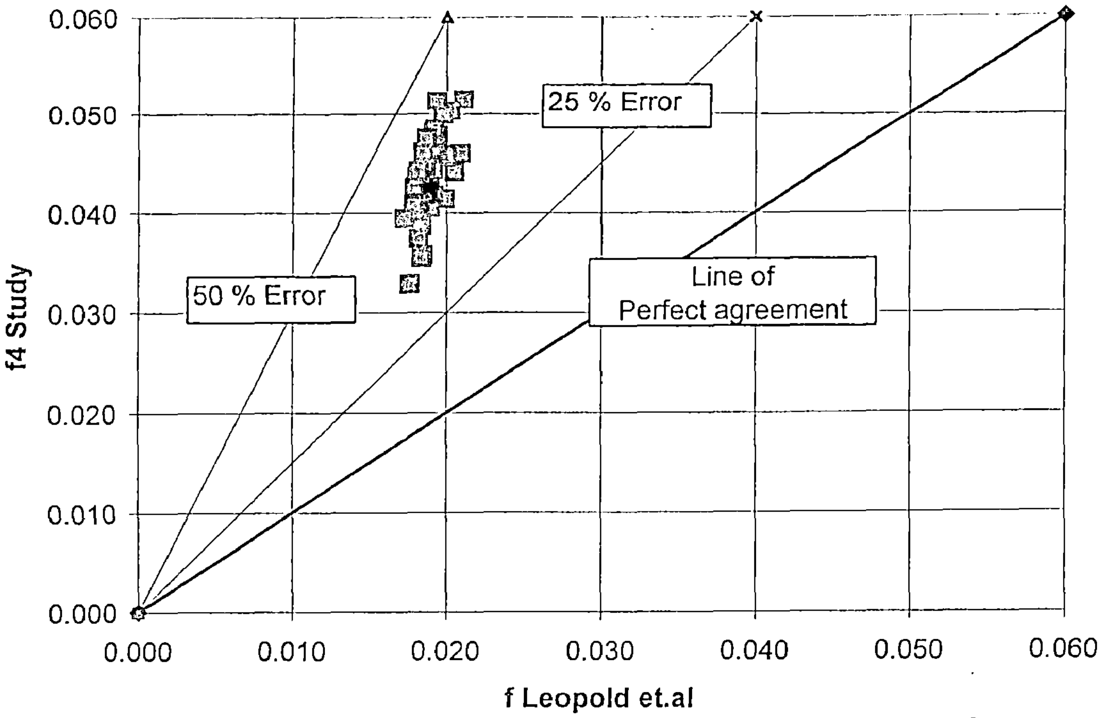


Fig.5.34 Comparison between f4 Study and f Leopold et.al

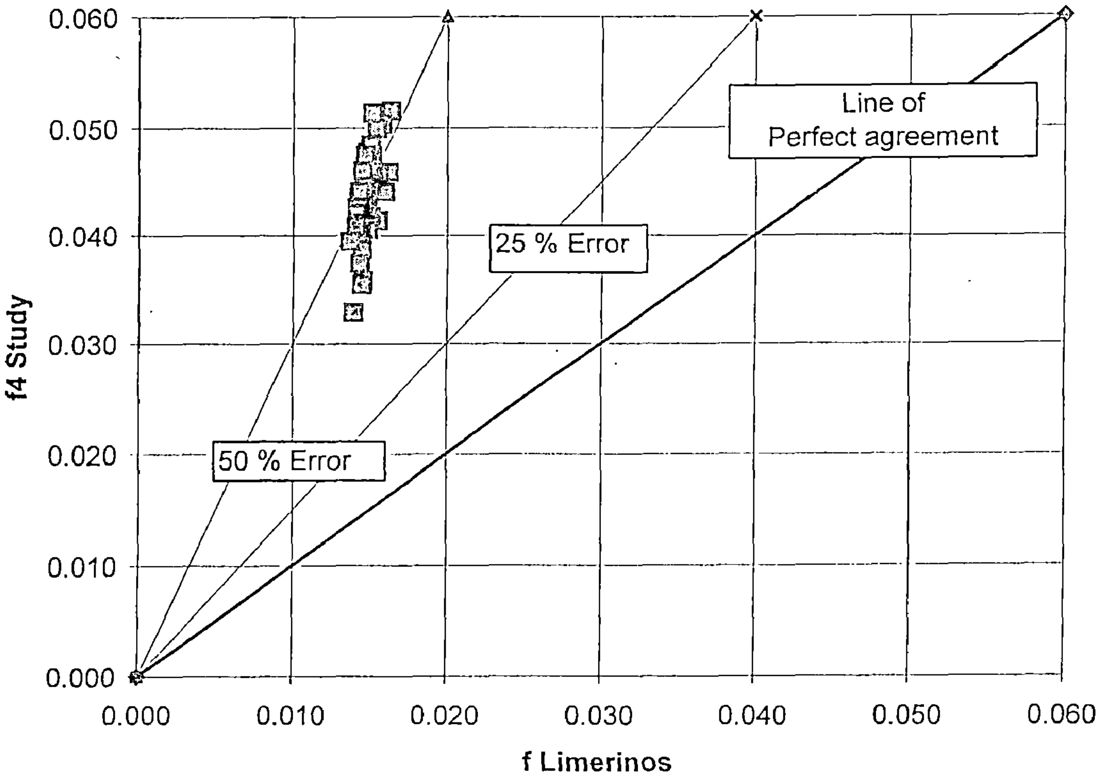


Fig.5.35 Comparison between f4 Study and f and f Limerinos (d50)

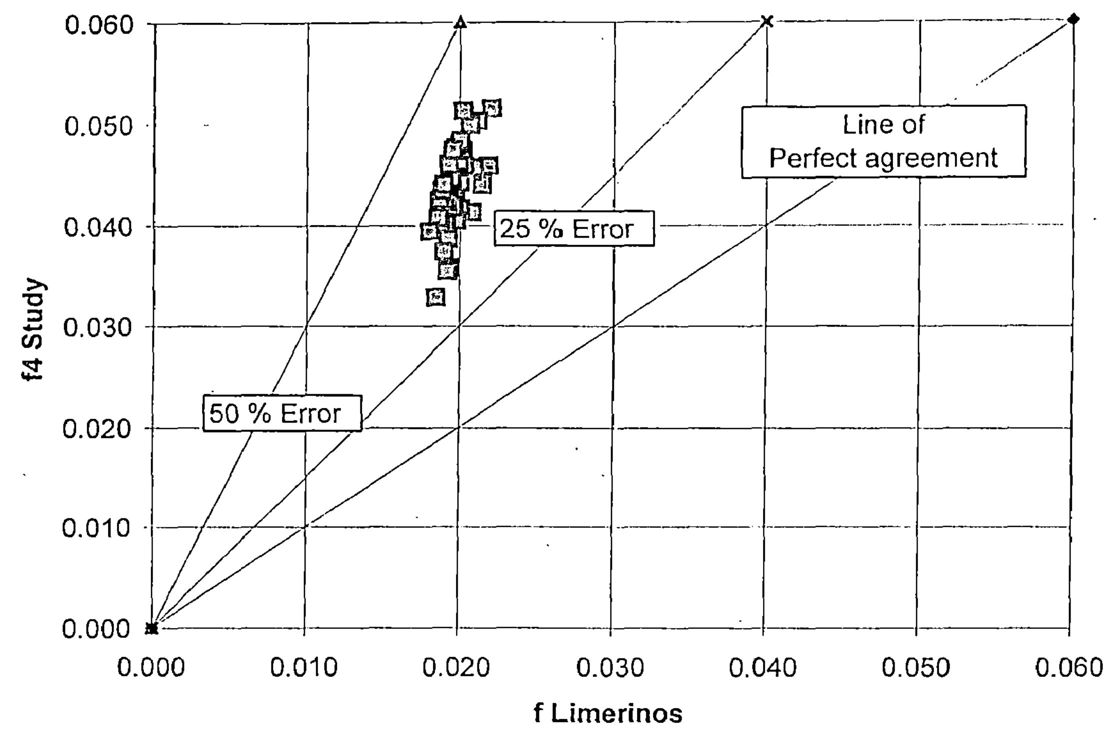


Fig.5.36 Comparison between f4 Study and f and f Limerinos (d84)

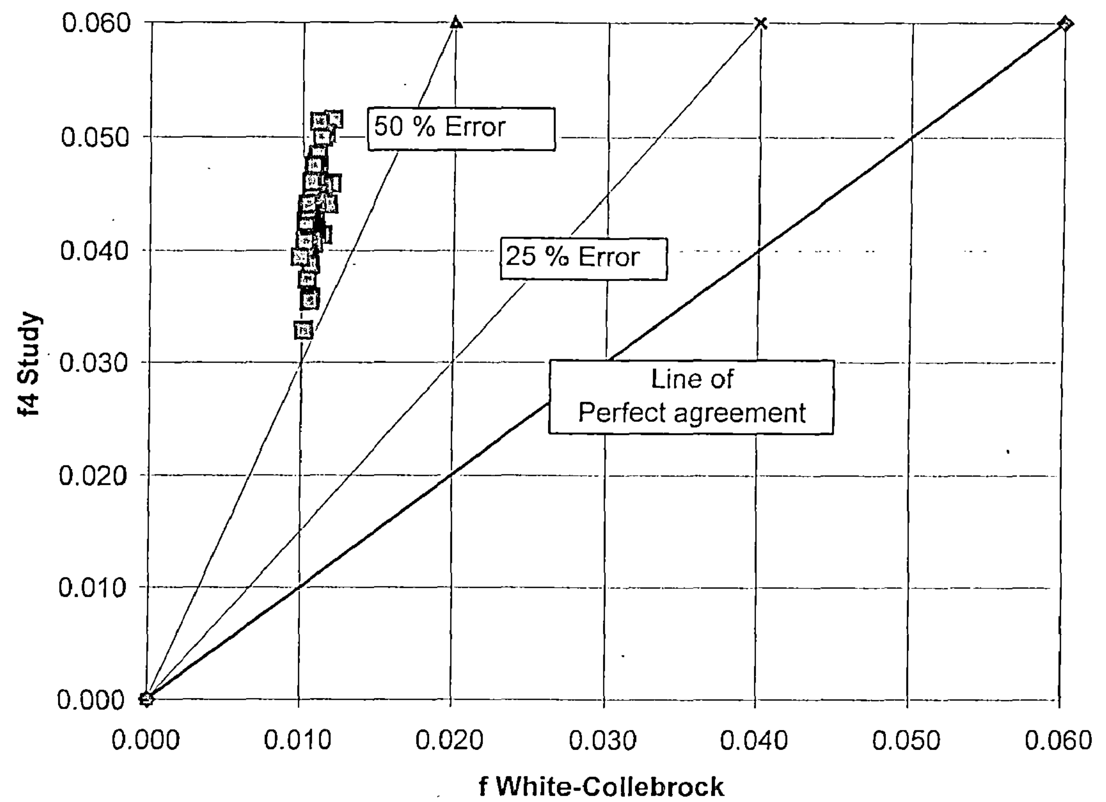


Fig.5.37 Comparison between f4 Study and f and ff White-Collebrock

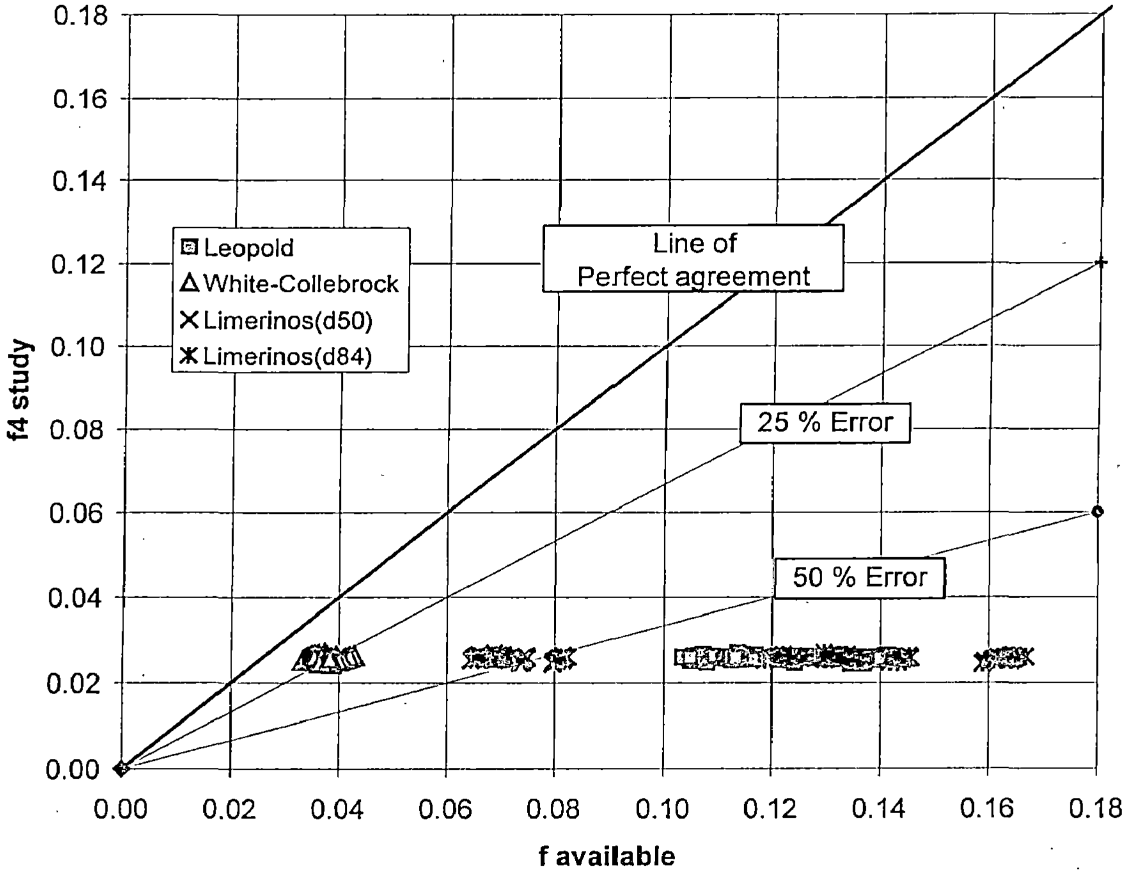


Fig.5.38 Comparisson between f4 study and f Available

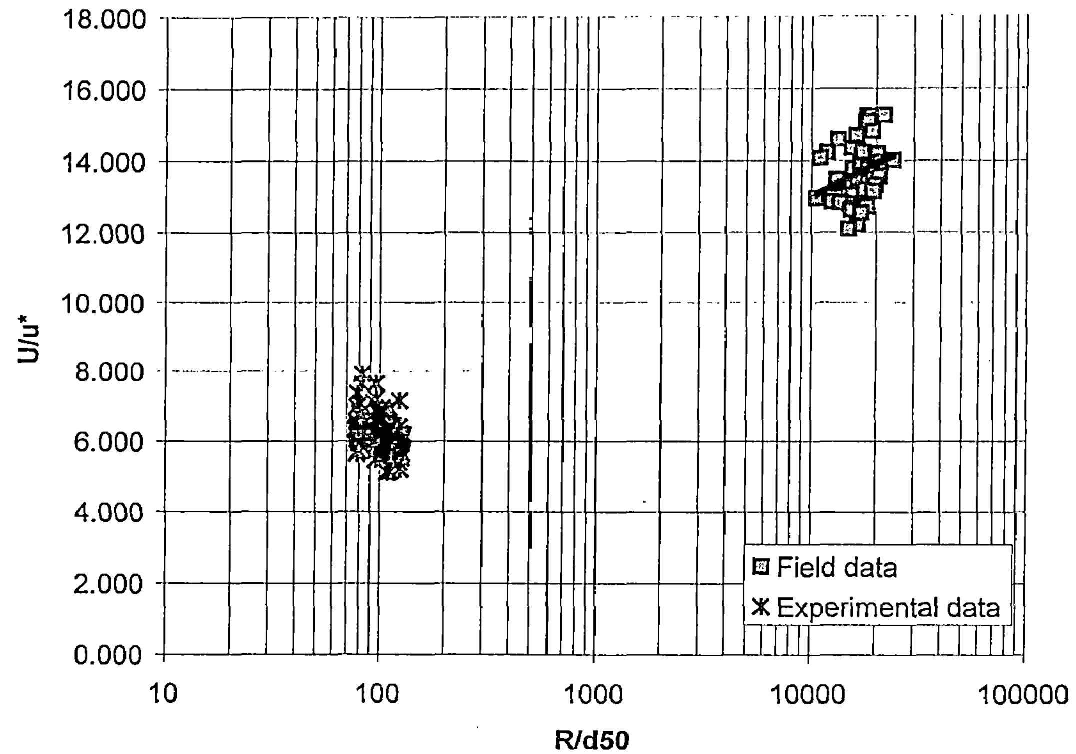


Fig. 5.39 Relations between U/u* and R/d50
(Semi-log graph)

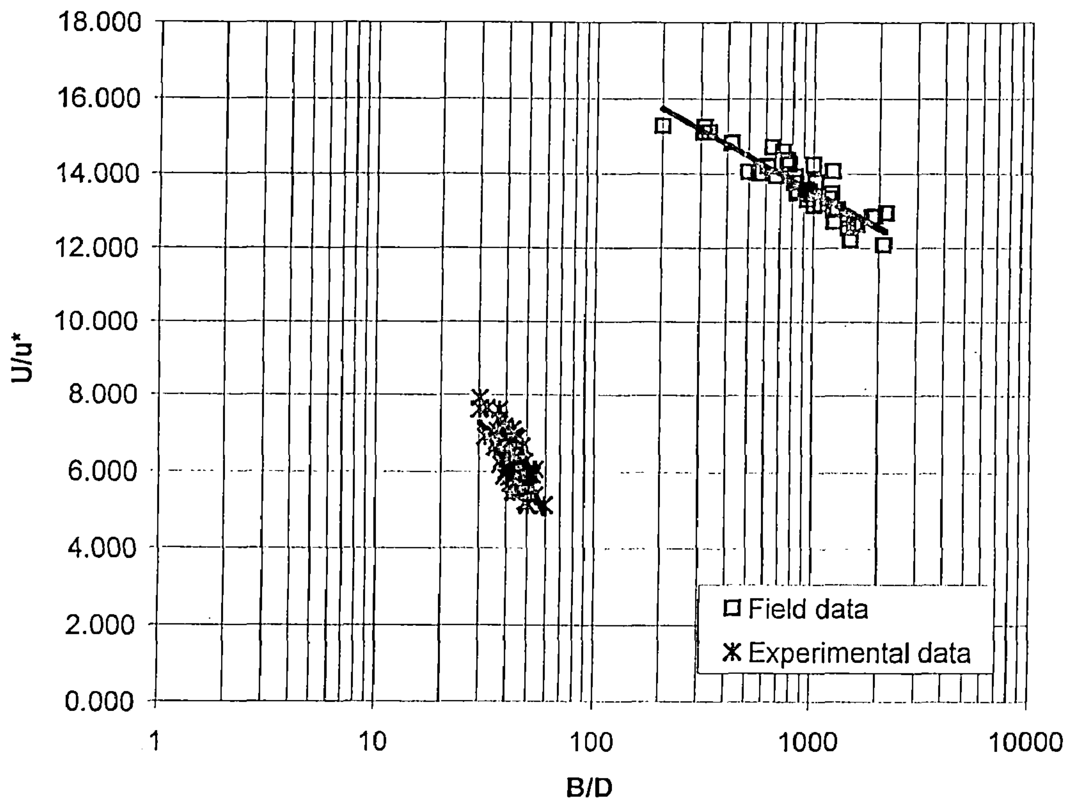


Fig.5. 40 Relations between U/u* and B/D
(Semi-log graph)

CONCLUSIONS

6.1 CONCLUSIONS

Available data from flume and natural stream were analyzed to study the problem of resistance to flow in braided river. The main objective of the present study was to explore the possibility of developing a resistance model for braided channel configuration in the light of available information on the fluvial characteristics of braided channel. The salient conclusions drawn on the basis of the present study are summarized below:

1. Many investigators used parameter R/d ratio as a function of the roughness coefficient. In the present study, the functional relationships given by this parameter could not be developed into a satisfactory resistance relationship using the available data. The failure of these models is ascribed to errors in extrapolation at high R/d values.

2. The parameter B/D based on Taizo – Hayashi relation for braiding indicator was examined in the present study. According to this, the resistance relationship for braided river can be expressed by the following functional relationship:

$$\frac{U}{u*} = -4.8095.\ln(B/D) + 24.461$$

$$\frac{1}{\sqrt{f}} = 8.648 - 1.70.\ln(B/D)$$

3. Compared with other equations for experimental data it showed that for Limerinos (d84) equation and Leopold – Woldman & Miller equation the present proposed equation gave fairly satisfactory value, and for Limerinos (d50) equation, most of data points of the present equation lie between 25% and 50% error margin levels. Only for White – Collebrook friction factor, the proposed equation did not give satisfactory comparison.

4. Verification of the present proposed equation using field data with the high scale of B/D ratio, as shown in (fig.5.33) has yielded satisfactory results. This figure showed that more than 65% of the data points for field data lie between 25% and 50% error margins in comparison to similar exercise done with the other equations such as Limerinos (d50), Limerinos (d84), Leopold – Wolman & Miller. Only for White – Collebrook friction factor, this proposed equation of the present study did not give satisfactory agreement.

5. Unsatisfactory agreement given by White – Collebrook equation could perhaps attributed to the fact that the same was recommended only for friction factor in pipe.

6.2 SUGGESTIONS FOR THE FUTURE STUDY

1. Extensive study needs to be carried out for ascertaining the appropriate reference level in the movable bed conditions.

2. It is felt that an extensive study to understand the hydraulics of the resistance in braided river is essential. As all the equation available until date for this roughness range are only empirically based with smaller flume and field data, therefore research for

developing an equation with theoretical support with a more extensive database is needed

3. There is need to study effect of the slope on the resistance to flow in the braided river.

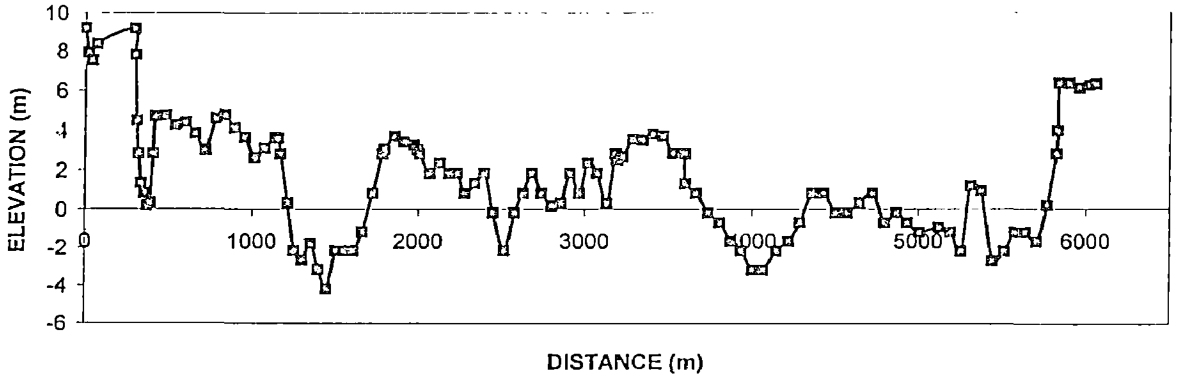
REFERENCES

1. Bakhmetteff, Boris A. (1932), Hydraulics of open channels, McGraw – Hill International editions.
2. Ben, Chie Yen., Wenzel Harry G., Jr., and Yong Nam Yoon (1972), Resistance coefficients for steady spatially varied flow, JHDE, ASCE vol. 98, no. HY8
3. Best, J. I & Bristow. C. S (1993), Braided Rivers, Geological society special publications no. 75, the geological Society London.
4. Burkham, Durl E. and Dawdy, David R. (1976), Resistance equation for alluvial – channel flow, JHDE, ASCE vol. 102, no. HY10
5. Chanson, H (2000), Boundary shear stress measurement in undular flows: Application to standing wave bed forms, Journal of Water Resources Research, Vol. 36, no 10
6. Chin-lien, Yen and Overton, Donald E. (1973), Shape effect on resistance in flood-plain channels, JHDE, ASCE vol.99, no.HY1
7. Chow, Ven Te (1973), Open Channel hydraulics, McGraw – Hill International editions.
8. Garde, R. J., Ranga Raju, K. G. (2000), Mechanics of sediment transportation and alluvial stream problems, New Age International (P) limited, Publisher.
9. Gonzales, Juan A.,. Melching, Charles S and Oberg, Kevin A (1996) Analysis of open-channel velocity measurements collected with an acoustic Doppler current profiler, paper proceeding from the 1st international conference on new emerging concepts for rivers, Chicago-Illinois USA.
10. Gregory, K. J (1977), River channel change, A Wiley – Interscience Publications, Jhon Wiley & Sons-New York.
11. Holtroff, Gerd (1982), Resistance to flow in alluvial channels, JHDE, ASCE vol.108, no. HY9

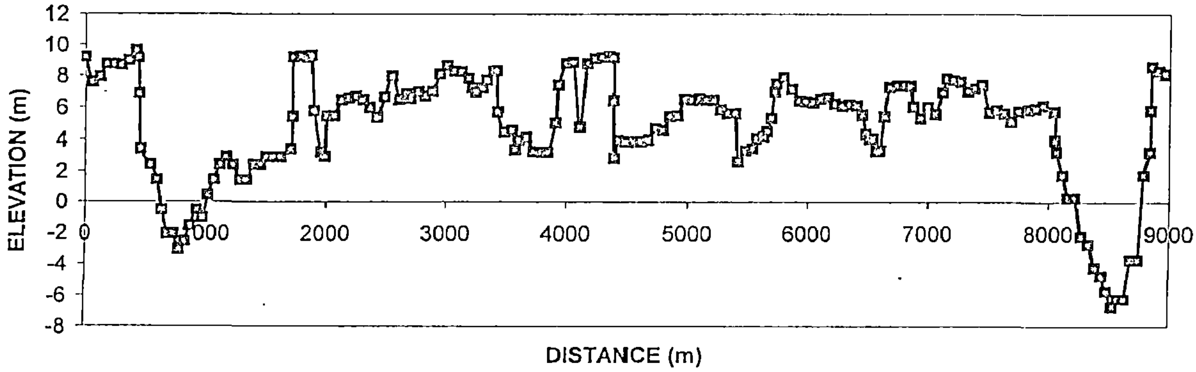
12. Howard, H. Chang (1979), Geometry of rivers in regime, JHDE, ASCE vol. 105 no. HY6
13. Knighton, David (1984), Fluvial forms and process, Arnold – Heineman.
14. Lau, Y. Lam (1988), Hydraulic resistance of ripples, JHDE, ASCE vol. 114, no. 10
15. Myers, W. R. C., Lyness, J. F & Cassels, J (2000), Influence of boundary roughness on velocity and discharge in compound river channels, Journal of Hydraulic Research, Vol. 39, no. 3
16. Ranga Raju, K.G (1988), Flow through open channels, Tata Mc Graw Hill Pub. Co. Ltd.
17. Schum, S. A (march 1980), Plan forms of alluvial rivers, paper Proceedings of the International Workshop on Alluvial River problems held at Roorkee, India
18. Senturk, Husein Ali (1977), Resistance to flow in sand-bed channels, JHDE, ASCE vol.104, no. HY3
19. Shiqiang, Wang and William Rodney White (1993), Alluvial resistance in transition regime, JHDE, ASCE vol. 119, no. 6Subramanya K. (1986), Flow in open channels, Tata Mc Graw Hill Pub. Co. Ltd.
20. Taizo Hayashi (march 1980), Plan forms of alluvial rivers, pape, Proceedings of the International Workshop on Alluvial River problems held at Roorkee, India
21. van Rijn, Leo C. (1984) sediment transport, part III: Bed forms and alluvial roughness, JHDE, ASCE vol. 110, no. 12
22. Wu, S. and Rajaratnam, N. (2001), A simple method for measuring shear stress on rough boundaries, Journal of Hydraulic Research, Vol. 38 no. 5

APPENDIX - I

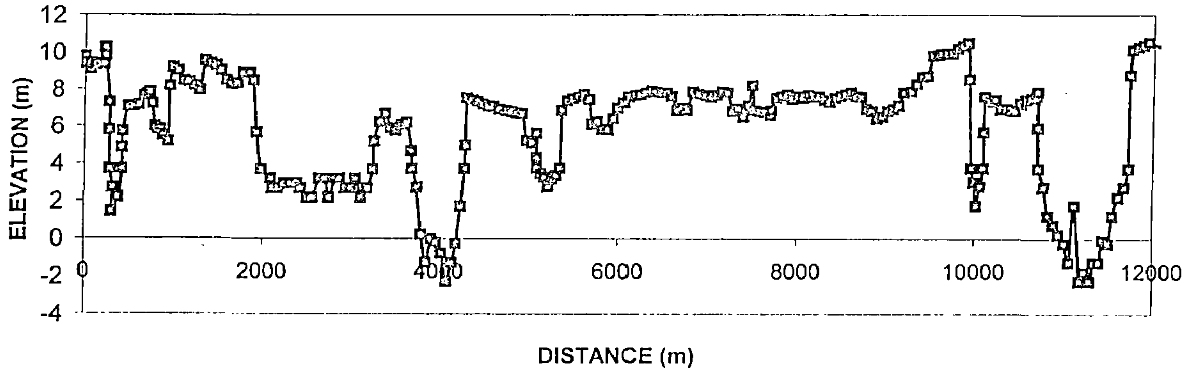
FIELD DATA OF PADMA RIVER
(Source; Bangladesh Water Resources Board)



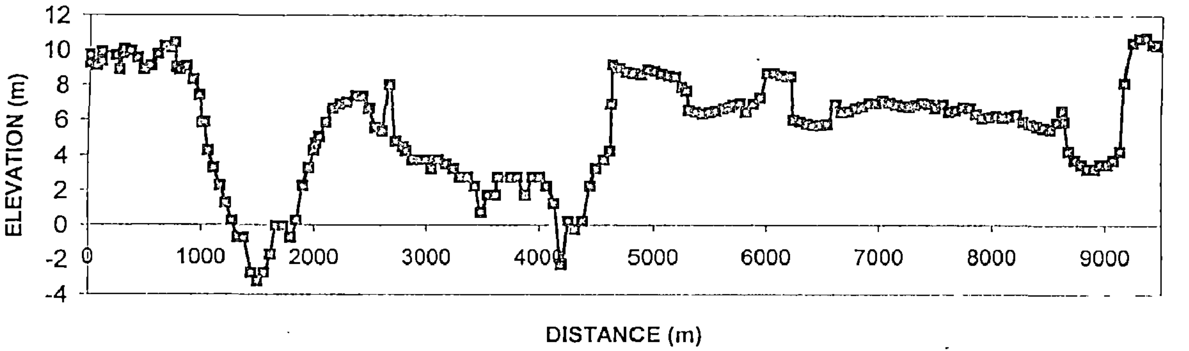
CROSS SECTION OF PADMA RIVER P # 0 - 1



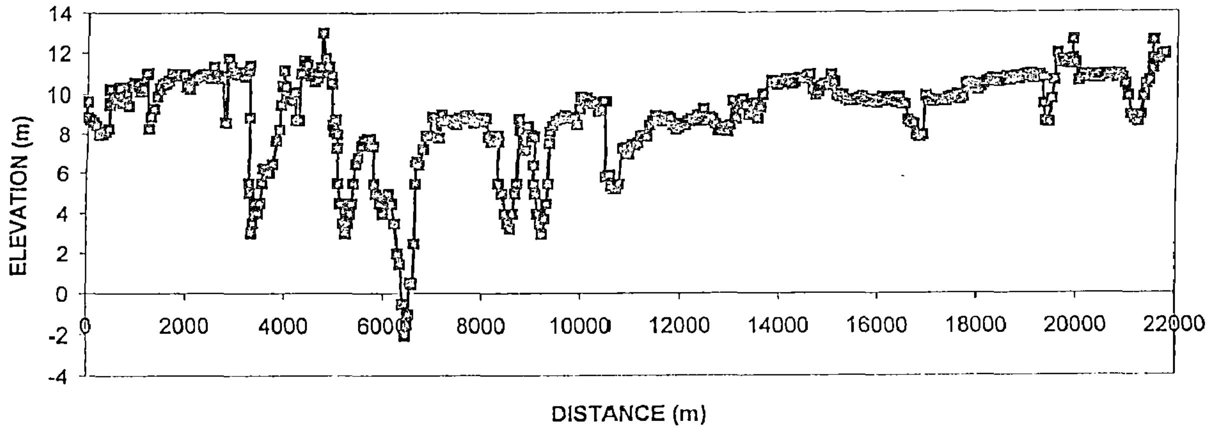
CROSS SECTION OF PADMA RIVER P # 1 - 1



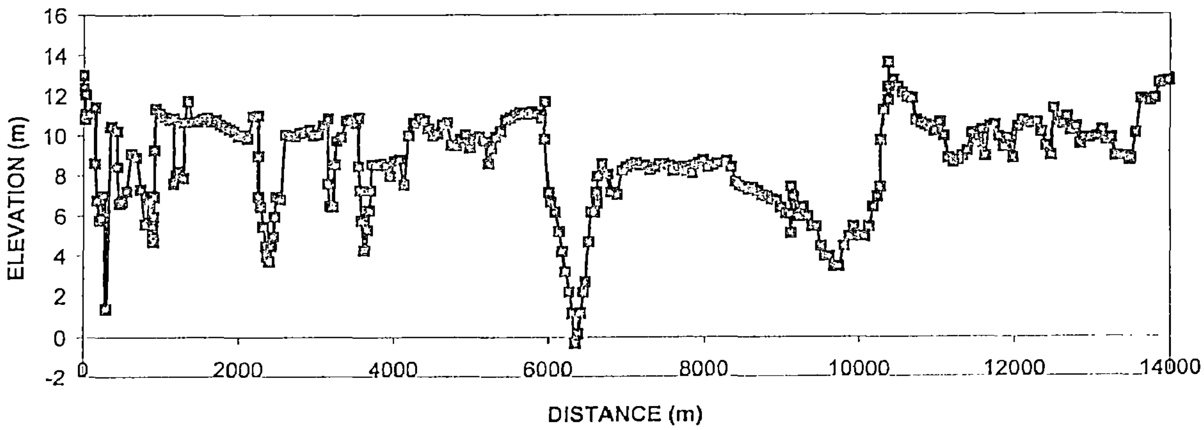
CROSS SECTION OF PADMA RIVER P # 2 - 1



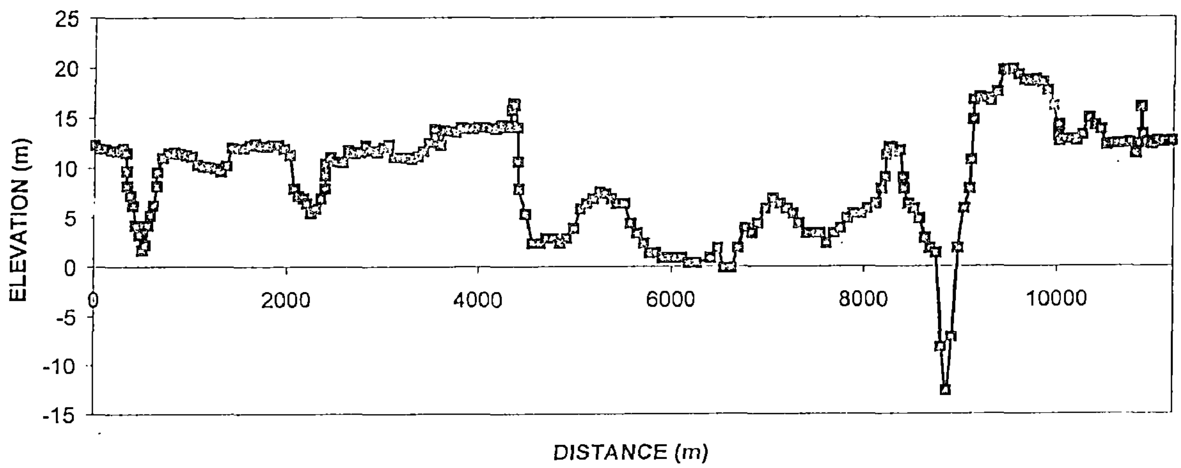
CROSS SECTION OF PADMA RIVER P # 3 - 1



CROSS SECTION OF PADMA RIVER P # 4 - 1



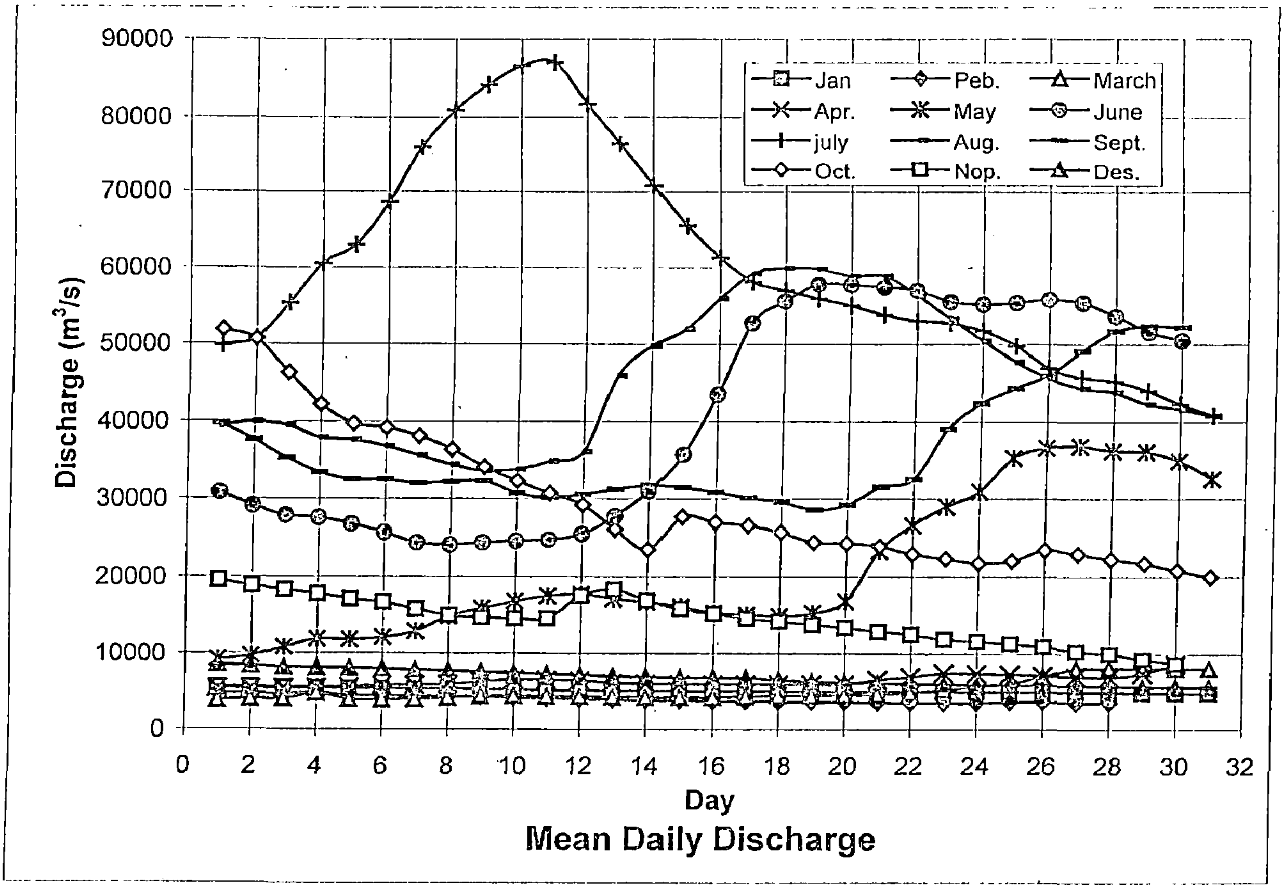
CROSS SECTION OF PADMA RIVER P # 5 - 1



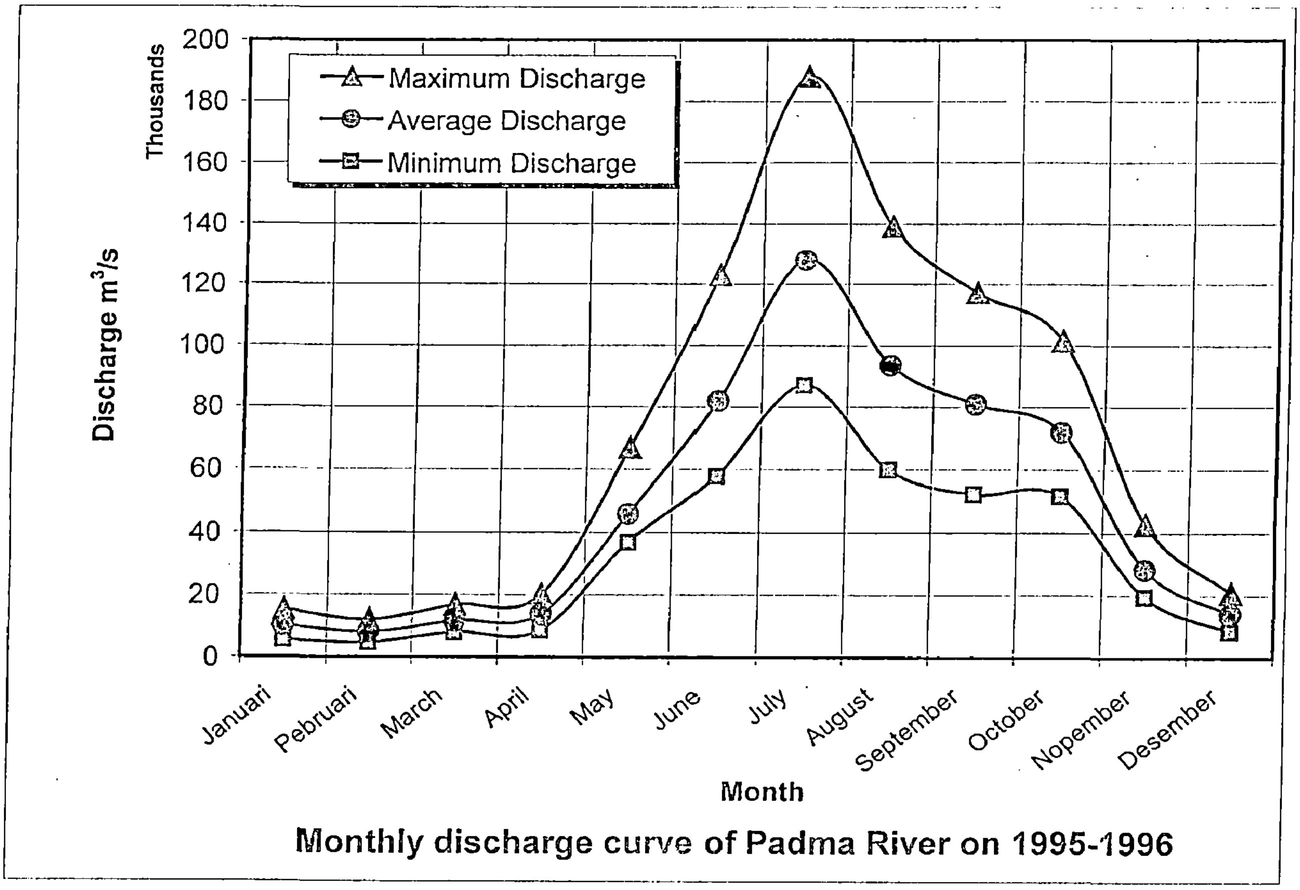
CROSS SECTION OF PADMA RIVER P # 6 - 1

MEAN DAILY DISCHARGE OF THE PADMA RIVER
1995 - 1996
STATION : HARDINGE BRIDGE

	Month											
Date	Jan	peb	march	april	may	june	july	august	sept	oct	nop.	Des.
1	5480	4620	3690	5250	9160	30800	49800	39400	39700	51800	19500	8440
2	5460	4580	3890	5290	9610	29100	50700	39900	37600	50600	18800	8270
3	5440	4550	3920	5300	10800	27900	55300	39500	35300	46300	18300	8090
4	5380	4700	4620	5360	11900	27600	60500	37900	33400	42200	17800	8010
5	5320	4360	3830	5470	11800	26800	63000	37600	32500	39700	17100	7980
6	5270	4280	3810	5670	12100	25700	68600	36800	32500	39200	16700	7890
7	5240	4200	3850	5740	12900	24400	76000	35600	32000	38100	15800	7720
8	5220	4130	4000	5790	14900	24100	80900	34400	32200	36400	15000	7570
9	5160	4080	4220	6120	15900	24400	84200	33600	32300	34100	14700	7460
10	5100	4010	4240	6430	16800	24600	86600	33800	30700	32300	14600	7280
11	4990	3920	4180	6420	17500	24800	87000	34800	30200	30700	14600	7160
12	4990	3840	4160	6320	17700	25500	81700	36100	30500	29200	17500	7000
13	4960	3790	4150	5990	17100	27800	76500	45900	31200	26100	18300	6880
14	4930	3710	4090	5910	16700	31000	70800	49700	31700	23500	16900	6770
15	4910	3670	4070	5880	16100	35700	65500	51900	31400	27700	15800	6690
16	4900	3600	4090	5870	15300	43500	61300	55900	30800	27000	15200	6670
17	4900	3570	4160	5880	15100	52700	58100	59200	30100	26600	14600	6640
18	4860	3540	4280	5840	14900	55600	57000	59900	29600	25700	14200	6390
19	4840	3520	4340	5850	15300	57800	55900	59800	28600	24400	13800	6210
20	4830	3490	4380	5870	16800	57700	55000	58900	29200	24300	13400	6050
21	4830	3450	4460	6460	23300	57400	53800	58900	31500	23900	12900	5970
22	4830	3410	4720	6830	26600	57000	53000	56300	32500	22900	12500	5890
23	4820	3430	5100	7330	29000	55500	52700	53300	39000	22300	11900	5840
24	4820	3420	5540	7250	30900	55200	51700	50400	42300	21700	11600	5770
25	4790	3520	5910	7150	35300	55400	49800	47700	44300	22000	11300	5740
26	4790	3580	6950	7050	36600	55800	46900	45600	46000	23400	10900	5700
27	4790	3430	7910	6880	36800	55400	45700	44300	49100	22900	10300	5640
28	4760	3470	8020	6810	36200	53600	45200	43800	51700	22200	9930	5590
29	4740		8000	7350	36100	51600	44000	42300	52300	21700	9220	5540
30	4690		7950	8600	34900	50500	42300	41600	52200	20800	8650	5490
31	4680		7950		32600		40800	40800		20000		5480
Monthly Means and Extremes												
Max	5480	4700	8020	8600	36800	57800	87000	59900	52300	51800	19500	8440
Mean	4680	3410	3690	5250	9160	24100	40800	33600	28600	20000	8650	5480
Min.	4990.97	3852.5	4983.2	6265.333	20860.32	40830	60332.3	45341.94	36080	29667.7	14393.3	6703.87
Ten Daily Average												
AV - 1	5254.17	4272.5	4034.2	5763.333	13422.5	26308.33	70358.3	36616.67	33241.7	39216.7	16700	7739.17
AV - 2	4873.64	3561.82	4349.1	6155.455	18745.45	48336.36	59963.6	55427.27	31418.2	24945.5	14500	6363.64
AV - 3	4757.5	3484	7278.8	7298.571	34925	53928.57	45800	44562.5	48271.4	21837.5	10271.4	5618.75



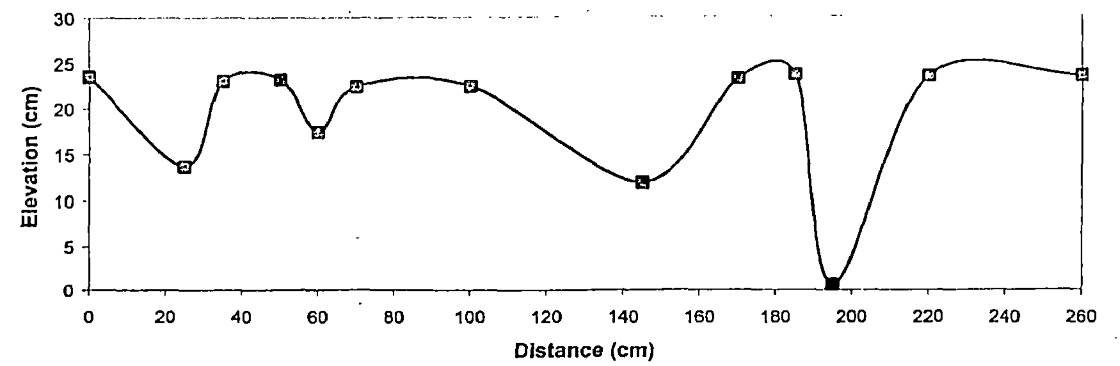
90000
80000
70000
60000
50000
40000
30000
20000
10000
0
Discharge (m³/s)
0
2
4
6
8
10
12
14
16
18
20
22
24
26
28
30
32
Day
Jan
Peb.
March
Apr.
May
June
july
Aug.
Sept.
Oct.
Nop.
Des.
Mean Daily Discharge



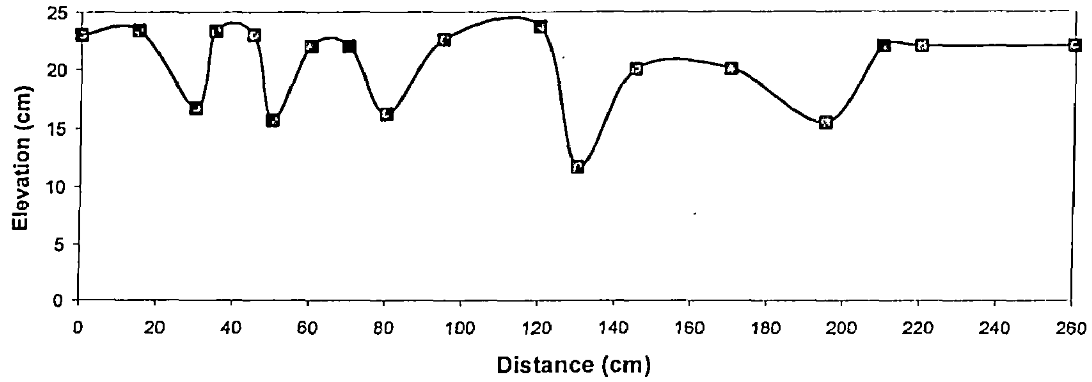
200
180
160
140
120
100
80
60
40
20
0
Thousands
Discharge m³/s
Maximum Discharge
Average Discharge
Minimum Discharge
Januari
Pebruari
March
April
May
June
July
August
September
October
Nopember
Desember
Month
Monthly discharge curve of Padma River on 1995-1996

APPENDIX - II

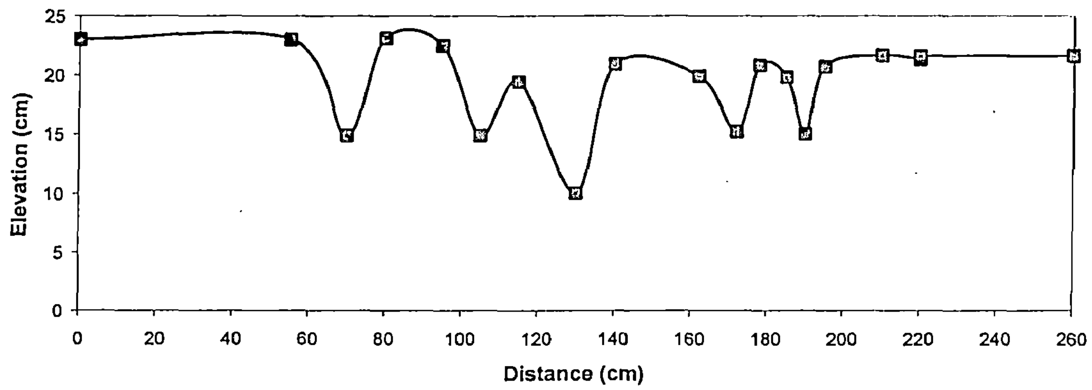
CROSS SECTION OF THE MODEL STUDY



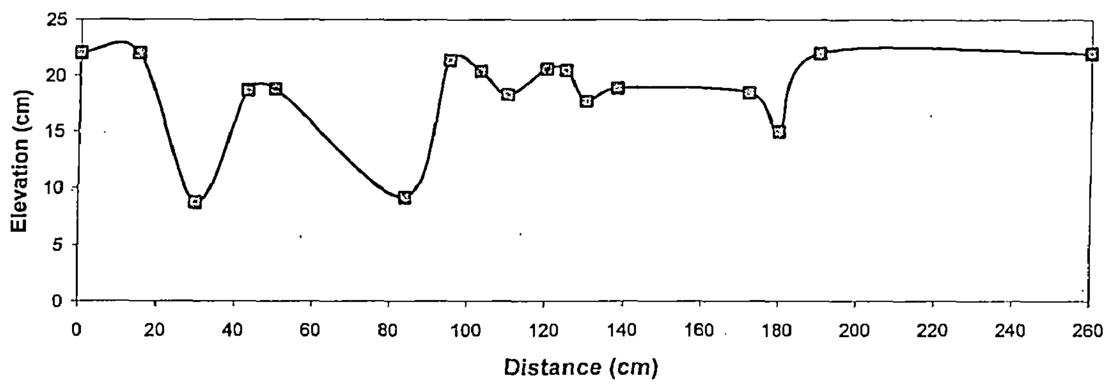
Initial channel cross section P # 6-1 for model experiment



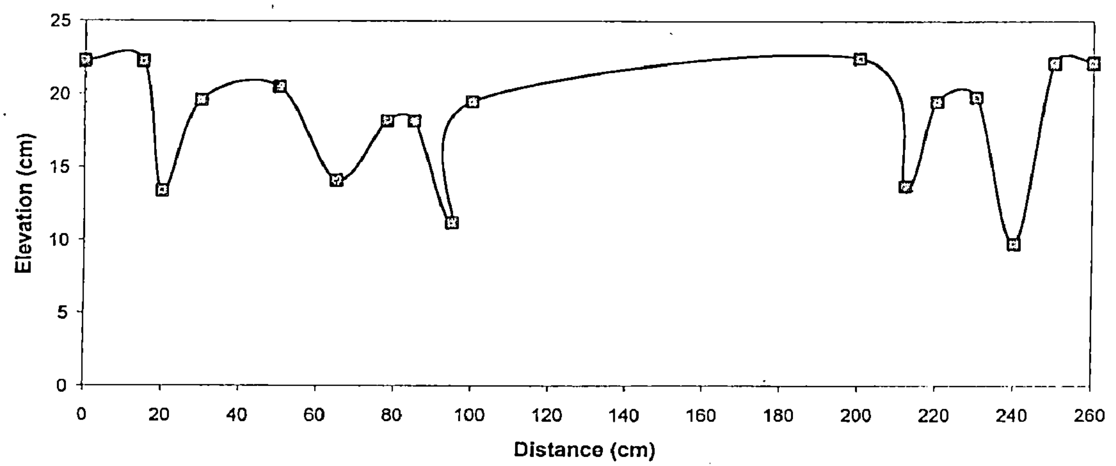
nitial channel cross section P # 6-1 for model experiment



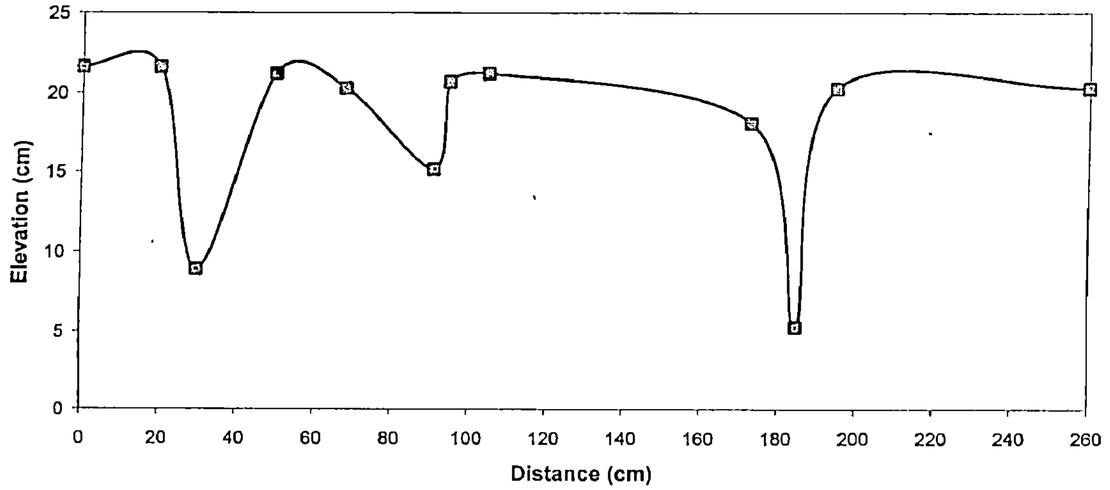
nitial channel cross section P # 6-1 for model experiment



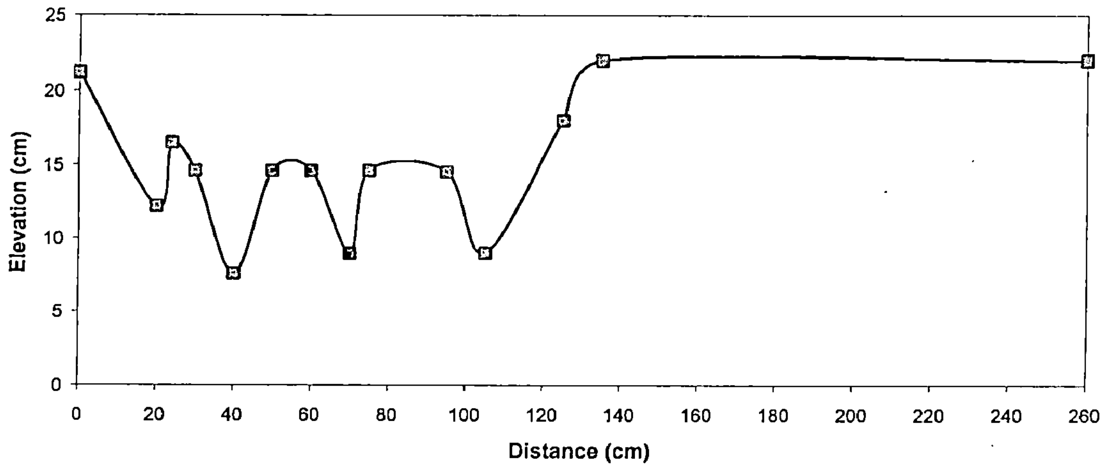
Initial channel cross section P # 3-1 for model experiment



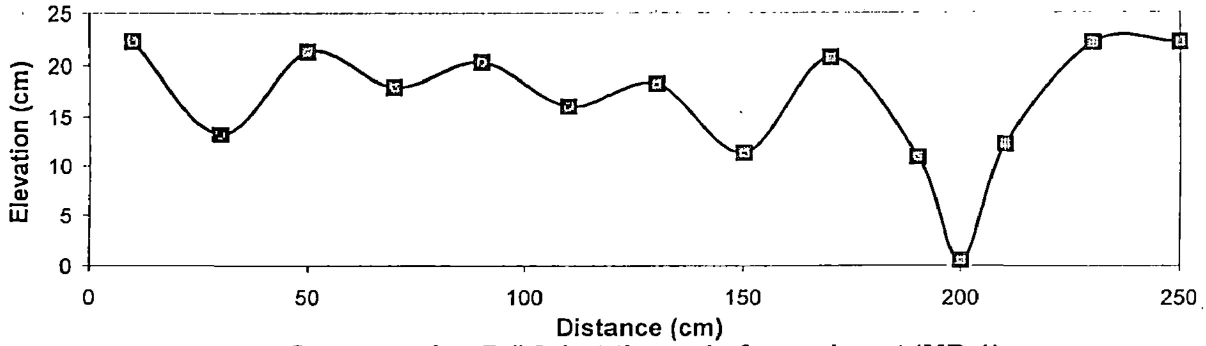
Initial channel cross section P # 2-1 for model experiment



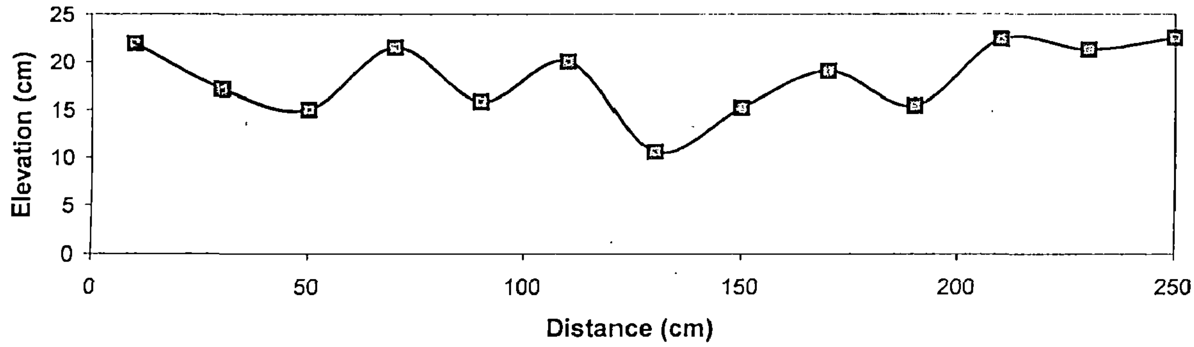
Initial channel cross section P # 1-1 for model experiment



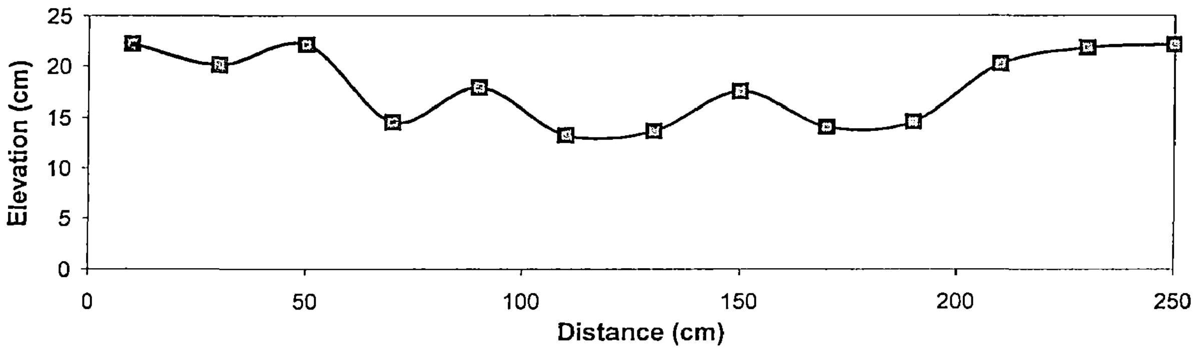
Initial channel cross section P # 0-1 for model experiment



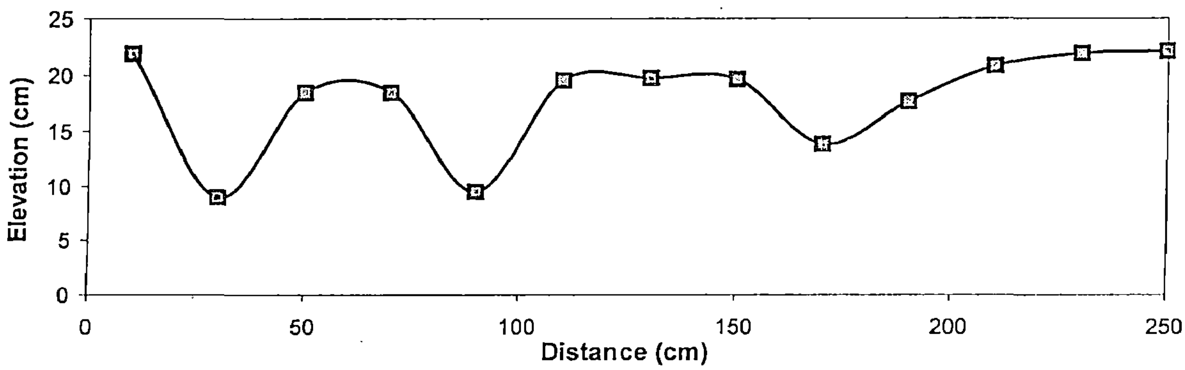
Cross-section P # 6-1 at the end of experiment (MR-1)



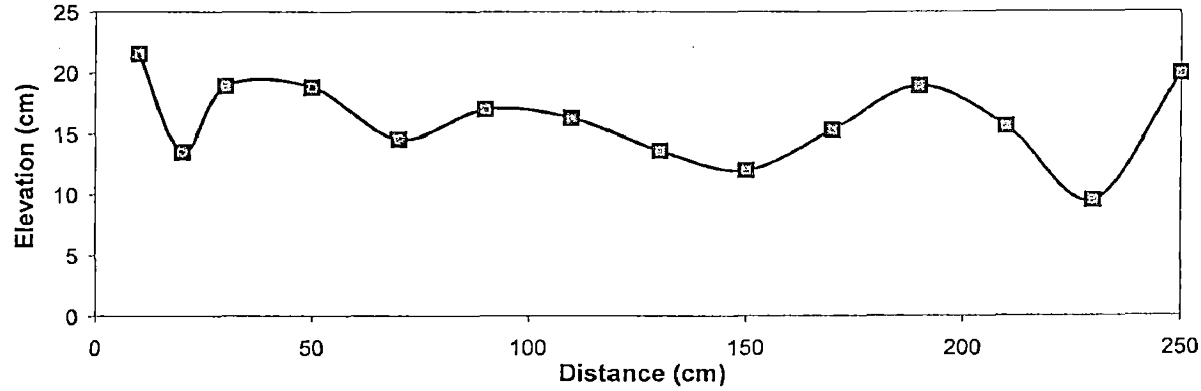
Cross-section P # 5-1 at the end of experiment (MR-1)



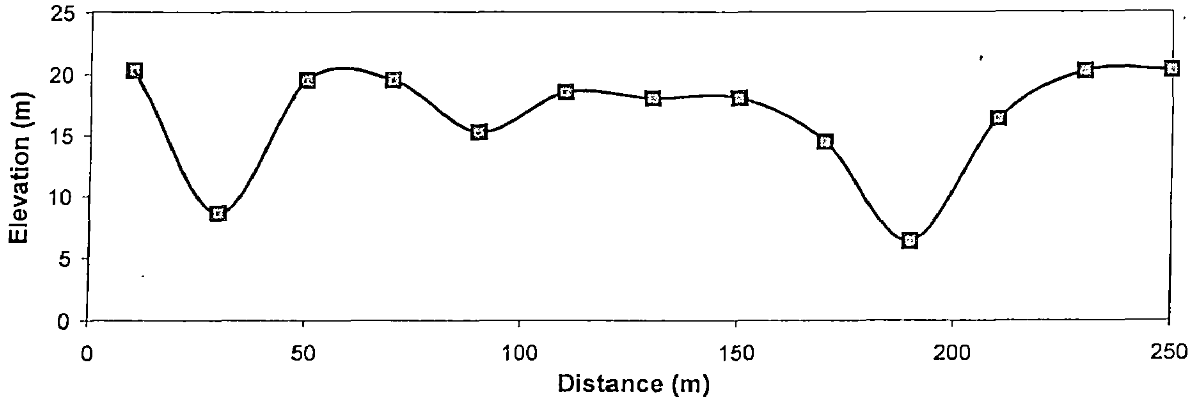
Cross-section P # 4-1 at the end of experiment (MR-1)



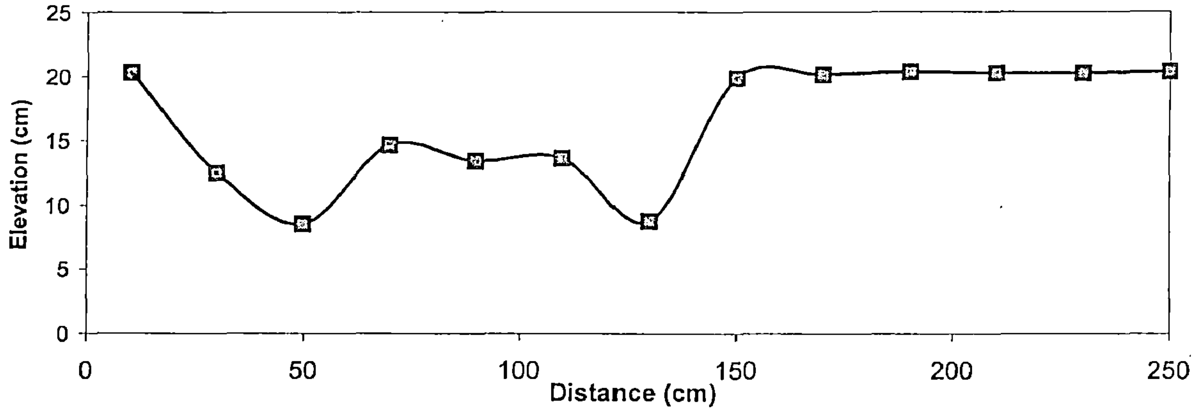
Cross-section P # 3-1 at the end of experiment (MR-1)



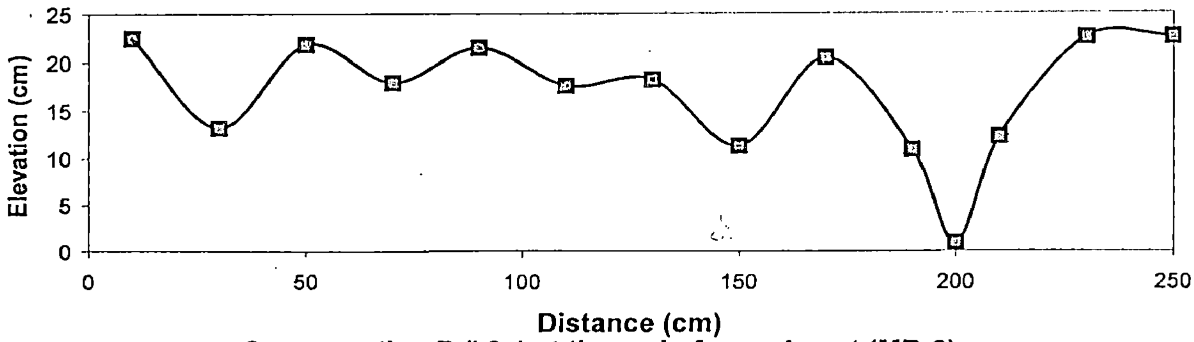
Cross-section P # 2-1 at the end of experiment (MR-1)



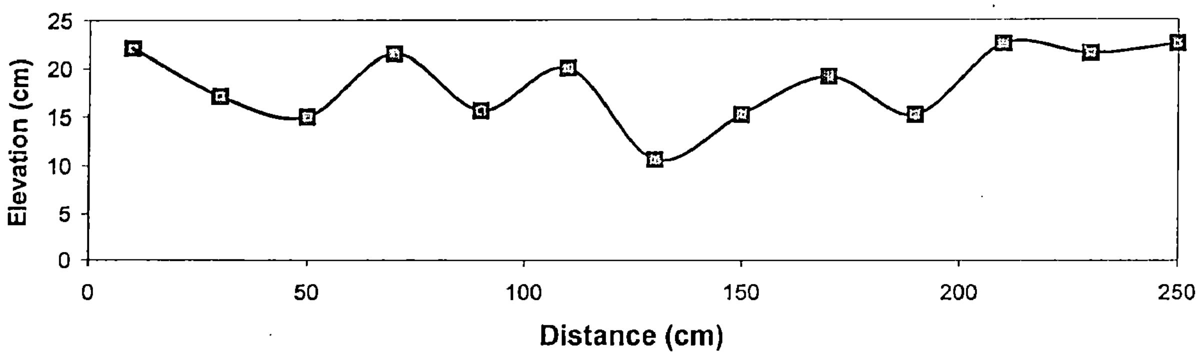
Cross-section P # 1-1 at the end of experiment (MR-1)



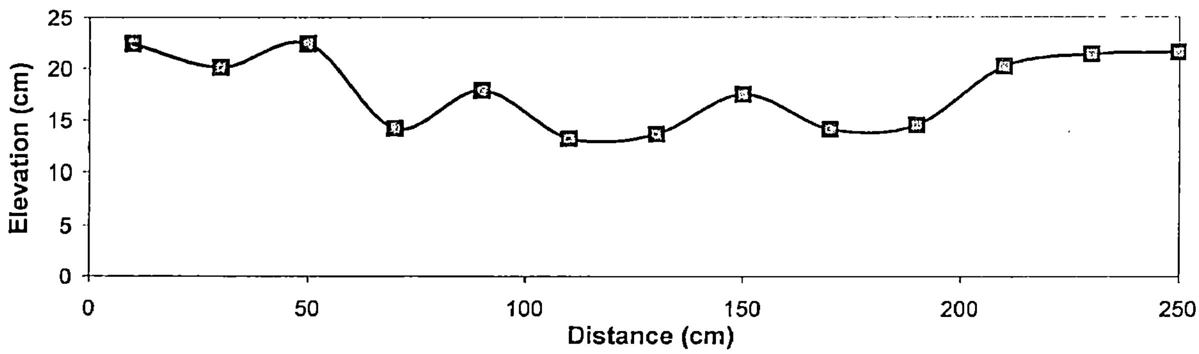
Cross-section P # 0-1 at the end of experiment (MR-1)



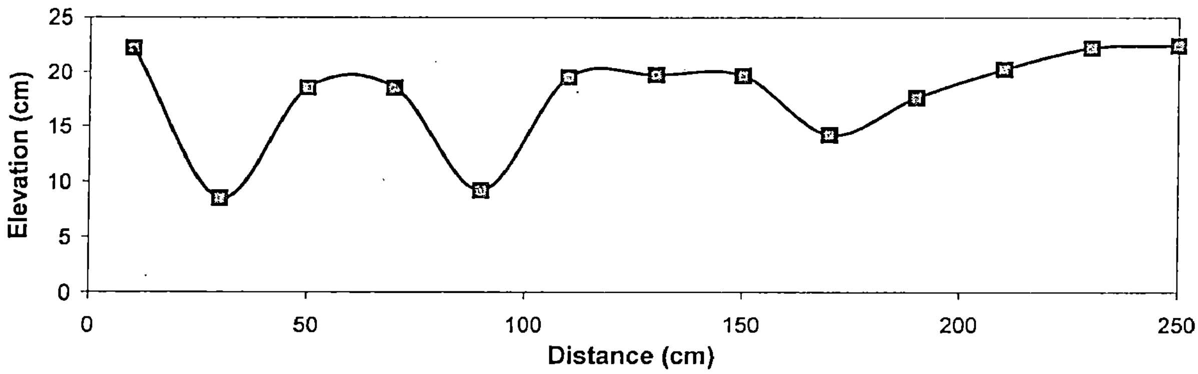
Cross-section P # 6-1 at the end of experiment (MR-2)



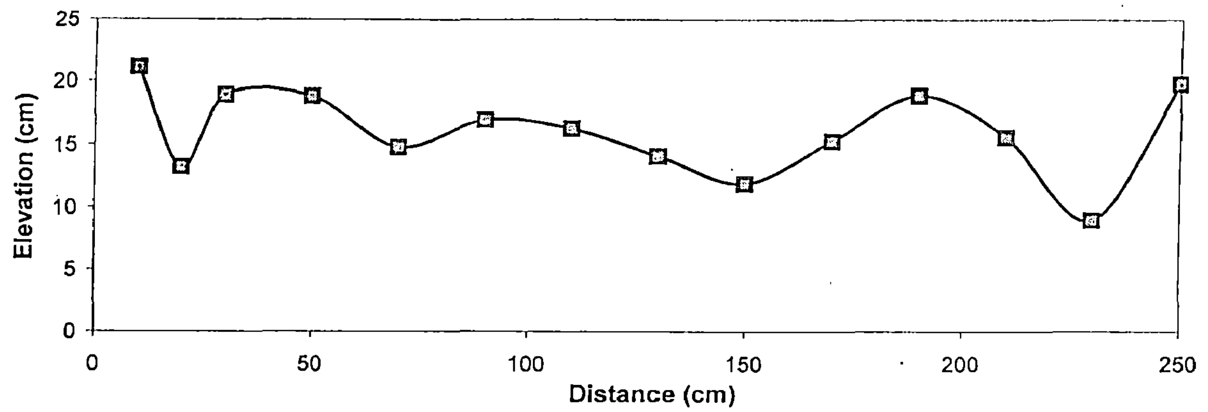
Cross-section P # 5-1 at the end of experiment (MR-2)



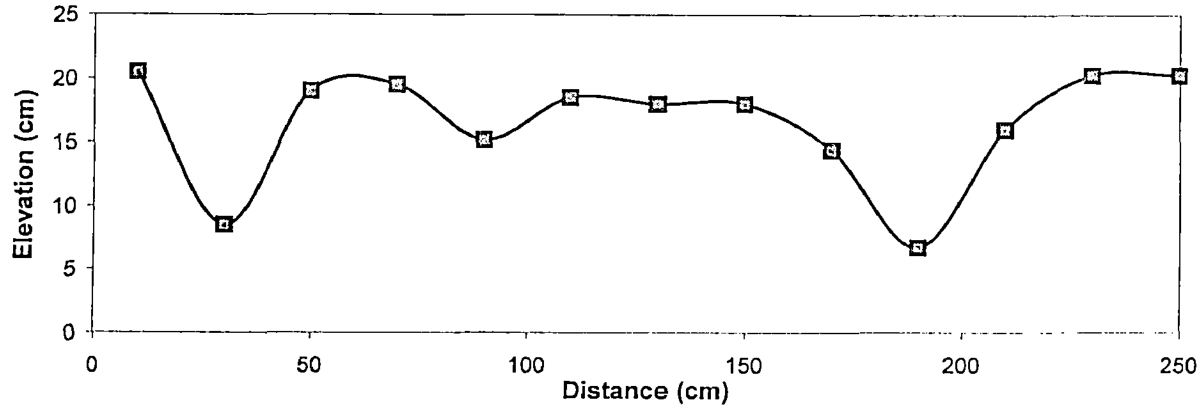
Cross-section P # 4-1 at the end of experiment (MR-2)



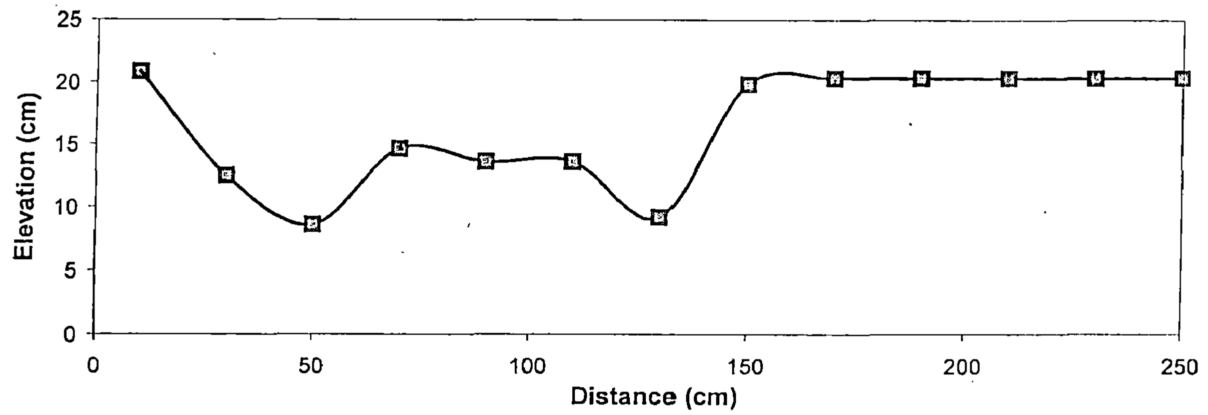
Cross-section P # 3-1 at the end of experiment (MR-2)



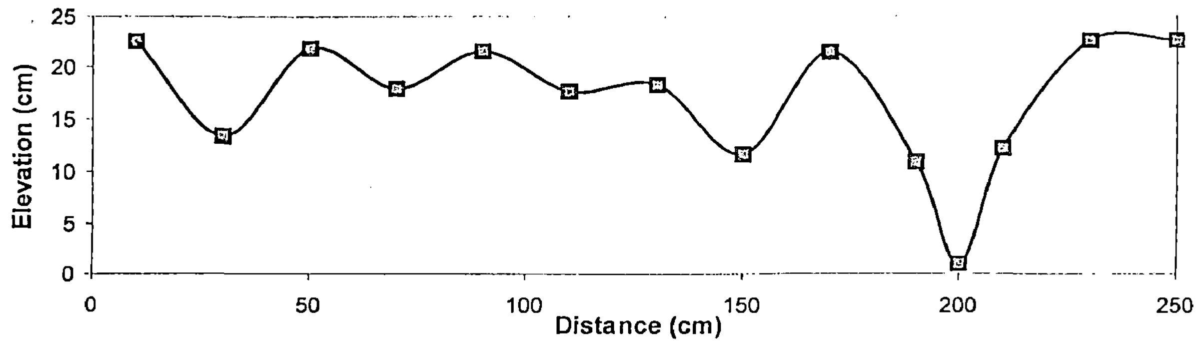
Cross-section P # 2-1 at the end of experiment (MR-2)



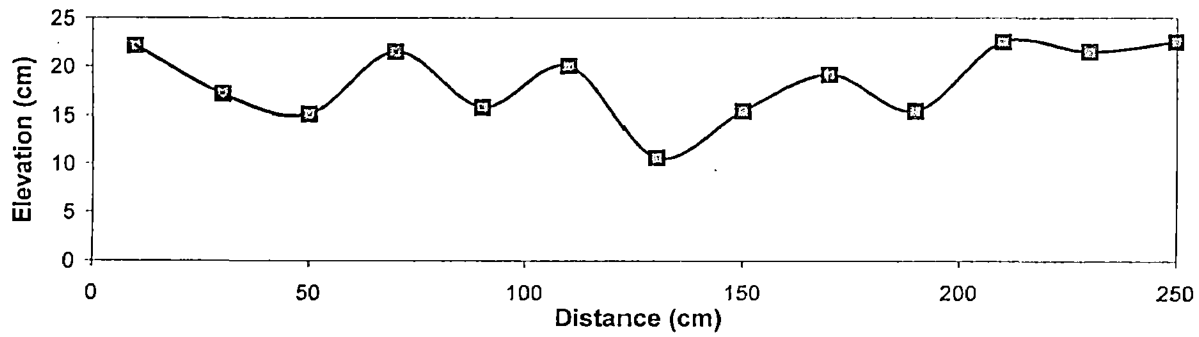
Cross-section P # 1-1 at the end of experiment (MR-2)



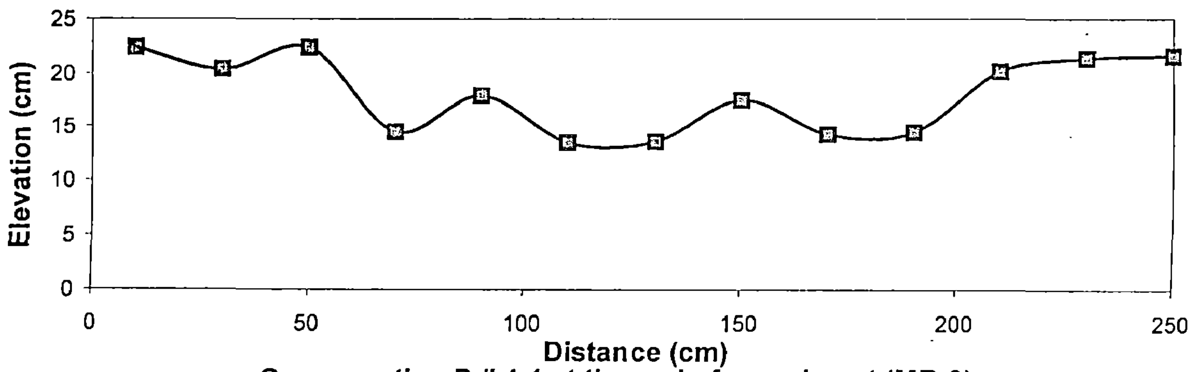
Cross-section P # 0-1 at the end of experiment (MR-2)



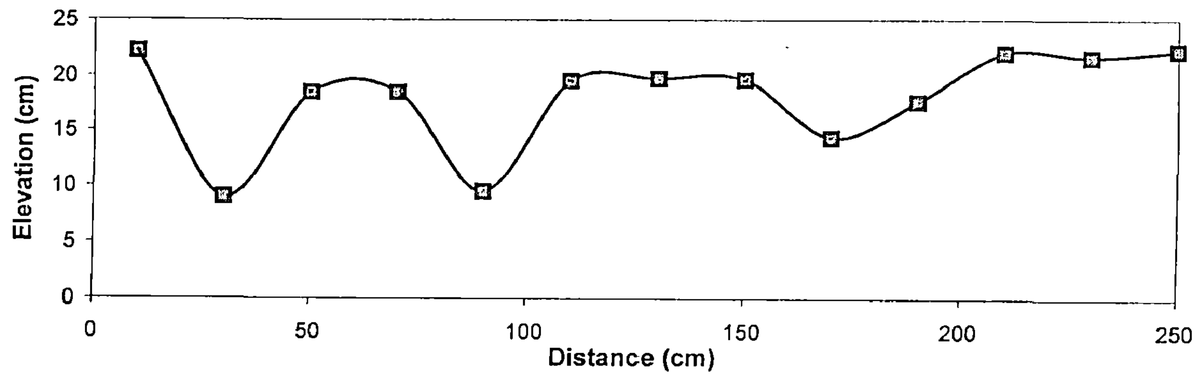
Cross-section P # 6-1 at the end of experiment (MR-3)



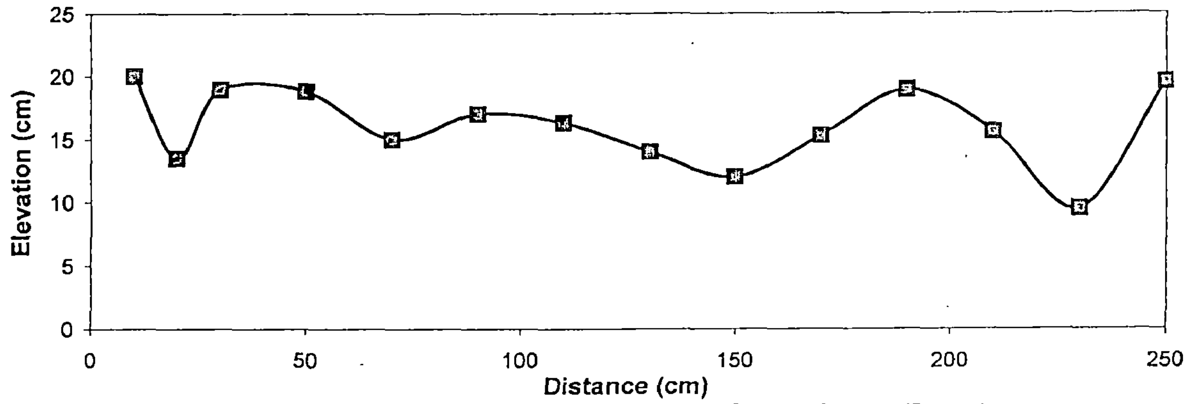
Cross-section P # 5-1 at the end of experiment (MR-3)



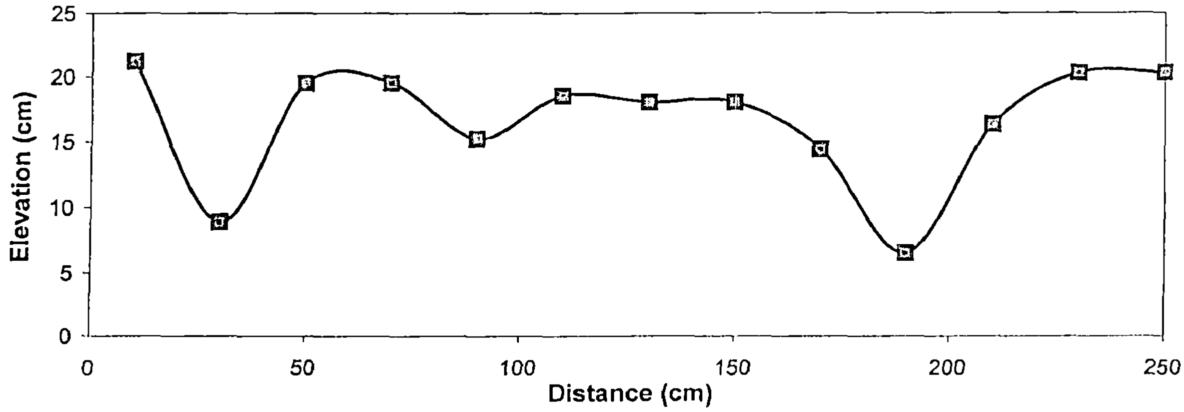
Cross-section P # 4-1 at the end of experiment (MR-3)



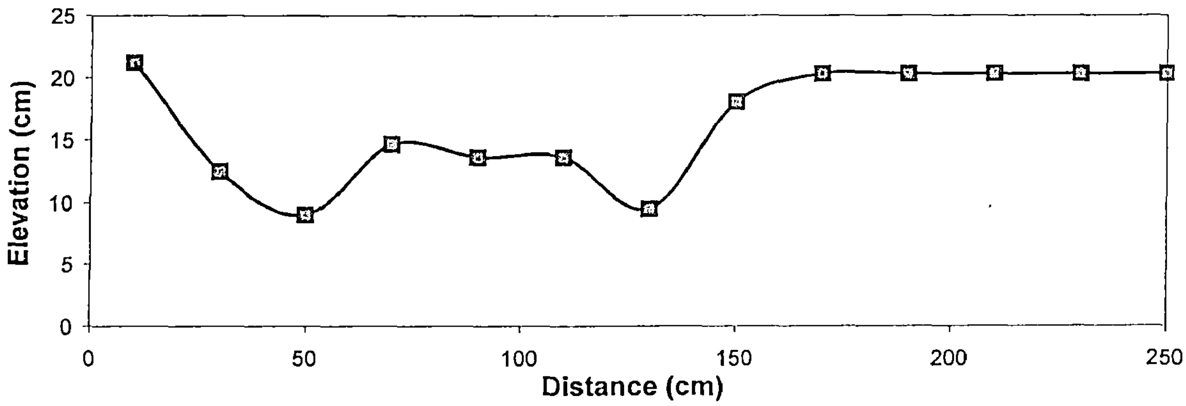
Cross-section P # 3-1 at the end of experiment (MR-3)



Cross-section P # 2-1 at the end of experiment (MR-3)



Cross-section P # 1-1 at the end of experiment (MR-3)



Cross-section P # 0-1 at the end of experiment (MR-3)

APPENDIX - III

PHOTOGRAPH SHOWING EXPERIMENTAL INSTALATIONS

Initial channel bed form pattern for Run – 2

Water flow condition for Run - 2

Bed form pattern at the end of experiment Run - 2

Initial channel bed form pattern for Run – 3

Water flow condition for Run - 3

Bed form pattern at the end of experiment Run - 3

Measuring water surface level using pointer gauge

Photograph showing manometer of the pitot tube

Control gate fixed at down stream of the flume

Honey combe brick and sediment feeder fixed at the upstream of the flume

APPENDIX - IV

DEVELOPING MODEL EQUATION OF FLOW RESISTANCE IN BRAIDED RIVER WITH PARAMETER R/d50 RATIO

TABLE A-4.1 SUMMARY OF FIELD DATA FROM PADMA RIVER

(Sources ; Bangladesh Water Resources Board)

C/S	Qw m3/s	Area m2	Witdh m	Slope	d50 m	d84 m	vel. m/s	Depth m	R m	n
P # 0-1	3730	6223.0	2496	7.3E-05	0.00021	0.00029	0.599	2.493	2.488	0.026
P # 1-1	3730	4755.6	1249	7.3E-05	0.00021	0.00029	0.784	3.808	3.784	0.026
P # 2-1	3730	4675.6	1209	7.3E-05	0.00021	0.00029	0.798	3.867	3.843	0.026
P # 3-1	3730	5717.7	2032	7.3E-05	0.00021	0.00029	0.652	2.814	2.806	0.026
P # 4-1	3730	4705.0	1208	7.3E-05	0.00021	0.00029	0.793	3.895	3.870	0.027
P # 5-1	3730	4277.9	925	7.3E-05	0.00021	0.00029	0.872	4.625	4.579	0.027
P # 6-1	3730	6545.0	2840	7.3E-05	0.00021	0.00029	0.570	2.305	2.301	0.026
P # 0-1	5980	9259.7	3293	8.5E-05	0.00021	0.00029	0.646	2.812	2.807	0.028
P # 1-1	5980	7503.9	1939	8.5E-05	0.00021	0.00029	0.797	3.870	3.855	0.028
P # 2-1	5980	8003.0	2459	8.5E-05	0.00021	0.00029	0.747	3.255	3.246	0.027
P # 3-1	5980	9253.0	3350	8.5E-05	0.00021	0.00029	0.646	2.762	2.758	0.028
P # 4-1	5980	7612.6	2217	8.5E-05	0.00021	0.00029	0.786	3.434	3.423	0.027
P # 5-1	5980	6940.2	1704	8.5E-05	0.00021	0.00029	0.862	4.073	4.054	0.027
P # 6-1	5980	10717.3	4812	8.5E-05	0.00021	0.00029	0.558	2.227	2.225	0.028
P # 0-1	8120	11007.3	3178	8.8E-05	0.00021	0.00029	0.738	3.464	3.456	0.029
P # 1-1	8120	9777.1	2456	8.8E-05	0.00021	0.00029	0.831	3.981	3.968	0.028
P # 2-1	8120	11066.4	3366	8.8E-05	0.00021	0.00029	0.734	3.288	3.281	0.028
P # 3-1	8120	12020.6	3858	8.8E-05	0.00021	0.00029	0.676	3.116	3.111	0.030
P # 4-1	8120	10502.2	2943	8.8E-05	0.00021	0.00029	0.773	3.569	3.560	0.028
P # 5-1	8120	10184.5	2800	8.8E-05	0.00021	0.00029	0.797	3.637	3.628	0.028
P # 6-1	8120	13264.6	5056	8.8E-05	0.00021	0.00029	0.612	2.624	2.621	0.029
P # 0-1	9930	14017.0	4248	9.1E-05	0.00021	0.00029	0.708	3.300	3.295	0.030
P # 1-1	9930	11318.5	2647	9.1E-05	0.00021	0.00029	0.877	4.276	4.262	0.029
P # 2-1	9930	12822.6	3499	9.1E-05	0.00021	0.00029	0.774	3.665	3.657	0.029
P # 3-1	9930	14580.3	4594	9.1E-05	0.00021	0.00029	0.681	3.174	3.169	0.030
P # 4-1	9930	12259.0	3160	9.1E-05	0.00021	0.00029	0.810	3.879	3.870	0.029
P # 5-1	9930	12697.7	3423	9.1E-05	0.00021	0.00029	0.782	3.710	3.702	0.029
P # 6-1	9930	15278.5	5326	9.1E-05	0.00021	0.00029	0.650	2.869	2.866	0.030
P # 0-1	11600	15905.7	4598	9.5E-05	0.00021	0.00029	0.694	3.077	3.455	0.032
P # 1-1	11600	12985.4	2947	9.5E-05	0.00021	0.00029	0.893	4.406	4.393	0.029
P # 2-1	11600	14317.5	3675	9.5E-05	0.00021	0.00029	0.810	3.896	3.888	0.030
P # 3-1	11600	16578.6	5058	9.5E-05	0.00021	0.00029	0.700	3.278	3.273	0.031
P # 4-1	11600	13975.3	3433	9.5E-05	0.00021	0.00029	0.830	4.071	4.061	0.030
P # 5-1	11600	14938.5	4012	9.5E-05	0.00021	0.00029	0.777	3.723	3.717	0.030
P # 6-1	11600	16724.7	5170	9.5E-05	0.00021	0.00029	0.694	3.235	3.231	0.031
P # 0-1	13800	18071.3	4748	9.7E-05	0.00021	0.00029	0.764	3.806	3.800	0.031
P # 1-1	13800	14256.7	2822	9.7E-05	0.00021	0.00029	0.968	5.052	5.034	0.030
P # 2-1	13800	15860.3	3645	9.7E-05	0.00021	0.00029	0.870	4.351	4.341	0.030
P # 3-1	13800	20906.6	6655	9.7E-05	0.00021	0.00029	0.660	3.141	3.139	0.032
P # 4-1	13800	16456.5	3927	9.7E-05	0.00021	0.00029	0.839	4.191	4.182	0.030
P # 5-1	13800	16857.4	4118	9.7E-05	0.00021	0.00029	0.819	4.094	4.085	0.031
P # 6-1	13800	18842.6	5235	9.7E-05	0.00021	0.00029	0.732	3.599	3.594	0.032

TABLE.A-4.2 COMPUTATION STANDARD ERROR ESTIMATE RESISTANCE COEFFICIENT OF AVAILABLE FIELD DATA

Equation (log. Form); U/u* =1.3173.ln(R/d50)+0.851 Power form;U/u*=5.3624(R/d50)$^{0.096}$

X SECT.	DISCH. M3/S	R/d50 RATIO	SLOPE	U/u* Obs.	U/u* Plot Log form	Standar Error Est.	U/u* Plot Pwr.form	Standar Error Est.
P # 0-1	3730	11848.73	7.3E-05	14.23	13.207843	1.045267	13.19568	1.07
P # 1-1	3730	18021.2	7.3E-05	15.10	13.760224	1.792787	13.73771	1.85
P # 2-1	3730	18298.63	7.3E-05	15.24	13.780348	2.132893	13.75788	2.20
P # 3-1	3730	13362.15	7.3E-05	14.58	13.366189	1.484279	13.34883	1.53
P # 4-1	3730	18428.23	7.3E-05	15.09	13.789645	1.696151	13.7672	1.76
P # 5-1	3730	21804.62	7.3E-05	15.26	14.011265	1.558548	13.99136	1.61
P # 6-1	3730	10956.4	7.3E-05	14.07	13.104701	0.932599	13.09686	0.95
P # 0-1	5980	13367.33	8.5E-05	13.34	13.3667	0.000702	13.34933	0.00
P # 1-1	5980	18355.16	8.5E-05	14.05	13.784411	0.069527	13.76195	0.08
P # 2-1	5980	15457.04	8.5E-05	14.35	13.558039	0.633198	13.53678	0.67
P # 3-1	5980	13131.13	8.5E-05	13.47	13.343214	0.015929	13.3265	0.02
P # 4-1	5980	16300.62	8.5E-05	14.69	13.628038	1.136781	13.60601	1.18
P # 5-1	5980	19302.43	8.5E-05	14.81	13.850698	0.923443	13.82859	0.97
P # 6-1	5980	10595.92	8.5E-05	12.95	13.060632	0.0132	13.05487	0.01
P # 0-1	8120	16457.43	8.8E-05	13.50	13.64065	0.020965	13.61852	0.02
P # 1-1	8120	18895.35	8.8E-05	14.18	13.82262	0.127727	13.80032	0.14
P # 2-1	8120	15625.19	8.8E-05	13.78	13.572292	0.041757	13.55085	0.05
P # 3-1	8120	14813.02	8.8E-05	13.03	13.501977	0.226462	13.48159	0.21
P # 4-1	8120	16951.93	8.8E-05	13.94	13.679648	0.066275	13.65728	0.08
P # 5-1	8120	17275.63	8.8E-05	14.24	13.704565	0.283101	13.6821	0.31
P # 6-1	8120	12480.08	8.8E-05	12.86	13.276227	0.172789	13.2616	0.16
P # 0-1	9930	15688.34	9.1E-05	13.04	13.577605	0.286619	13.5561	0.26
P # 1-1	9930	20296.2	9.1E-05	14.20	13.91683	0.080391	13.8954	0.09
P # 2-1	9930	17414.22	9.1E-05	13.53	13.715091	0.033458	13.6926	0.03
P # 3-1	9930	15092.34	9.1E-05	12.78	13.526585	0.552121	13.50579	0.52
P # 4-1	9930	18428.22	9.1E-05	13.76	13.789644	0.000915	13.7672	0.00
P # 5-1	9930	17626.22	9.1E-05	13.58	13.731031	0.021963	13.70852	0.02
P # 6-1	9930	13645.6	9.1E-05	12.83	13.393841	0.318182	13.37576	0.30
P # 0-1	11600	16450.68	9.5E-05	12.21	13.640109	2.046756	13.61798	1.98
P # 1-1	11600	20919.88	9.5E-05	13.94	13.9567	0.000142	13.93583	0.00
P # 2-1	11600	18512.74	9.5E-05	13.44	13.795672	0.123334	13.77325	0.11
P # 3-1	11600	15587.89	9.5E-05	12.65	13.569143	0.838694	13.54774	0.80
P # 4-1	11600	19339.25	9.5E-05	13.48	13.853209	0.142183	13.83112	0.13
P # 5-1	11600	17697.91	9.5E-05	13.18	13.736377	0.310817	13.71386	0.29
P # 6-1	11600	15385.28	9.5E-05	12.63	13.551908	0.858929	13.53073	0.82
P # 0-1	13800	18095.21	9.7E-05	12.71	13.765622	1.10534	13.74312	1.06
P # 1-1	13800	23971.24	9.7E-05	14.00	14.136057	0.017899	14.11918	0.01
P # 2-1	13800	20670.88	9.7E-05	13.55	13.940927	0.149607	13.91982	0.13
P # 3-1	13800	14945.35	9.7E-05	12.09	13.513693	2.018992	13.4931	1.96
P # 4-1	13800	19912.8	9.7E-05	13.31	13.891708	0.339102	13.86998	0.31
P # 5-1	13800	19454.6	9.7E-05	13.15	13.861043	0.512703	13.83902	0.48
P # 6-1	13800	17116.23	9.7E-05	12.54	13.692354	1.333227	13.66993	1.28
					Total	25.466	Total	25.446
					Std.error	0.808	Std.error	0.808

TABLE.A-4.3 COMPUTATION RESISTANCE COEFFICIENT vs R/d50 RATIO AT DIFFERENT SLOPE

Table A-4.3.1 Slope 0.000073

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
3730	0.599	0.00021	7.3E-05	2.488	11848.73	0.042	14.23	14.28
3730	0.784	0.00021	7.3E-05	3.784	18021.20	0.052	15.10	15.06
3730	0.798	0.00021	7.3E-05	3.843	18298.63	0.052	15.24	15.09
3730	0.652	0.00021	7.3E-05	2.806	13362.15	0.045	14.58	14.50
3730	0.793	0.00021	7.3E-05	3.870	18428.23	0.053	15.09	15.10
3730	0.872	0.00021	7.3E-05	4.579	21804.62	0.057	15.26	15.41
3730	0.570	0.00021	7.3E-05	2.301	10956.40	0.041	14.07	14.13

Table A-4.3.2 Slope 0.000085

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
5980	0.646	0.00021	8.5E-05	2.807	13367.33	0.048	13.34	13.62
5980	0.797	0.00021	8.5E-05	3.855	18355.16	0.057	14.05	14.57
5980	0.747	0.00021	8.5E-05	3.246	15457.04	0.052	14.35	14.06
5980	0.646	0.00021	8.5E-05	2.758	13131.13	0.048	13.47	13.56
5980	0.786	0.00021	8.5E-05	3.423	16300.62	0.053	14.69	14.22
5980	0.862	0.00021	8.5E-05	4.054	19302.43	0.058	14.81	14.72
5980	0.558	0.00021	8.5E-05	2.225	10595.92	0.043	12.95	12.92

Table A-4.3.3 Slope 0.000088

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
8120	0.738	0.00021	8.8E-05	3.456	16457.43	0.055	13.50	13.76
8120	0.831	0.00021	8.8E-05	3.968	18895.35	0.059	14.18	14.26
8120	0.734	0.00021	8.8E-05	3.281	15625.19	0.053	13.78	13.57
8120	0.676	0.00021	8.8E-05	3.111	14813.02	0.052	13.03	13.37
8120	0.773	0.00021	8.8E-05	3.560	16951.93	0.055	13.94	13.87
8120	0.797	0.00021	8.8E-05	3.628	17275.63	0.056	14.24	13.94
8120	0.612	0.00021	8.8E-05	2.621	12480.08	0.048	12.86	12.75

Table A-4.3.4 Slope 0.000091

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
9930	0.708	0.00021	9.1E-05	3.295	15688.34	0.054	13.04	13.14
9930	0.877	0.00021	9.1E-05	4.262	20296.20	0.062	14.20	14.12
9930	0.774	0.00021	9.1E-05	3.657	17414.22	0.057	13.53	13.54
9930	0.681	0.00021	9.1E-05	3.169	15092.34	0.053	12.78	12.99
9930	0.810	0.00021	9.1E-05	3.870	18428.22	0.059	13.76	13.75
9930	0.782	0.00021	9.1E-05	3.702	17626.22	0.058	13.58	13.58
9930	0.650	0.00021	9.1E-05	2.866	13645.60	0.051	12.83	12.61

Table A-4.3.5 Slope 0.000095

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
4600	0.729	0.00021	9.5E-05	3.454	16447.94	0.057	12.84	12.88
0	0.893	0.00021	9.5E-05	4.393	20919.88	0.064	13.94	13.90
0	0.810	0.00021	9.5E-05	3.888	18512.74	0.060	13.44	13.38
0	0.700	0.00021	9.5E-05	3.273	15587.89	0.055	12.65	12.65
0	0.830	0.00021	9.5E-05	4.061	19339.25	0.062	13.48	13.57
0	0.777	0.00021	9.5E-05	3.717	17697.91	0.059	13.18	13.19
0	0.694	0.00021	9.5E-05	3.231	15385.28	0.055	12.63	12.59

Table.A - 4.3.6 Slope 0.000097

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
13800	0.764	0.00021	9.7E-05	3.800	18095.21	0.060	12.71	12.85
13800	0.968	0.00021	9.7E-05	5.034	23971.24	0.069	14.00	14.05
13800	0.870	0.00021	9.7E-05	4.341	20670.88	0.064	13.55	13.42
13800	0.660	0.00021	9.7E-05	3.139	14945.35	0.055	12.09	12.03
13800	0.839	0.00021	9.7E-05	4.182	19912.80	0.063	13.31	13.26
13800	0.819	0.00021	9.7E-05	4.085	19454.60	0.062	13.15	13.16
13800	0.732	0.00021	9.7E-05	3.594	17116.23	0.058	12.54	12.61

TABLE A-4.4 COMPUTATION OF CORRECTION FACTOR (K1)

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	K1	K1.U/u*
3730	0.599	0.00021	7.3E-05	2.488	11848.7	0.04	14.23	0.88	13.11
3730	0.784	0.00021	7.3E-05	3.784	18021.2	0.05	15.10	0.93	13.91
3730	0.798	0.00021	7.3E-05	3.843	18298.6	0.05	15.24	0.92	14.04
3730	0.652	0.00021	7.3E-05	2.806	13362.2	0.04	14.58	0.89	13.44
3730	0.793	0.00021	7.3E-05	3.870	18428.2	0.05	15.09	0.94	13.91
3730	0.872	0.00021	7.3E-05	4.579	21804.6	0.06	15.26	0.97	14.06
3730	0.570	0.00021	7.3E-05	2.301	10956.4	0.04	14.07	0.91	12.97
5980	0.646	0.00021	8.5E-05	2.807	13367.3	0.05	13.34	0.97	12.79
5980	0.797	0.00021	8.5E-05	3.855	18355.2	0.06	14.05	1.01	13.47
5980	0.747	0.00021	8.5E-05	3.246	15457.0	0.05	14.35	0.96	13.77
5980	0.646	0.00021	8.5E-05	2.758	13131.1	0.05	13.47	0.96	12.92
5980	0.786	0.00021	8.5E-05	3.423	16300.6	0.05	14.69	0.92	14.09
5980	0.862	0.00021	8.5E-05	4.054	19302.4	0.06	14.81	0.96	14.21
5980	0.558	0.00021	8.5E-05	2.225	10595.9	0.04	12.95	0.94	12.42
8120	0.738	0.00021	8.8E-05	3.456	16457.4	0.05	13.50	1.00	13.50
8120	0.831	0.00021	8.8E-05	3.968	18895.4	0.06	14.18	1.00	14.18
8120	0.734	0.00021	8.8E-05	3.281	15625.2	0.05	13.78	1.00	13.78
8120	0.676	0.00021	8.8E-05	3.111	14813.0	0.05	13.03	1.00	13.03
8120	0.773	0.00021	8.8E-05	3.560	16951.9	0.06	13.94	1.00	13.94
8120	0.797	0.00021	8.8E-05	3.628	17275.6	0.06	14.24	1.00	14.24
8120	0.612	0.00021	8.8E-05	2.621	12480.1	0.05	12.86	1.00	12.86
9930	0.708	0.00021	9.1E-05	3.295	15688.3	0.05	13.04	1.06	13.61
9930	0.877	0.00021	9.1E-05	4.262	20296.2	0.06	14.20	1.02	14.82
9930	0.774	0.00021	9.1E-05	3.657	17414.2	0.06	13.53	1.05	14.12
9930	0.681	0.00021	9.1E-05	3.169	15092.3	0.05	12.78	1.08	13.34
9930	0.810	0.00021	9.1E-05	3.870	18428.2	0.06	13.76	1.03	14.36
9930	0.782	0.00021	9.1E-05	3.702	17626.2	0.06	13.58	1.05	14.17
9930	0.650	0.00021	9.1E-05	2.866	13645.6	0.05	12.83	1.02	13.39
11600	0.729	0.00021	9.5E-05	3.454	16447.9	0.06	12.84	1.09	13.76
11600	0.893	0.00021	9.5E-05	4.393	20919.9	0.06	13.94	1.05	14.94
11600	0.810	0.00021	9.5E-05	3.888	18512.7	0.06	13.44	1.05	14.41
11600	0.700	0.00021	9.5E-05	3.273	15587.9	0.06	12.65	1.09	13.56
11600	0.830	0.00021	9.5E-05	4.061	19339.2	0.06	13.48	1.05	14.44
11600	0.777	0.00021	9.5E-05	3.717	17697.9	0.06	13.18	1.08	14.12
11600	0.694	0.00021	9.5E-05	3.231	15385.3	0.05	12.63	1.09	13.53
13800	0.764	0.00021	9.7E-05	3.800	18095.2	0.06	12.71	1.12	13.93
13800	0.968	0.00021	9.7E-05	5.034	23971.2	0.07	14.00	1.08	15.34
13800	0.870	0.00021	9.7E-05	4.341	20670.9	0.06	13.55	1.08	14.85
13800	0.660	0.00021	9.7E-05	3.139	14945.4	0.05	12.09	1.08	13.25
13800	0.839	0.00021	9.7E-05	4.182	19912.8	0.06	13.31	1.09	14.58
13800	0.819	0.00021	9.7E-05	4.085	19454.6	0.06	13.15	1.10	14.40
13800	0.732	0.00021	9.7E-05	3.594	17116.2	0.06	12.54	1.14	13.73

TABLE A-4.5 COMPUTATION RESISTANCE COEFFICIENT BASE FROM REGRESSION ANALYSIS OF AVAILABLE FIELD DATA

Equation(without K); U/u*=1.3134.ln(R/d50)+0.9045   with K; U/u*=3.1474.ln(R/d50)-16.743

X Section	Qw m^3/s	Slope	R/d50 ratio	U/u* obs.	U/u* cal. without K	Standard error estimate	U/u* cal. with K	Standard error estimate
P # 0-1	3730	7.3E-05	11848.73	14.230	11.517	7.362	12.780	2.104
P # 1-1	3730	7.3E-05	18021.20	15.099	11.991	9.658	14.099	1.000
P # 2-1	3730	7.3E-05	18298.63	15.241	12.009	10.446	14.147	1.195
P # 3-1	3730	7.3E-05	13362.15	14.584	11.653	8.594	13.158	2.035
P # 4-1	3730	7.3E-05	18428.23	15.092	12.017	9.458	14.170	0.851
P # 5-1	3730	7.3E-05	21804.62	15.260	12.207	9.319	14.699	0.314
P # 6-1	3730	7.3E-05	10956.40	14.070	11.428	6.980	12.533	2.363
P # 0-1	5980	8.5E-05	13367.33	13.340	11.653	2.845	13.159	0.033
P # 1-1	5980	8.5E-05	18355.16	14.048	12.012	4.145	14.157	0.012
P # 2-1	5980	8.5E-05	15457.04	14.354	11.818	6.431	13.616	0.544
P # 3-1	5980	8.5E-05	13131.13	13.469	11.633	3.371	13.103	0.134
P # 4-1	5980	8.5E-05	16300.62	14.694	11.878	7.932	13.784	0.829
P # 5-1	5980	8.5E-05	19302.43	14.812	12.069	7.521	14.315	0.246
P # 6-1	5980	8.5E-05	10595.92	12.946	11.391	2.419	12.428	0.268
P # 0-1	8120	8.8E-05	16457.43	13.496	11.889	2.583	13.814	0.101
P # 1-1	8120	8.8E-05	18895.35	14.180	12.045	4.558	14.248	0.005
P # 2-1	8120	8.8E-05	15625.19	13.777	11.830	3.789	13.650	0.016
P # 3-1	8120	8.8E-05	14813.02	13.026	11.770	1.579	13.482	0.208
P # 4-1	8120	8.8E-05	16951.93	13.937	11.922	4.060	13.907	0.001
P # 5-1	8120	8.8E-05	17275.63	14.237	11.944	5.258	13.966	0.073
P # 6-1	8120	8.8E-05	12480.08	12.861	11.576	1.651	12.943	0.007
P # 0-1	9930	9.1E-05	15688.34	13.042	11.835	1.458	13.663	0.385
P # 1-1	9930	9.1E-05	20296.20	14.200	12.126	4.303	14.474	0.075
P # 2-1	9930	9.1E-05	17414.22	13.532	11.953	2.495	13.991	0.211
P # 3-1	9930	9.1E-05	15092.34	12.784	11.791	0.986	13.541	0.574
P # 4-1	9930	9.1E-05	18428.22	13.759	12.017	3.037	14.170	0.168
P # 5-1	9930	9.1E-05	17626.22	13.583	11.966	2.613	14.030	0.200
P # 6-1	9930	9.1E-05	13645.60	12.830	11.677	1.329	13.224	0.155
P # 0-1	11600	9.5E-05	16447.94	12.839	11.888	0.905	13.812	0.946
P # 1-1	11600	9.5E-05	20919.88	13.945	12.160	3.185	14.569	0.389
P # 2-1	11600	9.5E-05	18512.74	13.444	12.022	2.024	14.184	0.547
P # 3-1	11600	9.5E-05	15587.89	12.653	11.827	0.682	13.643	0.979
P # 4-1	11600	9.5E-05	19339.25	13.476	12.071	1.974	14.321	0.715
P # 5-1	11600	9.5E-05	17697.91	13.179	11.971	1.459	14.042	0.746
P # 6-1	11600	9.5E-05	15385.28	12.625	11.813	0.660	13.602	0.954
P # 0-1	13800	9.7E-05	18095.21	12.714	11.996	0.516	14.112	1.954
P # 1-1	13800	9.7E-05	23971.24	14.002	12.314	2.849	14.997	0.990
P # 2-1	13800	9.7E-05	20670.88	13.554	12.147	1.981	14.531	0.954
P # 3-1	13800	9.7E-05	14945.35	12.093	11.780	0.098	13.510	2.009
P # 4-1	13800	9.7E-05	19912.80	13.309	12.104	1.452	14.413	1.219
P # 5-1	13800	9.7E-05	19454.60	13.145	12.078	1.138	14.340	1.429
P # 6-1	13800	9.7E-05	17116.23	12.538	11.933	0.365	13.937	1.959
					Total	155.468	Total	29.898
					Std.error	1.997	Std.error	0.876

TABLE A-4.6 COMPUTATION FRICTION FACTOR BASE FROM REGRESSION ANALYSIS OF AVAILABLE FIELD DATA

without K $\frac{1}{\sqrt{f}} = 0.464\ln\left(\frac{R}{d50}\right) + 0.32$ with K $\frac{1}{\sqrt{f}} = 1.113\ln\left(\frac{R}{d50}\right) - 5.92$

X Section	Qw m^3/s	Slope	R/d50 ratio	f obs.	f cal. without K	Standard error estimate	f cal. with K	Standard error estimate
P # 0-1	3730	7.268E-05	11848.734	0.040	0.060	0.0004	0.049	0.0001
P # 1-1	3730	7.268E-05	18021.202	0.035	0.056	0.0004	0.040	0.0000
P # 2-1	3730	7.268E-05	18298.626	0.034	0.055	0.0004	0.040	0.0000
P # 3-1	3730	7.268E-05	13362.154	0.038	0.059	0.0005	0.046	0.0001
P # 4-1	3730	7.268E-05	18428.233	0.035	0.055	0.0004	0.040	0.0000
P # 5-1	3730	7.268E-05	21804.617	0.034	0.054	0.0004	0.037	0.0000
P # 6-1	3730	7.268E-05	10956.397	0.040	0.061	0.0004	0.051	0.0001
P # 0-1	5980	8.51E-05	13367.335	0.045	0.059	0.0002	0.046	0.0000
P # 1-1	5980	8.51E-05	18355.156	0.041	0.055	0.0002	0.040	0.0000
P # 2-1	5980	8.51E-05	15457.041	0.039	0.057	0.0003	0.043	0.0000
P # 3-1	5980	8.51E-05	13131.126	0.044	0.059	0.0002	0.047	0.0000
P # 4-1	5980	8.51E-05	16300.625	0.037	0.057	0.0004	0.042	0.0000
P # 5-1	5980	8.51E-05	19302.429	0.036	0.055	0.0003	0.039	0.0000
P # 6-1	5980	8.51E-05	10595.919	0.048	0.062	0.0002	0.052	0.0000
P # 0-1	8120	8.813E-05	16457.429	0.044	0.057	0.0002	0.042	0.0000
P # 1-1	8120	8.813E-05	18895.353	0.040	0.055	0.0002	0.039	0.0000
P # 2-1	8120	8.813E-05	15625.193	0.042	0.057	0.0002	0.043	0.0000
P # 3-1	8120	8.813E-05	14813.024	0.047	0.058	0.0001	0.044	0.0000
P # 4-1	8120	8.813E-05	16951.932	0.041	0.056	0.0002	0.041	0.0000
P # 5-1	8120	8.813E-05	17275.627	0.039	0.056	0.0003	0.041	0.0000
P # 6-1	8120	8.813E-05	12480.079	0.048	0.060	0.0001	0.048	0.0000
P # 0-1	9930	9.129E-05	15688.344	0.047	0.057	0.0001	0.043	0.0000
P # 1-1	9930	9.129E-05	20296.202	0.040	0.054	0.0002	0.038	0.0000
P # 2-1	9930	9.129E-05	17414.223	0.044	0.056	0.0002	0.041	0.0000
P # 3-1	9930	9.129E-05	15092.338	0.049	0.058	0.0001	0.044	0.0000
P # 4-1	9930	9.129E-05	18428.216	0.042	0.055	0.0002	0.040	0.0000
P # 5-1	9930	9.129E-05	17626.224	0.043	0.056	0.0002	0.041	0.0000
P # 6-1	9930	9.129E-05	13645.601	0.049	0.059	0.0001	0.046	0.0000
P # 0-1	11600	9.522E-05	16447.941	0.049	0.057	0.0001	0.042	0.0000
P # 1-1	11600	9.522E-05	20919.878	0.041	0.054	0.0002	0.038	0.0000
P # 2-1	11600	9.522E-05	18512.741	0.044	0.055	0.0001	0.040	0.0000
P # 3-1	11600	9.522E-05	15587.886	0.050	0.057	0.0001	0.043	0.0000
P # 4-1	11600	9.522E-05	19339.248	0.044	0.055	0.0001	0.039	0.0000
P # 5-1	11600	9.522E-05	17697.91	0.046	0.056	0.0001	0.041	0.0000
P # 6-1	11600	9.522E-05	15385.278	0.050	0.057	0.0001	0.043	0.0000
P # 0-1	13800	9.677E-05	18095.212	0.049	0.056	0.0000	0.040	0.0001
P # 1-1	13800	9.677E-05	23971.241	0.041	0.053	0.0001	0.036	0.0000
P # 2-1	13800	9.677E-05	20670.878	0.044	0.054	0.0001	0.038	0.0000
P # 3-1	13800	9.677E-05	14945.355	0.055	0.058	0.0000	0.044	0.0001
P # 4-1	13800	9.677E-05	19912.804	0.045	0.055	0.0001	0.039	0.0000
P # 5-1	13800	9.677E-05	19454.603	0.046	0.055	0.0001	0.039	0.0001
P # 6-1	13800	9.677E-05	17116.228	0.051	0.056	0.0000	0.041	0.0001
					Total	0.0084	Total	0.0012
					Std.error	0.0147	Std.error	0.0056

TABLE A - 4.7 SUMMARY OF EXPERIMENTAL DATA FOR ERODIBLE BED CHANNEL

C/S	Qw m3/s	Area m2	Witdh m	Slope	d50 m	d84 m	velocity m/s	Depth m	R m	n
P # 6 - 1	0.003	0.021	0.950	0.0020	0.000225	0.00029	0.143	0.022	0.021	0.024
P # 5 - 1	0.003	0.022	0.940	0.0020	0.000225	0.00029	0.140	0.023	0.022	0.025
P # 4 - 1	0.003	0.024	1.080	0.0020	0.000225	0.00029	0.126	0.022	0.021	0.027
P # 3 - 1	0.003	0.021	0.900	0.0020	0.000225	0.00029	0.146	0.023	0.022	0.023
P # 2 - 1	0.003	0.023	1.000	0.0020	0.000225	0.00029	0.133	0.023	0.022	0.026
P # 1 - 1	0.003	0.019	0.850	0.0020	0.000225	0.00029	0.155	0.023	0.022	0.022
P # 0 - 1	0.003	0.022	1.000	0.0020	0.000225	0.00029	0.134	0.022	0.021	0.026
P # 6 - 1	0.005	0.032	1.160	0.0023	0.000225	0.00029	0.158	0.027	0.026	0.027
P # 5 - 1	0.005	0.034	1.270	0.0023	0.000225	0.00029	0.146	0.027	0.026	0.029
P # 4 - 1	0.005	0.034	1.260	0.0023	0.000225	0.00029	0.145	0.027	0.026	0.029
P # 3 - 1	0.005	0.030	1.150	0.0023	0.000225	0.00029	0.166	0.026	0.025	0.025
P # 2 - 1	0.005	0.040	1.550	0.0023	0.000225	0.00029	0.124	0.026	0.025	0.034
P # 1 - 1	0.005	0.036	1.300	0.0023	0.000225	0.00029	0.140	0.027	0.026	0.030
P # 0 - 1	0.005	0.033	1.240	0.0023	0.000225	0.00029	0.152	0.027	0.025	0.028
P # 6 - 1	0.006	0.039	1.300	0.0023	0.000225	0.00029	0.154	0.030	0.029	0.029
P # 5 - 1	0.006	0.039	1.300	0.0023	0.000225	0.00029	0.155	0.030	0.028	0.029
P # 4 - 1	0.006	0.040	1.350	0.0023	0.000225	0.00029	0.150	0.030	0.028	0.029
P # 3 - 1	0.006	0.034	1.150	0.0023	0.000225	0.00029	0.178	0.029	0.028	0.025
P # 2 - 1	0.006	0.045	1.550	0.0023	0.000225	0.00029	0.135	0.029	0.028	0.033
P # 1 - 1	0.006	0.042	1.450	0.0023	0.000225	0.00029	0.143	0.029	0.028	0.031
P # 0 - 1	0.006	0.039	1.300	0.0023	0.000225	0.00029	0.155	0.030	0.028	0.029
P # 6 - 1	0.004	0.027	1.040	0.0024	0.000225	0.00029	0.150	0.026	0.024	0.028
P # 5 - 1	0.004	0.027	1.050	0.0024	0.000225	0.00029	0.146	0.026	0.025	0.029
P # 4 - 1	0.004	0.030	1.150	0.0024	0.000225	0.00029	0.134	0.026	0.025	0.031
P # 3 - 1	0.004	0.026	1.020	0.0024	0.000225	0.00029	0.152	0.026	0.025	0.027
P # 2 - 1	0.004	0.030	1.150	0.0024	0.000225	0.00029	0.133	0.026	0.025	0.032
P # 1 - 1	0.004	0.027	1.000	0.0024	0.000225	0.00029	0.151	0.027	0.025	0.028
P # 0 - 1	0.004	0.033	1.280	0.0024	0.000225	0.00029	0.123	0.025	0.024	0.034
P # 6 - 1	0.002	0.016	0.850	0.0025	0.000225	0.00029	0.128	0.018	0.018	0.026
P # 5 - 1	0.002	0.015	0.800	0.0025	0.000225	0.00029	0.134	0.019	0.018	0.025
P # 4 - 1	0.002	0.017	0.920	0.0025	0.000225	0.00029	0.118	0.018	0.018	0.029
P # 3 - 1	0.002	0.015	0.800	0.0025	0.000225	0.00029	0.131	0.019	0.018	0.026
P # 2 - 1	0.002	0.016	0.850	0.0025	0.000225	0.00029	0.127	0.019	0.018	0.027
P # 1 - 1	0.002	0.012	0.600	0.0025	0.000225	0.00029	0.168	0.020	0.019	0.021
P # 0 - 1	0.002	0.013	0.700	0.0025	0.000225	0.00029	0.153	0.019	0.018	0.022
P # 6 - 1	0.002	0.015	0.840	0.0025	0.000225	0.00029	0.130	0.018	0.018	0.026
P # 5 - 1	0.002	0.015	0.850	0.0025	0.000225	0.00029	0.130	0.018	0.017	0.026
P # 4 - 1	0.002	0.017	0.930	0.0025	0.000225	0.00029	0.117	0.018	0.018	0.029
P # 3 - 1	0.002	0.016	0.850	0.0025	0.000225	0.00029	0.124	0.019	0.018	0.028
P # 2 - 1	0.002	0.015	0.800	0.0025	0.000225	0.00029	0.135	0.019	0.018	0.025
P # 1 - 1	0.002	0.014	0.750	0.0025	0.000225	0.00029	0.144	0.019	0.018	0.023
P # 0 - 1	0.002	0.013	0.700	0.0025	0.000225	0.00029	0.148	0.019	0.018	0.023
P # 6 - 1	0.004	0.026	1.040	0.0025	0.000225	0.00029	0.152	0.025	0.024	0.027
P # 5 - 1	0.004	0.028	1.100	0.0025	0.000225	0.00029	0.144	0.025	0.024	0.029
P # 4 - 1	0.004	0.028	1.100	0.0025	0.000225	0.00029	0.144	0.025	0.024	0.029
P # 3 - 1	0.004	0.027	1.070	0.0025	0.000225	0.00029	0.149	0.025	0.024	0.028
P # 2 - 1	0.004	0.028	1.110	0.0025	0.000225	0.00029	0.143	0.025	0.024	0.029
P # 1 - 1	0.004	0.024	1.000	0.0025	0.000225	0.00029	0.165	0.024	0.023	0.025
P # 0 - 1	0.004	0.030	1.180	0.0025	0.000225	0.00029	0.135	0.025	0.024	0.031

P # 1 - 1	0.003	0.017	0.750	0.0025	0.000225	0.00029	0.174	0.023	0.022	0.022
P # 6 - 1	0.006	0.040	1.390	0.0025	0.000225	0.00029	0.152	0.028	0.027	0.030
P # 5 - 1	0.006	0.040	1.390	0.0025	0.000225	0.00029	0.151	0.029	0.027	0.030
P # 4 - 1	0.006	0.039	1.400	0.0025	0.000225	0.00029	0.152	0.028	0.027	0.030
P # 3 - 1	0.006	0.036	1.220	0.0025	0.000225	0.00029	0.169	0.029	0.028	0.027
P # 2 - 1	0.006	0.041	1.400	0.0025	0.000225	0.00029	0.147	0.029	0.028	0.031
P # 1 - 1	0.006	0.038	1.300	0.0025	0.000225	0.00029	0.159	0.029	0.028	0.029
P # 0 - 1	0.006	0.037	1.250	0.0025	0.000225	0.00029	0.164	0.029	0.028	0.028
P # 6 - 1	0.005	0.034	1.330	0.0026	0.000225	0.00029	0.148	0.025	0.024	0.029
P # 5 - 1	0.005	0.033	1.340	0.0026	0.000225	0.00029	0.150	0.025	0.024	0.028
P # 4 - 1	0.005	0.034	1.310	0.0026	0.000225	0.00029	0.148	0.026	0.025	0.029
P # 3 - 1	0.005	0.030	1.200	0.0026	0.000225	0.00029	0.166	0.025	0.024	0.026
P # 2 - 1	0.005	0.033	1.300	0.0026	0.000225	0.00029	0.150	0.026	0.025	0.029
P # 1 - 1	0.005	0.029	1.150	0.0026	0.000225	0.00029	0.171	0.025	0.024	0.025
P # 0 - 1	0.005	0.031	1.200	0.0026	0.000225	0.00029	0.162	0.026	0.025	0.027
P # 6 - 1	0.004	0.026	1.040	0.0027	0.000225	0.00029	0.154	0.025	0.024	0.028
P # 5 - 1	0.004	0.027	1.100	0.0027	0.000225	0.00029	0.147	0.025	0.024	0.029
P # 4 - 1	0.004	0.029	1.140	0.0027	0.000225	0.00029	0.139	0.025	0.024	0.031
P # 3 - 1	0.004	0.025	1.000	0.0027	0.000225	0.00029	0.161	0.025	0.024	0.027
P # 2 - 1	0.004	0.027	1.090	0.0027	0.000225	0.00029	0.149	0.025	0.024	0.029
P # 1 - 1	0.004	0.025	1.000	0.0027	0.000225	0.00029	0.161	0.025	0.024	0.027
P # 0 - 1	0.004	0.029	1.150	0.0027	0.000225	0.00029	0.139	0.025	0.024	0.031
P # 6 - 1	0.002	0.015	0.780	0.0027	0.000225	0.00029	0.138	0.019	0.018	0.025
P # 5 - 1	0.002	0.015	0.800	0.0027	0.000225	0.00029	0.132	0.019	0.018	0.027
P # 4 - 1	0.002	0.016	0.860	0.0027	0.000225	0.00029	0.124	0.019	0.018	0.029
P # 3 - 1	0.002	0.014	0.700	0.0027	0.000225	0.00029	0.146	0.020	0.019	0.025
P # 2 - 1	0.002	0.015	0.760	0.0027	0.000225	0.00029	0.137	0.019	0.018	0.026
P # 1 - 1	0.002	0.012	0.600	0.0027	0.000225	0.00029	0.168	0.020	0.019	0.022
P # 0 - 1	0.002	0.014	0.700	0.0027	0.000225	0.00029	0.148	0.019	0.018	0.024
P # 6 - 1	0.006	0.039	1.300	0.0027	0.000225	0.00029	0.154	0.030	0.029	0.031
P # 5 - 1	0.006	0.039	1.300	0.0027	0.000225	0.00029	0.155	0.030	0.029	0.031
P # 4 - 1	0.006	0.040	1.350	0.0027	0.000225	0.00029	0.150	0.030	0.028	0.032
P # 3 - 1	0.006	0.035	1.150	0.0027	0.000225	0.00029	0.170	0.031	0.029	0.029
P # 2 - 1	0.006	0.042	1.450	0.0027	0.000225	0.00029	0.142	0.029	0.028	0.034
P # 1 - 1	0.006	0.040	1.350	0.0027	0.000225	0.00029	0.150	0.030	0.028	0.032
P # 0 - 1	0.006	0.039	1.300	0.0027	0.000225	0.00029	0.154	0.030	0.029	0.031
P # 6 - 1	0.005	0.029	1.110	0.0028	0.000225	0.00029	0.170	0.026	0.025	0.027
P # 5 - 1	0.005	0.031	1.170	0.0028	0.000225	0.00029	0.162	0.026	0.025	0.028
P # 4 - 1	0.005	0.032	1.200	0.0028	0.000225	0.00029	0.158	0.026	0.025	0.029
P # 3 - 1	0.005	0.030	1.120	0.0028	0.000225	0.00029	0.166	0.027	0.026	0.028
P # 2 - 1	0.005	0.033	1.250	0.0028	0.000225	0.00029	0.150	0.027	0.026	0.031
P # 1 - 1	0.005	0.032	1.200	0.0028	0.000225	0.00029	0.157	0.027	0.025	0.029
P # 0 - 1	0.005	0.031	1.200	0.0028	0.000225	0.00029	0.159	0.026	0.025	0.028
P # 6 - 1	0.003	0.021	0.920	0.0029	0.000225	0.00029	0.146	0.022	0.021	0.028
P # 5 - 1	0.003	0.021	0.930	0.0029	0.000225	0.00029	0.144	0.022	0.021	0.029
P # 4 - 1	0.003	0.022	0.980	0.0029	0.000225	0.00029	0.135	0.023	0.022	0.031
P # 3 - 1	0.003	0.021	0.900	0.0029	0.000225	0.00029	0.146	0.023	0.022	0.029
P # 2 - 1	0.003	0.019	0.860	0.0029	0.000225	0.00029	0.155	0.023	0.021	0.027
P # 1 - 1	0.003	0.018	0.750	0.0029	0.000225	0.00029	0.171	0.023	0.022	0.024
P # 0 - 1	0.003	0.021	0.950	0.0029	0.000225	0.00029	0.140	0.023	0.022	0.030

TABLE.A-4.8 COMPUTATION STANDARD ERROR ESTIMATE RESISTANCE COEFFICIENT OF EXPERIMENTAL DATA

Equation (log. Form); U/u* =1.3173.ln(R/d50)+0.8 Power form;U/u*=5.3624(R/d50)$^{0.096}$

X SECT.	DISCH. M3/S	R/d50 RATIO	SLOPE	U/u* Cal.	U/u* Plot Log form	Standar Error Est.	U/u* Plot Pwr.form	Standar Error Est.
P # 6 - 1	0.003	93.877	0.001953	7.101	6.315	0.618	6.288	0.661
P # 5 - 1	0.003	96.937	0.001953	6.826	6.270	0.309	6.244	0.338
P # 4 - 1	0.003	94.102	0.001953	6.258	6.311	0.003	6.285	0.001
P # 3 - 1	0.003	96.357	0.001953	7.180	6.278	0.813	6.252	0.861
P # 2 - 1	0.003	96.101	0.001953	6.522	6.282	0.057	6.256	0.071
P # 1 - 1	0.003	96.150	0.001953	7.605	6.281	1.752	6.255	1.823
P # 0 - 1	0.003	95.450	0.001953	6.591	6.292	0.089	6.265	0.106
P # 6 - 1	0.005	115.991	0.002344	6.439	6.020	0.176	6.002	0.191
P # 5 - 1	0.005	114.816	0.002344	5.999	6.034	0.001	6.016	0.000
P # 4 - 1	0.005	116.300	0.002344	5.926	6.016	0.008	5.999	0.005
P # 3 - 1	0.005	111.264	0.002344	6.924	6.078	0.716	6.057	0.751
P # 2 - 1	0.005	112.073	0.002344	5.140	6.068	0.861	6.048	0.824
P # 1 - 1	0.005	116.789	0.002344	5.714	6.010	0.088	5.993	0.078
P # 0 - 1	0.005	113.082	0.002344	6.283	6.055	0.052	6.036	0.061
P # 6 - 1	0.006	127.451	0.002279	6.076	5.888	0.035	5.879	0.039
P # 5 - 1	0.006	126.514	0.002279	6.146	5.899	0.061	5.889	0.066
P # 4 - 1	0.006	125.848	0.002279	5.977	5.906	0.005	5.896	0.007
P # 3 - 1	0.006	123.926	0.002279	7.131	5.928	1.449	5.916	1.478
P # 2 - 1	0.006	123.307	0.002279	5.402	5.934	0.283	5.922	0.270
P # 1 - 1	0.006	123.506	0.002279	5.746	5.932	0.035	5.920	0.030
P # 0 - 1	0.006	126.201	0.002279	6.170	5.902	0.072	5.892	0.077
P # 6 - 1	0.004	108.540	0.002409	6.248	6.112	0.018	6.091	0.025
P # 5 - 1	0.004	110.487	0.002409	6.023	6.088	0.004	6.067	0.002
P # 4 - 1	0.004	110.203	0.002409	5.545	6.091	0.298	6.070	0.276
P # 3 - 1	0.004	109.477	0.002409	6.280	6.100	0.032	6.079	0.040
P # 2 - 1	0.004	111.264	0.002409	5.464	6.078	0.377	6.057	0.353
P # 1 - 1	0.004	111.850	0.002409	6.190	6.071	0.014	6.050	0.019
P # 0 - 1	0.004	108.541	0.002409	5.123	6.112	0.978	6.091	0.936
P # 6 - 1	0.002	78.432	0.002474	6.175	6.566	0.152	6.542	0.134
P # 5 - 1	0.002	79.095	0.002474	6.459	6.554	0.009	6.530	0.005
P # 4 - 1	0.002	78.954	0.002474	5.666	6.556	0.793	6.532	0.750
P # 3 - 1	0.002	81.121	0.002474	6.211	6.519	0.095	6.493	0.080
P # 2 - 1	0.002	79.152	0.002474	6.089	6.553	0.215	6.528	0.193
P # 1 - 1	0.002	82.682	0.002474	7.910	6.492	2.010	6.466	2.084
P # 0 - 1	0.002	78.953	0.002474	7.353	6.556	0.634	6.532	0.674
P # 6 - 1	0.002	78.074	0.002474	6.290	6.572	0.080	6.548	0.067
P # 5 - 1	0.002	77.231	0.002474	6.324	6.587	0.069	6.564	0.058
P # 4 - 1	0.002	78.612	0.002474	5.645	6.562	0.841	6.538	0.798
P # 3 - 1	0.002	80.591	0.002474	5.922	6.528	0.367	6.503	0.338
P # 2 - 1	0.002	78.588	0.002474	6.523	6.563	0.002	6.539	0.000
P # 1 - 1	0.002	78.491	0.002474	6.950	6.565	0.149	6.541	0.168
P # 0 - 1	0.002	81.067	0.002474	7.057	6.519	0.289	6.494	0.317
P # 6 - 1	0.004	107.569	0.002474	6.252	6.125	0.016	6.103	0.022
P # 5 - 1	0.004	107.019	0.002474	5.973	6.132	0.025	6.110	0.019
P # 4 - 1	0.004	107.019	0.002474	5.973	6.132	0.025	6.110	0.019
P # 3 - 1	0.004	106.719	0.002474	6.160	6.136	0.001	6.113	0.002
P # 2 - 1	0.004	107.238	0.002474	5.903	6.129	0.051	6.107	0.041

P # 1 - 1	0.004	102.994	0.002474	6.941	6.186	0.571	6.161	0.608
P # 0 - 1	0.004	106.941	0.002474	5.592	6.133	0.293	6.110	0.269
P # 1 - 1	0.003	96.052	0.002454	7.646	6.283	1.858	6.256	1.931
P # 6 - 1	0.006	121.338	0.002539	5.825	5.957	0.017	5.943	0.014
P # 5 - 1	0.006	121.928	0.002539	5.782	5.950	0.028	5.937	0.024
P # 4 - 1	0.006	120.245	0.002539	5.866	5.970	0.011	5.955	0.008
P # 3 - 1	0.006	123.770	0.002539	6.399	5.929	0.221	5.917	0.232
P # 2 - 1	0.006	124.054	0.002539	5.591	5.926	0.112	5.914	0.104
P # 1 - 1	0.006	123.384	0.002539	6.052	5.934	0.014	5.921	0.017
P # 0 - 1	0.006	124.310	0.002539	6.211	5.923	0.083	5.912	0.090
P # 6 - 1	0.005	108.791	0.002604	5.916	6.109	0.037	6.087	0.030
P # 5 - 1	0.005	106.498	0.002604	6.069	6.139	0.005	6.116	0.002
P # 4 - 1	0.005	110.013	0.002604	5.900	6.094	0.037	6.073	0.030
P # 3 - 1	0.005	107.349	0.002604	6.665	6.128	0.289	6.105	0.313
P # 2 - 1	0.005	109.530	0.002604	5.984	6.100	0.013	6.078	0.009
P # 1 - 1	0.005	108.078	0.002604	6.870	6.118	0.565	6.096	0.599
P # 0 - 1	0.005	109.735	0.002604	6.443	6.097	0.120	6.076	0.135
P # 6 - 1	0.004	105.625	0.002669	6.191	6.150	0.002	6.127	0.004
P # 5 - 1	0.004	105.171	0.002669	5.908	6.156	0.062	6.133	0.051
P # 4 - 1	0.004	107.515	0.002669	5.518	6.126	0.369	6.103	0.342
P # 3 - 1	0.004	105.417	0.002669	6.446	6.153	0.086	6.130	0.100
P # 2 - 1	0.004	104.932	0.002669	5.980	6.160	0.032	6.136	0.024
P # 1 - 1	0.004	105.417	0.002669	6.446	6.153	0.086	6.130	0.100
P # 0 - 1	0.004	106.304	0.002669	5.569	6.141	0.328	6.119	0.302
P # 6 - 1	0.002	78.862	0.002669	6.399	6.558	0.025	6.534	0.018
P # 5 - 1	0.002	80.109	0.002669	6.097	6.536	0.193	6.511	0.172
P # 4 - 1	0.002	79.733	0.002669	5.731	6.543	0.658	6.518	0.619
P # 3 - 1	0.002	82.378	0.002669	6.626	6.497	0.017	6.471	0.024
P # 2 - 1	0.002	81.272	0.002669	6.260	6.516	0.065	6.491	0.053
P # 1 - 1	0.002	82.682	0.002669	7.615	6.492	1.261	6.466	1.319
P # 0 - 1	0.002	81.238	0.002669	6.772	6.517	0.065	6.491	0.079
P # 6 - 1	0.006	127.139	0.002669	5.636	5.892	0.066	5.882	0.061
P # 5 - 1	0.006	126.826	0.002669	5.657	5.895	0.057	5.886	0.052
P # 4 - 1	0.006	125.848	0.002669	5.522	5.906	0.147	5.896	0.139
P # 3 - 1	0.006	129.163	0.002669	6.179	5.870	0.096	5.862	0.100
P # 2 - 1	0.006	124.923	0.002669	5.216	5.916	0.490	5.905	0.475
P # 1 - 1	0.006	125.848	0.002669	5.522	5.906	0.147	5.896	0.139
P # 0 - 1	0.006	127.139	0.002669	5.636	5.892	0.066	5.882	0.061
P # 6 - 1	0.005	112.356	0.002799	6.454	6.064	0.152	6.044	0.168
P # 5 - 1	0.005	111.961	0.002799	6.172	6.069	0.011	6.049	0.015
P # 4 - 1	0.005	112.116	0.002799	6.012	6.067	0.003	6.047	0.001
P # 3 - 1	0.005	114.336	0.002799	6.229	6.040	0.036	6.021	0.043
P # 2 - 1	0.005	113.560	0.002799	5.668	6.049	0.145	6.030	0.131
P # 1 - 1	0.005	113.136	0.002799	5.928	6.055	0.016	6.035	0.011
P # 0 - 1	0.005	111.436	0.002799	6.068	6.076	0.000	6.055	0.000
P # 6 - 1	0.003	94.458	0.002865	5.988	6.306	0.101	6.280	0.085
P # 5 - 1	0.003	95.276	0.002865	5.848	6.294	0.199	6.268	0.176
P # 4 - 1	0.003	96.231	0.002865	5.478	6.280	0.643	6.254	0.601
P # 3 - 1	0.003	96.805	0.002865	5.886	6.272	0.149	6.246	0.129
P # 2 - 1	0.003	95.261	0.002865	6.301	6.294	0.000	6.268	0.001
P # 1 - 1	0.003	97.629	0.002865	6.900	6.260	0.409	6.234	0.443
P # 0 - 1	0.003	95.584	0.002865	5.702	6.290	0.345	6.263	0.315
					Total	25.830	Total	25.926
					Std.error	0.530	Std.error	0.531

TABLE.A - 4.9 COMPUTATION RESISTANCE COEFFICIEN(U/u*) vs R/d50 RATIO AT DIFFERENT SLOPE

TABLE A-4.9.1 Slope 0.0020

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.003	0.143	0.000225	0.0020	0.0211	93.88	0.020	7.101	5.880
0.003	0.140	0.000225	0.0020	0.0218	96.94	0.020	6.826	6.237
0.003	0.126	0.000225	0.0020	0.0212	94.10	0.020	6.258	5.907
0.003	0.146	0.000225	0.0020	0.0217	96.36	0.020	7.180	6.170
0.003	0.133	0.000225	0.0020	0.0216	96.10	0.020	6.522	6.141
0.003	0.155	0.000225	0.0020	0.0216	96.15	0.020	7.605	6.146
0.003	0.134	0.000225	0.0020	0.0215	95.45	0.020	6.591	6.065

TABLE A-4.9.2 Slope 0.0023

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.005	0.158	0.000225	0.00234	0.0261	115.99	0.024	6.439	6.074
0.005	0.146	0.000225	0.00234	0.02583	114.82	0.024	5.999	6.073
0.005	0.145	0.000225	0.00234	0.02617	116.30	0.025	5.926	6.074
0.005	0.166	0.000225	0.00234	0.02503	111.26	0.024	6.924	6.070
0.005	0.124	0.000225	0.00234	0.02522	112.07	0.024	5.140	6.070
0.005	0.140	0.000225	0.00234	0.02628	116.79	0.025	5.714	6.074
0.005	0.152	0.000225	0.00234	0.02544	113.08	0.024	6.283	6.071
0.006	0.154	0.000225	0.00228	0.02868	127.45	0.025	6.076	6.083
0.006	0.155	0.000225	0.00228	0.02847	126.51	0.025	6.146	6.082
0.006	0.150	0.000225	0.00228	0.02832	125.85	0.025	5.977	6.081
0.006	0.178	0.000225	0.00228	0.02788	123.93	0.025	7.131	6.080
0.006	0.135	0.000225	0.00228	0.02774	123.31	0.025	5.402	6.079
0.006	0.143	0.000225	0.00228	0.02779	123.51	0.025	5.746	6.080
0.006	0.155	0.000225	0.00228	0.0284	126.20	0.025	6.170	6.082

TABLE A-4.9.3 Slope 0.0024

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.004	0.150	0.000225	0.00241	0.02442	108.54	0.024	6.248	5.774
0.004	0.146	0.000225	0.00241	0.02486	110.49	0.024	6.023	5.858
0.004	0.134	0.000225	0.00241	0.0248	110.20	0.024	5.545	5.846
0.004	0.152	0.000225	0.00241	0.02463	109.48	0.024	6.280	5.815
0.004	0.133	0.000225	0.00241	0.02503	111.26	0.024	5.464	5.891
0.004	0.151	0.000225	0.00241	0.02517	111.85	0.024	6.190	5.916
0.004	0.123	0.000225	0.00241	0.02442	108.54	0.024	5.123	5.774

TABLE A-4.9.4 Slope 0.0025

Qw m³/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.002	0.128	0.000225	0.00247	0.01765	78.43	0.021	6.175	6.517
0.002	0.134	0.000225	0.00247	0.0178	79.09	0.021	6.459	6.508
0.002	0.118	0.000225	0.00247	0.01776	78.95	0.021	5.666	6.510
0.002	0.131	0.000225	0.00247	0.01825	81.12	0.021	6.211	6.480
0.002	0.127	0.000225	0.00247	0.01781	79.15	0.021	6.089	6.507
0.002	0.168	0.000225	0.00247	0.0186	82.68	0.021	7.910	6.459
0.002	0.153	0.000225	0.00247	0.01776	78.95	0.021	7.353	6.510
0.002	0.130	0.000225	0.00247	0.01757	78.07	0.021	6.290	6.522
0.002	0.130	0.000225	0.00247	0.01738	77.23	0.021	6.324	6.534
0.002	0.117	0.000225	0.00247	0.01769	78.61	0.021	5.645	6.515
0.002	0.124	0.000225	0.00247	0.01813	80.59	0.021	5.922	6.487
0.002	0.135	0.000225	0.00247	0.01768	78.59	0.021	6.523	6.515
0.002	0.144	0.000225	0.00247	0.01766	78.49	0.021	6.950	6.516
0.002	0.148	0.000225	0.00247	0.01824	81.07	0.021	7.057	6.480
0.004	0.152	0.000225	0.00247	0.0242	107.57	0.024	6.252	6.166
0.004	0.144	0.000225	0.00247	0.02408	107.02	0.024	5.973	6.172
0.004	0.144	0.000225	0.00247	0.02408	107.02	0.024	5.973	6.172
0.004	0.149	0.000225	0.00247	0.02401	106.72	0.024	6.160	6.175
0.004	0.143	0.000225	0.00247	0.02413	107.24	0.024	5.903	6.170
0.004	0.165	0.000225	0.00247	0.02317	102.99	0.024	6.941	6.215
0.004	0.135	0.000225	0.00247	0.02406	106.94	0.024	5.592	6.173
0.003	0.174	0.000225	0.00245	0.02161	96.05	0.023	7.646	6.292
0.006	0.152	0.000225	0.00254	0.0273	121.34	0.026	5.825	6.033
0.006	0.151	0.000225	0.00254	0.02743	121.93	0.026	5.782	6.027
0.006	0.152	0.000225	0.00254	0.02706	120.25	0.026	5.866	6.043
0.006	0.169	0.000225	0.00254	0.02785	123.77	0.026	6.399	6.011
0.006	0.147	0.000225	0.00254	0.02791	124.05	0.026	5.591	6.008
0.006	0.159	0.000225	0.00254	0.02776	123.38	0.026	6.052	6.014
0.006	0.164	0.000225	0.00254	0.02797	124.31	0.026	6.211	6.006

TABLE A-4.9.5 Slope 0.0026

Qw m³/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.005	0.148	0.000225	0.0026	0.02448	108.79	0.025	5.916	6.239
0.005	0.150	0.000225	0.0026	0.02396	106.50	0.025	6.069	6.469
0.005	0.148	0.000225	0.0026	0.02475	110.01	0.025	5.900	6.119
0.005	0.166	0.000225	0.0026	0.02415	107.35	0.025	6.665	6.383
0.005	0.150	0.000225	0.0026	0.02464	109.53	0.025	5.984	6.167
0.005	0.171	0.000225	0.0026	0.02432	108.08	0.025	6.870	6.310
0.005	0.162	0.000225	0.0026	0.02469	109.73	0.025	6.443	6.146

TABLE A-4.9.6 Slope 0.0027

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.004	0.154	0.000225	0.00267	0.02377	105.63	0.025	6.191	5.992
0.004	0.147	0.000225	0.00267	0.02366	105.17	0.025	5.908	6.000
0.004	0.139	0.000225	0.00267	0.02419	107.52	0.025	5.518	5.959
0.004	0.161	0.000225	0.00267	0.02372	105.42	0.025	6.446	5.996
0.004	0.149	0.000225	0.00267	0.02361	104.93	0.025	5.980	6.004
0.004	0.161	0.000225	0.00267	0.02372	105.42	0.025	6.446	5.996
0.004	0.139	0.000225	0.00267	0.02392	106.30	0.025	5.569	5.980
0.002	0.138	0.000225	0.00267	0.01774	78.86	0.022	6.399	6.537
0.002	0.132	0.000225	0.00267	0.01802	80.11	0.022	6.097	6.508
0.002	0.124	0.000225	0.00267	0.01794	79.73	0.022	5.731	6.517
0.002	0.146	0.000225	0.00267	0.01853	82.38	0.022	6.626	6.456
0.002	0.137	0.000225	0.00267	0.01829	81.27	0.022	6.260	6.481
0.002	0.168	0.000225	0.00267	0.0186	82.68	0.022	7.615	6.449
0.002	0.148	0.000225	0.00267	0.01828	81.24	0.022	6.772	6.482
0.006	0.154	0.000225	0.00267	0.02861	127.14	0.027	5.636	5.646
0.006	0.155	0.000225	0.00267	0.02854	126.83	0.027	5.657	5.651
0.006	0.150	0.000225	0.00267	0.02832	125.85	0.027	5.522	5.665
0.006	0.170	0.000225	0.00267	0.02906	129.16	0.028	6.179	5.617
0.006	0.142	0.000225	0.00267	0.02811	124.92	0.027	5.216	5.679
0.006	0.150	0.000225	0.00267	0.02832	125.85	0.027	5.522	5.665
0.006	0.154	0.000225	0.00267	0.02861	127.14	0.027	5.636	5.646

TABLE A-4.9.7 Slope 0.0028

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.005	0.170	0.000225	0.0028	0.02528	112.36	0.026	6.454	6.094
0.005	0.162	0.000225	0.0028	0.02519	111.96	0.026	6.172	6.114
0.005	0.158	0.000225	0.0028	0.02523	112.12	0.026	6.012	6.106
0.005	0.166	0.000225	0.0028	0.02573	114.34	0.027	6.229	5.992
0.005	0.150	0.000225	0.0028	0.02555	113.56	0.026	5.668	6.032
0.005	0.157	0.000225	0.0028	0.02546	113.14	0.026	5.928	6.053
0.005	0.159	0.000225	0.0028	0.02507	111.44	0.026	6.068	6.141

TABLE A-4.9.8 Slope 0.0029

Qw m^3/s	Vel. m/s	d50 m	Slope	R m	R/d50 ratio	u*	U/u*	Computed U/u* (plot)
0.003	0.146	0.000225	0.00286	0.02125	94.46	0.024	5.988	5.744
0.003	0.144	0.000225	0.00286	0.02144	95.28	0.025	5.848	5.899
0.003	0.135	0.000225	0.00286	0.02165	96.23	0.025	5.478	6.077
0.003	0.146	0.000225	0.00286	0.02178	96.80	0.025	5.886	6.183
0.003	0.155	0.000225	0.00286	0.02143	95.26	0.025	6.301	5.896
0.003	0.171	0.000225	0.00286	0.02197	97.63	0.025	6.900	6.335
0.003	0.140	0.000225	0.00286	0.02151	95.58	0.025	5.702	5.956

TABLE.A-4.10 COMPUTATION OF CORRECTION FACTOR (K1) FOR EXPERIMENTAL DATA

Qw m^3/s	Vel. m/s	Slope	d50 m	R m	R/d50 ratio	u*	U/u*	K1	K1.U/u*
0.003	0.143	0.0020	0.000225	0.021	93.88	0.0201	7.101	0.877	6.41756
0.003	0.140	0.0020	0.000225	0.022	96.94	0.0204	6.826	0.904	6.16857
0.003	0.126	0.0020	0.000225	0.021	94.10	0.0201	6.258	0.992	5.65577
0.003	0.146	0.0020	0.000225	0.022	96.36	0.0204	7.180	0.859	6.48892
0.003	0.133	0.0020	0.000225	0.022	96.10	0.0204	6.522	0.946	5.89382
0.003	0.155	0.0020	0.000225	0.022	96.15	0.0204	7.605	0.811	6.87308
0.003	0.134	0.0020	0.000225	0.021	95.45	0.0203	6.591	0.936	5.95606
0.005	0.158	0.0023	0.000225	0.026	115.99	0.0245	6.439	0.906	6.09884
0.005	0.146	0.0023	0.000225	0.026	114.82	0.0244	5.999	0.975	5.68187
0.005	0.145	0.0023	0.000225	0.026	116.30	0.0245	5.926	0.984	5.61267
0.005	0.166	0.0023	0.000225	0.025	111.26	0.0240	6.924	0.852	6.55805
0.005	0.140	0.0023	0.000225	0.026	116.79	0.0246	5.714	1.021	5.41212
0.005	0.152	0.0023	0.000225	0.025	113.08	0.0242	6.283	0.936	5.95149
0.006	0.154	0.0023	0.000225	0.029	127.45	0.0253	6.076	0.927	5.75547
0.006	0.155	0.0023	0.000225	0.028	126.51	0.0252	6.146	0.920	5.82153
0.006	0.150	0.0023	0.000225	0.028	125.85	0.0252	5.977	0.924	5.66137
0.006	0.135	0.0023	0.000225	0.028	123.31	0.0249	5.402	1.022	5.11668
0.006	0.143	0.0023	0.000225	0.028	123.51	0.0249	5.746	0.981	5.44199
0.006	0.155	0.0023	0.000225	0.028	126.20	0.0252	6.170	0.917	5.84384
0.004	0.150	0.0024	0.000225	0.024	108.54	0.0240	6.248	0.883	6.33469
0.004	0.146	0.0024	0.000225	0.025	110.49	0.0242	6.023	0.981	6.10677
0.004	0.134	0.0024	0.000225	0.025	110.20	0.0242	5.545	1.066	5.62219
0.004	0.152	0.0024	0.000225	0.025	109.48	0.0241	6.280	0.944	6.36726
0.004	0.133	0.0024	0.000225	0.025	111.26	0.0243	5.464	1.080	5.53955
0.004	0.151	0.0024	0.000225	0.025	111.85	0.0244	6.190	0.953	6.27559
0.004	0.123	0.0024	0.000225	0.024	108.54	0.0240	5.123	1.190	5.19442
0.002	0.128	0.0025	0.000225	0.018	78.43	0.0207	6.175	1.036	5.83239
0.002	0.134	0.0025	0.000225	0.018	79.09	0.0208	6.459	0.887	6.10025
0.002	0.131	0.0025	0.000225	0.018	81.12	0.0210	6.211	1.008	5.8661
0.002	0.127	0.0025	0.000225	0.018	79.15	0.0208	6.089	0.941	5.75068
0.002	0.168	0.0025	0.000225	0.019	82.68	0.0212	7.910	0.963	7.47061
0.002	0.153	0.0025	0.000225	0.018	78.95	0.0208	7.353	0.870	6.94468
0.002	0.130	0.0025	0.000225	0.018	78.07	0.0206	6.290	1.017	5.94067
0.002	0.130	0.0025	0.000225	0.017	77.23	0.0205	6.324	1.012	5.97301
0.002	0.124	0.0025	0.000225	0.018	80.59	0.0210	5.922	1.030	5.59292
0.002	0.135	0.0025	0.000225	0.018	78.59	0.0207	6.523	0.981	6.16126
0.002	0.144	0.0025	0.000225	0.018	78.49	0.0207	6.950	0.921	6.56422
0.002	0.148	0.0025	0.000225	0.018	81.07	0.0210	7.057	0.887	6.66529
0.004	0.152	0.0025	0.000225	0.024	107.57	0.0242	6.252	0.883	5.90459
0.004	0.144	0.0025	0.000225	0.024	107.02	0.0242	5.973	0.924	5.64193
0.004	0.144	0.0025	0.000225	0.024	107.02	0.0242	5.973	0.924	5.64193
0.004	0.149	0.0025	0.000225	0.024	106.72	0.0241	6.160	0.904	5.81788
0.004	0.143	0.0025	0.000225	0.024	107.24	0.0242	5.903	0.935	5.57578
0.004	0.165	0.0025	0.000225	0.023	102.99	0.0237	6.941	0.862	6.55579
0.004	0.135	0.0025	0.000225	0.024	106.94	0.0242	5.592	0.996	5.28171
0.003	0.174	0.0025	0.000225	0.022	96.05	0.0228	7.646	0.807	7.2217
0.006	0.152	0.0025	0.000225	0.027	121.34	0.0261	5.825	0.979	5.50166
0.006	0.151	0.0025	0.000225	0.027	121.93	0.0261	5.782	0.986	5.46068

0.006	0.152	0.0025	0.000225	0.027	120.25	0.0260	5.866	0.980	5.54063
0.006	0.169	0.0025	0.000225	0.028	123.77	0.0263	6.399	0.891	6.0441
0.006	0.147	0.0025	0.000225	0.028	124.05	0.0264	5.591	1.019	5.28067
0.006	0.159	0.0025	0.000225	0.028	123.38	0.0263	6.052	0.942	5.71634
0.006	0.164	0.0025	0.000225	0.028	124.31	0.0264	6.211	0.918	5.86618
0.005	0.148	0.0026	0.000225	0.024	108.79	0.0250	5.916	0.933	5.40409
0.005	0.150	0.0026	0.000225	0.024	106.50	0.0247	6.069	0.918	5.54399
0.005	0.148	0.0026	0.000225	0.025	110.01	0.0251	5.900	1.002	5.38994
0.005	0.166	0.0026	0.000225	0.024	107.35	0.0248	6.665	0.828	6.08878
0.005	0.150	0.0026	0.000225	0.025	109.53	0.0251	5.984	0.991	5.46671
0.005	0.171	0.0026	0.000225	0.024	108.08	0.0249	6.870	0.803	6.27604
0.005	0.162	0.0026	0.000225	0.025	109.73	0.0251	6.443	0.920	5.8858
0.004	0.154	0.0027	0.000225	0.024	105.63	0.0249	6.191	1.000	6.191
0.004	0.147	0.0027	0.000225	0.024	105.17	0.0249	5.908	1.000	5.908
0.004	0.139	0.0027	0.000225	0.024	107.52	0.0252	5.518	1.000	5.518
0.004	0.161	0.0027	0.000225	0.024	105.42	0.0249	6.446	1.000	6.446
0.004	0.149	0.0027	0.000225	0.024	104.93	0.0249	5.980	1.000	5.980
0.004	0.161	0.0027	0.000225	0.024	105.42	0.0249	6.446	1.000	6.446
0.004	0.139	0.0027	0.000225	0.024	106.30	0.0250	5.569	1.000	5.569
0.002	0.138	0.0027	0.000225	0.018	78.86	0.0216	6.399	1.000	6.399
0.002	0.132	0.0027	0.000225	0.018	80.11	0.0217	6.097	1.000	6.097
0.002	0.124	0.0027	0.000225	0.018	79.73	0.0217	5.731	1.000	5.731
0.002	0.146	0.0027	0.000225	0.019	82.38	0.0220	6.626	1.000	6.626
0.002	0.137	0.0027	0.000225	0.018	81.27	0.0219	6.260	1.000	6.260
0.002	0.168	0.0027	0.000225	0.019	82.68	0.0221	7.615	1.000	7.615
0.002	0.148	0.0027	0.000225	0.018	81.24	0.0219	6.772	1.000	6.772
0.006	0.154	0.0027	0.000225	0.029	127.14	0.0274	5.636	1.000	5.636
0.006	0.155	0.0027	0.000225	0.029	126.83	0.0273	5.657	1.000	5.657
0.006	0.150	0.0027	0.000225	0.028	125.85	0.0272	5.522	1.000	5.522
0.006	0.142	0.0027	0.000225	0.028	124.92	0.0271	5.216	1.000	5.216
0.006	0.150	0.0027	0.000225	0.028	125.85	0.0272	5.522	1.000	5.522
0.006	0.154	0.0027	0.000225	0.029	127.14	0.0274	5.636	1.000	5.636
0.005	0.170	0.0028	0.000225	0.025	112.36	0.0263	6.454	0.911	6.250
0.005	0.162	0.0028	0.000225	0.025	111.96	0.0263	6.172	0.953	5.977
0.005	0.158	0.0028	0.000225	0.025	112.12	0.0263	6.012	0.978	5.821
0.005	0.166	0.0028	0.000225	0.026	114.34	0.0266	6.229	0.942	6.032
0.005	0.150	0.0028	0.000225	0.026	113.56	0.0265	5.668	1.035	5.489
0.005	0.157	0.0028	0.000225	0.025	113.14	0.0264	5.928	0.990	5.741
0.005	0.159	0.0028	0.000225	0.025	111.44	0.0262	6.068	0.971	5.876
0.003	0.146	0.0029	0.000225	0.021	94.46	0.0244	5.988	1.035	6.144
0.003	0.144	0.0029	0.000225	0.021	95.28	0.0245	5.848	1.043	6.000
0.003	0.135	0.0029	0.000225	0.022	96.23	0.0247	5.478	1.126	5.621
0.003	0.146	0.0029	0.000225	0.022	96.80	0.0247	5.886	1.048	6.039
0.003	0.155	0.0029	0.000225	0.021	95.26	0.0245	6.301	0.968	6.465
0.003	0.171	0.0029	0.000225	0.022	97.63	0.0248	6.900	0.891	7.079
0.003	0.140	0.0029	0.000225	0.022	95.58	0.0246	5.702	1.070	5.851

TABLE A-4.11 COMPUTATION RESISTANCE COEFFICIENT BASE FROM REGRESSION ANALYSIS OFEXPERIMENTAL DATA

Equation(without K); U/u*=-1.3948.ln(R/d50)+12.65 with K; U/u*=-1.6464.ln(R/d50)+13.603

X Section	Qw m^3/s	Slope	R/d50 ratio	U/u* Cal	U/u* Plot without K	Standard error estimate	U/u* Plot with K	Standard error estimate
P # 6 - 1	0.003	0.0020	93.877	7.101	6.315	0.618	6.125	0.953
P # 5 - 1	0.003	0.0020	96.937	6.826	6.270	0.309	6.072	0.568
P # 4 - 1	0.003	0.0020	94.102	6.258	6.311	0.003	6.121	0.019
P # 3 - 1	0.003	0.0020	96.357	7.180	6.278	0.813	6.082	1.206
P # 2 - 1	0.003	0.0020	96.101	6.522	6.282	0.057	6.087	0.189
P # 1 - 1	0.003	0.0020	96.150	7.605	6.281	1.752	6.086	2.309
P # 0 - 1	0.003	0.0020	95.450	6.591	6.292	0.089	6.098	0.243
P # 6 - 1	0.005	0.0023	115.991	6.439	6.020	0.176	5.777	0.438
P # 5 - 1	0.005	0.0023	114.816	5.999	6.034	0.001	5.794	0.042
P # 4 - 1	0.005	0.0023	116.300	5.926	6.016	0.008	5.772	0.023
P # 3 - 1	0.005	0.0023	111.264	6.924	6.078	0.716	5.845	1.163
P # 2 - 1	0.005	0.0023	112.073	5.140	6.068	0.861	5.833	0.481
P # 1 - 1	0.005	0.0023	116.789	5.714	6.010	0.088	5.766	0.003
P # 0 - 1	0.005	0.0023	113.082	6.283	6.055	0.052	5.819	0.216
P # 6 - 1	0.006	0.0023	127.451	6.076	5.888	0.035	5.622	0.207
P # 5 - 1	0.006	0.0023	126.514	6.146	5.899	0.061	5.634	0.263
P # 4 - 1	0.006	0.0023	125.848	5.977	5.906	0.005	5.643	0.112
P # 3 - 1	0.006	0.0023	123.926	7.131	5.928	1.449	5.668	2.142
P # 2 - 1	0.006	0.0023	123.307	5.402	5.934	0.283	5.676	0.075
P # 1 - 1	0.006	0.0023	123.506	5.746	5.932	0.035	5.673	0.005
P # 0 - 1	0.006	0.0023	126.201	6.170	5.902	0.072	5.638	0.283
P # 6 - 1	0.004	0.0024	108.540	6.248	6.112	0.018	5.886	0.131
P # 5 - 1	0.004	0.0024	110.487	6.023	6.088	0.004	5.857	0.028
P # 4 - 1	0.004	0.0024	110.203	5.545	6.091	0.298	5.861	0.100
P # 3 - 1	0.004	0.0024	109.477	6.280	6.100	0.032	5.872	0.167
P # 2 - 1	0.004	0.0024	111.264	5.464	6.078	0.377	5.845	0.146
P # 1 - 1	0.004	0.0024	111.850	6.190	6.071	0.014	5.837	0.125
P # 0 - 1	0.004	0.0024	108.541	5.123	6.112	0.978	5.886	0.582
P # 6 - 1	0.002	0.0025	78.432	6.175	6.566	0.152	6.421	0.060
P # 5 - 1	0.002	0.0025	79.095	6.459	6.554	0.009	6.407	0.003
P # 4 - 1	0.002	0.0025	78.954	5.666	6.556	0.793	6.410	0.554
P # 3 - 1	0.002	0.0025	81.121	6.211	6.519	0.095	6.366	0.024
P # 2 - 1	0.002	0.0025	79.152	6.089	6.553	0.215	6.406	0.101
P # 1 - 1	0.002	0.0025	82.682	7.910	6.492	2.010	6.334	2.482
P # 0 - 1	0.002	0.0025	78.953	7.353	6.556	0.634	6.410	0.889
P # 6 - 1	0.002	0.0025	78.074	6.290	6.572	0.080	6.429	0.019
P # 5 - 1	0.002	0.0025	77.231	6.324	6.587	0.069	6.446	0.015
P # 4 - 1	0.002	0.0025	78.612	5.645	6.562	0.841	6.417	0.596
P # 3 - 1	0.002	0.0025	80.591	5.922	6.528	0.367	6.376	0.207
P # 2 - 1	0.002	0.0025	78.588	6.523	6.563	0.002	6.418	0.011
P # 1 - 1	0.002	0.0025	78.491	6.950	6.565	0.149	6.420	0.281
P # 0 - 1	0.002	0.0025	81.067	7.057	6.519	0.289	6.367	0.477
P # 6 - 1	0.004	0.0025	107.569	6.252	6.125	0.016	5.901	0.123
P # 5 - 1	0.004	0.0025	107.019	5.973	6.132	0.025	5.909	0.004
P # 4 - 1	0.004	0.0025	107.019	5.973	6.132	0.025	5.909	0.004
P # 3 - 1	0.004	0.0025	106.719	6.160	6.136	0.001	5.914	0.060
P # 2 - 1	0.004	0.0025	107.238	5.903	6.129	0.051	5.906	0.000

P # 1 - 1	0.004	0.0025	102.994	6.941	6.186	0.571	5.972	0.938
P # 0 - 1	0.004	0.0025	106.941	5.592	6.133	0.293	5.911	0.101
P # 1 - 1	0.003	0.0025	96.052	7.646	6.283	1.858	6.087	2.430
P # 6 - 1	0.006	0.0025	121.338	5.825	5.957	0.017	5.703	0.015
P # 5 - 1	0.006	0.0025	121.928	5.782	5.950	0.028	5.695	0.008
P # 4 - 1	0.006	0.0025	120.245	5.866	5.970	0.011	5.718	0.022
P # 3 - 1	0.006	0.0025	123.770	6.399	5.929	0.221	5.670	0.532
P # 2 - 1	0.006	0.0025	124.054	5.591	5.926	0.112	5.666	0.006
P # 1 - 1	0.006	0.0025	123.384	6.052	5.934	0.014	5.675	0.142
P # 0 - 1	0.006	0.0025	124.310	6.211	5.923	0.083	5.663	0.300
P # 6 - 1	0.005	0.0026	108.791	5.916	6.109	0.037	5.882	0.001
P # 5 - 1	0.005	0.0026	106.498	6.069	6.139	0.005	5.917	0.023
P # 4 - 1	0.005	0.0026	110.013	5.900	6.094	0.037	5.864	0.001
P # 3 - 1	0.005	0.0026	107.349	6.665	6.128	0.289	5.904	0.579
P # 2 - 1	0.005	0.0026	109.530	5.984	6.100	0.013	5.871	0.013
P # 1 - 1	0.005	0.0026	108.078	6.870	6.118	0.565	5.893	0.954
P # 0 - 1	0.005	0.0026	109.735	6.443	6.097	0.120	5.868	0.330
P # 6 - 1	0.004	0.0027	105.625	6.191	6.150	0.002	5.931	0.068
P # 5 - 1	0.004	0.0027	105.171	5.908	6.156	0.062	5.938	0.001
P # 4 - 1	0.004	0.0027	107.515	5.518	6.126	0.369	5.902	0.147
P # 3 - 1	0.004	0.0027	105.417	6.446	6.153	0.086	5.934	0.262
P # 2 - 1	0.004	0.0027	104.932	5.980	6.160	0.032	5.942	0.001
P # 1 - 1	0.004	0.0027	105.417	6.446	6.153	0.086	5.934	0.262
P # 0 - 1	0.004	0.0027	106.304	5.569	6.141	0.328	5.920	0.123
P # 6 - 1	0.002	0.0027	78.862	6.399	6.558	0.025	6.412	0.000
P # 5 - 1	0.002	0.0027	80.109	6.097	6.536	0.193	6.386	0.084
P # 4 - 1	0.002	0.0027	79.733	5.731	6.543	0.658	6.394	0.439
P # 3 - 1	0.002	0.0027	82.378	6.626	6.497	0.017	6.340	0.082
P # 2 - 1	0.002	0.0027	81.272	6.260	6.516	0.065	6.362	0.010
P # 1 - 1	0.002	0.0027	82.682	7.615	6.492	1.261	6.334	1.640
P # 0 - 1	0.002	0.0027	81.238	6.772	6.517	0.065	6.363	0.167
P # 6 - 1	0.006	0.0027	127.139	5.636	5.892	0.066	5.626	0.000
P # 5 - 1	0.006	0.0027	126.826	5.657	5.895	0.057	5.630	0.001
P # 4 - 1	0.006	0.0027	125.848	5.522	5.906	0.147	5.643	0.014
P # 3 - 1	0.006	0.0027	129.163	6.179	5.870	0.096	5.600	0.336
P # 2 - 1	0.006	0.0027	124.923	5.216	5.916	0.490	5.655	0.192
P # 1 - 1	0.006	0.0027	125.848	5.522	5.906	0.147	5.643	0.014
P # 0 - 1	0.006	0.0027	127.139	5.636	5.892	0.066	5.626	0.000
P # 6 - 1	0.005	0.0028	112.356	6.454	6.064	0.152	5.829	0.391
P # 5 - 1	0.005	0.0028	111.961	6.172	6.069	0.011	5.835	0.114
P # 4 - 1	0.005	0.0028	112.116	6.012	6.067	0.003	5.833	0.032
P # 3 - 1	0.005	0.0028	114.336	6.229	6.040	0.036	5.800	0.183
P # 2 - 1	0.005	0.0028	113.560	5.668	6.049	0.145	5.812	0.021
P # 1 - 1	0.005	0.0028	113.136	5.928	6.055	0.016	5.818	0.012
P # 0 - 1	0.005	0.0028	111.436	6.068	6.076	0.000	5.843	0.051
P # 6 - 1	0.003	0.0029	94.458	5.988	6.306	0.101	6.115	0.016
P # 5 - 1	0.003	0.0029	95.276	5.848	6.294	0.199	6.101	0.064
P # 4 - 1	0.003	0.0029	96.231	5.478	6.280	0.643	6.084	0.367
P # 3 - 1	0.003	0.0029	96.805	5.886	6.272	0.149	6.075	0.035
P # 2 - 1	0.003	0.0029	95.261	6.301	6.294	0.000	6.101	0.040
P # 1 - 1	0.003	0.0029	97.629	6.900	6.260	0.409	6.061	0.704
P # 0 - 1	0.003	0.0029	95.584	5.702	6.290	0.345	6.095	0.154
					Total	25.212	Total	29.598
					Std.error	0.523	Std.error	0.567

TABLE A-4.12 COMPUTATION RESISTANCE COEFFICIENT BASE FROM REGRESSION ANALYSIS OF AVAILABLE EXPERIMENTAL DATA

without K $\frac{1}{\sqrt{f}} = -0.354 \ln\left(\frac{R}{d50}\right) + 4.47$ with K $\frac{1}{\sqrt{f}} = -0.582 \ln\left(\frac{R}{d50}\right) + 4.80$

X Section	Qw m^3/s	Slope	R/d50 ratio	f Cal.	f Plot without K	Standard error estimate	f Plot with K	Standard error estimate
P # 6 - 1	0.003	0.001953	93.8768	0.159	0.201	0.0018	0.215	0.0032
P # 5 - 1	0.003	0.001953	96.9374	0.172	0.203	0.0010	0.217	0.0020
P # 4 - 1	0.003	0.001953	94.1021	0.204	0.201	0.0000	0.214	0.0001
P # 3 - 1	0.003	0.001953	96.3572	0.155	0.203	0.0023	0.216	0.0037
P # 2 - 1	0.003	0.001953	96.1007	0.188	0.203	0.0002	0.216	0.0008
P # 1 - 1	0.003	0.001953	96.1503	0.138	0.203	0.0042	0.216	0.0060
P # 0 - 1	0.003	0.001953	95.4496	0.184	0.202	0.0003	0.215	0.0010
P # 6 - 1	0.005	0.002344	115.991	0.193	0.221	0.0008	0.240	0.0022
P # 5 - 1	0.005	0.002344	114.816	0.222	0.220	0.0000	0.238	0.0003
P # 4 - 1	0.005	0.002344	116.3	0.228	0.221	0.0000	0.240	0.0002
P # 3 - 1	0.005	0.002344	111.264	0.167	0.217	0.0025	0.234	0.0045
P # 2 - 1	0.005	0.002344	112.073	0.303	0.217	0.0073	0.235	0.0046
P # 1 - 1	0.005	0.002344	116.789	0.245	0.221	0.0006	0.241	0.0000
P # 0 - 1	0.005	0.002344	113.082	0.203	0.218	0.0002	0.236	0.0011
P # 6 - 1	0.006	0.002279	127.451	0.217	0.231	0.0002	0.253	0.0013
P # 5 - 1	0.006	0.002279	126.514	0.212	0.230	0.0003	0.252	0.0016
P # 4 - 1	0.006	0.002279	125.848	0.224	0.229	0.0000	0.251	0.0007
P # 3 - 1	0.006	0.002279	123.926	0.157	0.228	0.0050	0.249	0.0084
P # 2 - 1	0.006	0.002279	123.307	0.274	0.227	0.0022	0.248	0.0007
P # 1 - 1	0.006	0.002279	123.506	0.242	0.227	0.0002	0.249	0.0000
P # 0 - 1	0.006	0.002279	126.201	0.210	0.230	0.0004	0.252	0.0017
P # 6 - 1	0.004	0.002409	108.54	0.205	0.214	0.0001	0.231	0.0007
P # 5 - 1	0.004	0.002409	110.487	0.221	0.216	0.0000	0.233	0.0002
P # 4 - 1	0.004	0.002409	110.203	0.260	0.216	0.0020	0.233	0.0007
P # 3 - 1	0.004	0.002409	109.477	0.203	0.215	0.0001	0.232	0.0009
P # 2 - 1	0.004	0.002409	111.264	0.268	0.217	0.0026	0.234	0.0011
P # 1 - 1	0.004	0.002409	111.85	0.209	0.217	0.0001	0.235	0.0007
P # 0 - 1	0.004	0.002409	108.541	0.305	0.214	0.0082	0.231	0.0055
P # 6 - 1	0.002	0.002474	78.4322	0.210	0.186	0.0006	0.194	0.0002
P # 5 - 1	0.002	0.002474	79.0949	0.192	0.186	0.0000	0.195	0.0000
P # 4 - 1	0.002	0.002474	78.954	0.249	0.186	0.0040	0.195	0.0030
P # 3 - 1	0.002	0.002474	81.1214	0.207	0.188	0.0004	0.197	0.0001
P # 2 - 1	0.002	0.002474	79.1525	0.216	0.186	0.0009	0.195	0.0004
P # 1 - 1	0.002	0.002474	82.682	0.128	0.190	0.0038	0.199	0.0051
P # 0 - 1	0.002	0.002474	78.953	0.148	0.186	0.0015	0.195	0.0022
P # 6 - 1	0.002	0.002474	78.0735	0.202	0.185	0.0003	0.194	0.0001
P # 5 - 1	0.002	0.002474	77.2306	0.200	0.184	0.0002	0.193	0.0001
P # 4 - 1	0.002	0.002474	78.6119	0.251	0.186	0.0043	0.194	0.0032
P # 3 - 1	0.002	0.002474	80.5913	0.228	0.188	0.0016	0.197	0.0010
P # 2 - 1	0.002	0.002474	78.5875	0.188	0.186	0.0000	0.194	0.0000
P # 1 - 1	0.002	0.002474	78.4912	0.166	0.186	0.0004	0.194	0.0008
P # 0 - 1	0.002	0.002474	81.0668	0.161	0.188	0.0008	0.197	0.0013
P # 6 - 1	0.004	0.002474	107.569	0.205	0.213	0.0001	0.230	0.0006
P # 5 - 1	0.004	0.002474	107.019	0.224	0.213	0.0001	0.229	0.0000
P # 4 - 1	0.004	0.002474	107.019	0.224	0.213	0.0001	0.229	0.0000
P # 3 - 1	0.004	0.002474	106.719	0.211	0.212	0.0000	0.229	0.0003
P # 2 - 1	0.004	0.002474	107.238	0.230	0.213	0.0003	0.229	0.0000

P # 1 - 1	0.004	0.002474	102.994	0.166	0.209	0.0019	0.224	0.0034
P # 0 - 1	0.004	0.002474	106.941	0.256	0.213	0.0019	0.229	0.0007
P # 1 - 1	0.003	0.002454	96.0518	0.137	0.203	0.0043	0.216	0.0062
P # 6 - 1	0.006	0.002539	121.338	0.236	0.225	0.0001	0.246	0.0001
P # 5 - 1	0.006	0.002539	121.928	0.239	0.226	0.0002	0.247	0.0001
P # 4 - 1	0.006	0.002539	120.245	0.232	0.224	0.0001	0.245	0.0002
P # 3 - 1	0.006	0.002539	123.77	0.195	0.228	0.0010	0.249	0.0029
P # 2 - 1	0.006	0.002539	124.054	0.256	0.228	0.0008	0.249	0.0000
P # 1 - 1	0.006	0.002539	123.384	0.218	0.227	0.0001	0.248	0.0009
P # 0 - 1	0.006	0.002539	124.31	0.207	0.228	0.0004	0.249	0.0018
P # 6 - 1	0.005	0.002604	108.791	0.229	0.214	0.0002	0.231	0.0000
P # 5 - 1	0.005	0.002604	106.498	0.217	0.212	0.0000	0.228	0.0001
P # 4 - 1	0.005	0.002604	110.013	0.230	0.215	0.0002	0.233	0.0000
P # 3 - 1	0.005	0.002604	107.349	0.180	0.213	0.0011	0.229	0.0024
P # 2 - 1	0.005	0.002604	109.53	0.223	0.215	0.0001	0.232	0.0001
P # 1 - 1	0.005	0.002604	108.078	0.170	0.214	0.0020	0.230	0.0037
P # 0 - 1	0.005	0.002604	109.735	0.193	0.215	0.0005	0.232	0.0016
P # 6 - 1	0.004	0.002669	105.625	0.209	0.211	0.0000	0.227	0.0003
P # 5 - 1	0.004	0.002669	105.171	0.229	0.211	0.0003	0.227	0.0000
P # 4 - 1	0.004	0.002669	107.515	0.263	0.213	0.0025	0.230	0.0011
P # 3 - 1	0.004	0.002669	105.417	0.193	0.211	0.0004	0.227	0.0012
P # 2 - 1	0.004	0.002669	104.932	0.224	0.211	0.0002	0.227	0.0000
P # 1 - 1	0.004	0.002669	105.417	0.193	0.211	0.0004	0.227	0.0012
P # 0 - 1	0.004	0.002669	106.304	0.258	0.212	0.0021	0.228	0.0009
P # 6 - 1	0.002	0.002669	78.862	0.195	0.186	0.0001	0.195	0.0000
P # 5 - 1	0.002	0.002669	80.1088	0.215	0.187	0.0008	0.196	0.0004
P # 4 - 1	0.002	0.002669	79.7328	0.244	0.187	0.0032	0.196	0.0023
P # 3 - 1	0.002	0.002669	82.3777	0.182	0.190	0.0001	0.199	0.0003
P # 2 - 1	0.002	0.002669	81.2715	0.204	0.188	0.0002	0.198	0.0000
P # 1 - 1	0.002	0.002669	82.682	0.138	0.190	0.0027	0.199	0.0038
P # 0 - 1	0.002	0.002669	81.2379	0.174	0.188	0.0002	0.198	0.0005
P # 6 - 1	0.006	0.002669	127.139	0.252	0.230	0.0005	0.253	0.0000
P # 5 - 1	0.006	0.002669	126.826	0.250	0.230	0.0004	0.252	0.0000
P # 4 - 1	0.006	0.002669	125.848	0.262	0.229	0.0011	0.251	0.0001
P # 3 - 1	0.006	0.002669	129.163	0.210	0.232	0.0005	0.255	0.0021
P # 2 - 1	0.006	0.002669	124.923	0.294	0.229	0.0043	0.250	0.0019
P # 1 - 1	0.006	0.002669	125.848	0.262	0.229	0.0011	0.251	0.0001
P # 0 - 1	0.006	0.002669	127.139	0.252	0.230	0.0005	0.253	0.0000
P # 6 - 1	0.005	0.002799	112.356	0.192	0.218	0.0007	0.235	0.0019
P # 5 - 1	0.005	0.002799	111.961	0.210	0.217	0.0001	0.235	0.0006
P # 4 - 1	0.005	0.002799	112.116	0.221	0.217	0.0000	0.235	0.0002
P # 3 - 1	0.005	0.002799	114.336	0.206	0.219	0.0002	0.238	0.0010
P # 2 - 1	0.005	0.002799	113.56	0.249	0.219	0.0009	0.237	0.0001
P # 1 - 1	0.005	0.002799	113.136	0.228	0.218	0.0001	0.236	0.0001
P # 0 - 1	0.005	0.002799	111.436	0.217	0.217	0.0000	0.234	0.0003
P # 6 - 1	0.003	0.002865	94.4582	0.223	0.201	0.0005	0.214	0.0001
P # 5 - 1	0.003	0.002865	95.2759	0.234	0.202	0.0010	0.215	0.0004
P # 4 - 1	0.003	0.002865	96.2314	0.267	0.203	0.0041	0.216	0.0025
P # 3 - 1	0.003	0.002865	96.8045	0.231	0.203	0.0008	0.217	0.0002
P # 2 - 1	0.003	0.002865	95.2609	0.202	0.202	0.0000	0.215	0.0002
P # 1 - 1	0.003	0.002865	97.629	0.168	0.204	0.0013	0.218	0.0025
P # 0 - 1	0.003	0.002865	95.584	0.246	0.202	0.0019	0.215	0.0009
					Total	0.108	Total	0.121
					Std.error	0.034	Std.error	0.036

APPENDIX - V

DEVELOPING MODEL EQUATION OF FLOW RESISTANCE IN BRAIDED RIVER WITH PARAMETER B/D RATIO

TABLE.A-5.1 COMPUTATION STANDARD ERROR ESTIMATE RESISTANCE COEFFICIENT OF EXPERIMENTAL DATA

Equation (log. Form); U/u* =-3.4874Ln(B/D)+19.339 Power form;U/u*=48,12(B/D)$^{-0.545}$

X SECT.	DISCH. M3/S	B/D RATIO	SLOPE	U/u* Obs.	U/u* Plot Log form	Standar Error Est.	U/u* Plot Pwr.form	Standar Error Est.
P # 6 - 1	0.002	46.166	0.002474	6.175	5.976	0.040	5.960	0.046
P # 5 - 1	0.002	42.953	0.002474	6.459	6.228	0.053	6.199	0.067
P # 4 - 1	0.002	49.788	0.002474	5.666	5.713	0.002	5.720	0.003
P # 3 - 1	0.002	41.830	0.002474	6.211	6.320	0.012	6.289	0.006
P # 2 - 1	0.002	45.728	0.002474	6.089	6.009	0.006	5.991	0.009
P # 1 - 1	0.002	30.252	0.002474	7.910	7.450	0.211	7.504	0.164
P # 0 - 1	0.002	37.405	0.002474	7.353	6.710	0.413	6.685	0.446
P # 6 - 1	0.002	45.818	0.002474	6.290	6.002	0.083	5.985	0.093
P # 5 - 1	0.002	46.916	0.002474	6.324	5.920	0.163	5.908	0.173
P # 4 - 1	0.002	50.579	0.002474	5.645	5.658	0.000	5.671	0.001
P # 3 - 1	0.002	44.876	0.002474	5.922	6.075	0.023	6.053	0.017
P # 2 - 1	0.002	43.243	0.002474	6.523	6.204	0.102	6.177	0.120
P # 1 - 1	0.002	40.468	0.002474	6.950	6.435	0.265	6.404	0.298
P # 0 - 1	0.002	36.377	0.002474	7.057	6.807	0.063	6.787	0.073
P # 6 - 1	0.004	40.970	0.002474	6.252	6.392	0.020	6.361	0.012
P # 5 - 1	0.004	43.682	0.002474	5.973	6.169	0.038	6.143	0.029
P # 4 - 1	0.004	43.682	0.002474	5.973	6.169	0.038	6.143	0.029
P # 3 - 1	0.004	42.561	0.002474	6.160	6.259	0.010	6.230	0.005
P # 2 - 1	0.004	44.004	0.002474	5.903	6.143	0.058	6.118	0.046
P # 1 - 1	0.004	41.152	0.002474	6.941	6.377	0.318	6.346	0.354
P # 0 - 1	0.004	47.041	0.002474	5.592	5.911	0.101	5.900	0.095
P # 1 - 1	0.003	32.703	0.002454	7.646	7.178	0.219	7.192	0.206
P # 6 - 1	0.006	48.914	0.002539	5.825	5.774	0.003	5.775	0.002
P # 5 - 1	0.006	48.668	0.002539	5.782	5.792	0.000	5.791	0.000
P # 4 - 1	0.006	49.746	0.002539	5.866	5.716	0.023	5.723	0.021
P # 3 - 1	0.006	41.809	0.002539	6.399	6.322	0.006	6.291	0.012
P # 2 - 1	0.006	48.157	0.002539	5.591	5.829	0.057	5.825	0.055
P # 1 - 1	0.006	44.828	0.002539	6.052	6.079	0.001	6.057	0.000
P # 0 - 1	0.006	42.691	0.002539	6.211	6.249	0.001	6.220	0.000
P # 6 - 1	0.004	40.585	0.002409	6.248	6.425	0.031	6.394	0.021
P # 5 - 1	0.004	40.237	0.002409	6.023	6.455	0.187	6.424	0.161
P # 4 - 1	0.004	44.379	0.002409	5.545	6.114	0.323	6.090	0.297
P # 3 - 1	0.004	39.409	0.002409	6.280	6.528	0.061	6.497	0.047
P # 2 - 1	0.004	43.937	0.002409	5.464	6.149	0.469	6.123	0.435
P # 1 - 1	0.004	37.736	0.002409	6.190	6.679	0.240	6.653	0.214
P # 0 - 1	0.004	50.412	0.002409	5.123	5.669	0.298	5.681	0.311
P # 6 - 1	0.003	42.976	0.001953	7.101	6.226	0.767	6.197	0.817
P # 5 - 1	0.003	41.098	0.001953	6.826	6.381	0.197	6.350	0.226
P # 4 - 1	0.003	49.008	0.001953	6.258	5.768	0.241	5.769	0.239
P # 3 - 1	0.003	39.512	0.001953	7.180	6.519	0.438	6.488	0.479
P # 2 - 1	0.003	44.248	0.001953	6.522	6.124	0.158	6.100	0.178
P # 1 - 1	0.003	37.290	0.001953	7.605	6.720	0.783	6.696	0.827
P # 0 - 1	0.003	44.563	0.001953	6.591	6.099	0.241	6.076	0.265
P # 6 - 1	0.005	42.448	0.002344	6.439	6.269	0.029	6.239	0.040
P # 5 - 1	0.005	47.161	0.002344	5.999	5.902	0.009	5.891	0.012
P # 4 - 1	0.005	46.151	0.002344	5.926	5.977	0.003	5.961	0.001
P # 3 - 1	0.005	43.937	0.002344	6.924	6.149	0.601	6.123	0.641

P # 2 - 1	0.005	59.468	0.002344	5.140	5.093	0.002	5.192	0.003
P # 1 - 1	0.005	47.472	0.002344	5.714	5.879	0.027	5.870	0.024
P # 0 - 1	0.005	46.736	0.002344	6.283	5.933	0.123	5.921	0.132
P # 6 - 1	0.006	43.333	0.002279	6.076	6.197	0.014	6.170	0.009
P # 5 - 1	0.006	43.669	0.002279	6.146	6.170	0.001	6.144	0.000
P # 4 - 1	0.006	45.677	0.002279	5.977	6.013	0.001	5.995	0.000
P # 3 - 1	0.006	39.243	0.002279	7.131	6.542	0.347	6.512	0.384
P # 2 - 1	0.006	53.868	0.002279	5.402	5.438	0.001	5.480	0.006
P # 1 - 1	0.006	50.179	0.002279	5.746	5.685	0.004	5.696	0.002
P # 0 - 1	0.006	43.782	0.002279	6.170	6.161	0.000	6.135	0.001
P # 6 - 1	0.004	41.761	0.002669	6.191	6.326	0.018	6.295	0.011
P # 5 - 1	0.004	44.485	0.002669	5.908	6.105	0.039	6.082	0.030
P # 4 - 1	0.004	45.125	0.002669	5.518	6.055	0.289	6.035	0.267
P # 3 - 1	0.004	40.161	0.002669	6.446	6.462	0.000	6.431	0.000
P # 2 - 1	0.004	44.167	0.002669	5.980	6.130	0.022	6.106	0.016
P # 1 - 1	0.004	40.161	0.002669	6.446	6.462	0.000	6.431	0.000
P # 0 - 1	0.004	46.080	0.002669	5.569	5.982	0.171	5.966	0.158
P # 6 - 1	0.002	41.959	0.002669	6.399	6.309	0.008	6.279	0.014
P # 5 - 1	0.002	42.384	0.002669	6.097	6.274	0.031	6.245	0.022
P # 4 - 1	0.002	45.938	0.002669	5.731	5.993	0.069	5.976	0.060
P # 3 - 1	0.002	35.766	0.002669	6.626	6.866	0.057	6.850	0.050
P # 2 - 1	0.002	39.562	0.002669	6.260	6.514	0.065	6.484	0.050
P # 1 - 1	0.002	30.252	0.002669	7.615	7.450	0.027	7.504	0.012
P # 0 - 1	0.002	36.296	0.002669	6.772	6.815	0.002	6.795	0.001
P # 6 - 1	0.006	43.445	0.002669	5.636	6.188	0.305	6.161	0.276
P # 5 - 1	0.006	43.557	0.002669	5.657	6.179	0.272	6.152	0.245
P # 4 - 1	0.006	45.677	0.002669	5.522	6.013	0.241	5.995	0.223
P # 3 - 1	0.006	37.571	0.002669	6.179	6.694	0.266	6.669	0.240
P # 2 - 1	0.006	49.587	0.002669	5.216	5.727	0.261	5.733	0.267
P # 1 - 1	0.006	45.677	0.002669	5.522	6.013	0.241	5.995	0.223
P # 0 - 1	0.006	43.445	0.002669	5.636	6.188	0.305	6.161	0.276
P # 6 - 1	0.005	52.334	0.002604	5.916	5.539	0.142	5.567	0.122
P # 5 - 1	0.005	53.922	0.002604	6.069	5.434	0.402	5.477	0.351
P # 4 - 1	0.005	50.923	0.002604	5.900	5.634	0.071	5.650	0.062
P # 3 - 1	0.005	47.682	0.002604	6.665	5.863	0.643	5.856	0.654
P # 2 - 1	0.005	50.751	0.002604	5.984	5.646	0.114	5.661	0.105
P # 1 - 1	0.005	45.291	0.002604	6.870	6.043	0.685	6.023	0.718
P # 0 - 1	0.005	46.602	0.002604	6.443	5.943	0.250	5.930	0.263
P # 6 - 1	0.003	41.288	0.002865	5.988	6.365	0.142	6.334	0.120
P # 5 - 1	0.003	41.383	0.002865	5.848	6.357	0.259	6.326	0.229
P # 4 - 1	0.003	43.261	0.002865	5.478	6.203	0.524	6.175	0.486
P # 3 - 1	0.003	39.320	0.002865	5.886	6.536	0.422	6.505	0.383
P # 2 - 1	0.003	38.124	0.002865	6.301	6.643	0.117	6.616	0.099
P # 1 - 1	0.003	32.143	0.002865	6.900	7.238	0.115	7.260	0.130
P # 0 - 1	0.003	42.173	0.002865	5.702	6.291	0.347	6.262	0.313
P # 6 - 1	0.005	41.908	0.002799	6.454	6.313	0.020	6.283	0.029
P # 5 - 1	0.005	44.445	0.002799	6.172	6.108	0.004	6.085	0.008
P # 4 - 1	0.005	45.570	0.002799	6.012	6.021	0.000	6.003	0.000
P # 3 - 1	0.005	41.536	0.002799	6.229	6.344	0.013	6.314	0.007
P # 2 - 1	0.005	46.922	0.002799	5.668	5.919	0.063	5.908	0.057
P # 1 - 1	0.005	45.141	0.002799	5.928	6.054	0.016	6.034	0.011
P # 0 - 1	0.005	45.860	0.002799	6.068	5.999	0.005	5.982	0.007
					TOTAL	14.968	TOTAL	14.749
					Std.Error	0.3949	Std.Error	0.3920

TABLE.A-5.2 COMPUTATION RESISTANCE COEFFICIEN(U/u*) vs B/D RATIO AT DIFFERENT SLOPE

TABLE A-5.2.1 Slope 0.0020

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.003	0.143	0.950	0.0020	0.022	0.021	42.976	0.020	7.101	6.818
0.003	0.140	0.940	0.0020	0.023	0.022	41.098	0.020	6.826	7.032
0.003	0.126	1.080	0.0020	0.022	0.021	49.008	0.020	6.258	6.189
0.003	0.146	0.900	0.0020	0.023	0.022	39.512	0.020	7.180	7.221
0.003	0.133	1.000	0.0020	0.023	0.022	44.248	0.020	6.522	6.678
0.003	0.155	0.850	0.0020	0.023	0.022	37.290	0.020	7.605	7.498
0.003	0.134	1.000	0.0020	0.022	0.021	44.563	0.020	6.591	6.644

TABLE A-5.2.2 Slope 0.0023

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.005	0.158	1.160	0.0023	0.027	0.026	42.448	0.024	6.439	6.474
0.005	0.146	1.270	0.0023	0.027	0.026	47.161	0.024	5.999	6.006
0.005	0.145	1.260	0.0023	0.027	0.026	46.151	0.025	5.926	6.102
0.005	0.166	1.150	0.0023	0.026	0.025	43.937	0.024	6.924	6.321
0.005	0.124	1.550	0.0023	0.026	0.025	59.468	0.024	5.140	4.977
0.005	0.140	1.300	0.0023	0.027	0.026	47.472	0.025	5.714	5.977
0.005	0.152	1.240	0.0023	0.027	0.025	46.736	0.024	6.283	6.046
0.006	0.154	1.300	0.0023	0.030	0.029	43.333	0.025	6.076	6.382
0.006	0.155	1.300	0.0023	0.030	0.028	43.669	0.025	6.146	6.348
0.006	0.150	1.350	0.0023	0.030	0.028	45.677	0.025	5.977	6.148
0.006	0.178	1.150	0.0023	0.029	0.028	39.243	0.025	7.131	6.822
0.006	0.135	1.550	0.0023	0.029	0.028	53.868	0.025	5.402	5.416
0.006	0.143	1.450	0.0023	0.029	0.028	50.179	0.025	5.746	5.731
0.006	0.155	1.300	0.0023	0.030	0.028	43.782	0.025	6.170	6.336

TABLE A-5.2.3 Slope 0.0024

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.004	0.150	1.040	0.0024	0.026	0.024	40.585	0.024	6.248	6.012
0.004	0.146	1.050	0.0024	0.026	0.025	40.237	0.024	6.023	6.050
0.004	0.134	1.150	0.0024	0.026	0.025	44.379	0.024	5.545	5.617
0.004	0.152	1.020	0.0024	0.026	0.025	39.409	0.024	6.280	6.143
0.004	0.133	1.150	0.0024	0.026	0.025	43.937	0.024	5.464	5.661
0.004	0.151	1.000	0.0024	0.027	0.025	37.736	0.024	6.190	6.335
0.004	0.123	1.280	0.0024	0.025	0.024	50.412	0.024	5.123	5.052

TABLE A-5.2.4 Slope 0.0025

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.002	0.128	0.850	0.0025	0.018	0.018	46.166	0.021	6.175	6.068
0.002	0.134	0.800	0.0025	0.019	0.018	42.953	0.021	6.459	6.403
0.002	0.118	0.920	0.0025	0.018	0.018	49.788	0.021	5.666	5.718
0.002	0.131	0.800	0.0025	0.019	0.018	41.830	0.021	6.211	6.525
0.002	0.127	0.850	0.0025	0.019	0.018	45.728	0.021	6.089	6.112
0.002	0.168	0.600	0.0025	0.020	0.019	30.252	0.021	7.910	8.028
0.002	0.153	0.700	0.0025	0.019	0.018	37.405	0.021	7.353	7.044
0.002	0.130	0.840	0.0025	0.018	0.018	45.818	0.021	6.290	6.103
0.002	0.130	0.850	0.0025	0.018	0.017	46.916	0.021	6.324	5.993
0.002	0.117	0.930	0.0025	0.018	0.018	50.579	0.021	5.645	5.645
0.002	0.124	0.850	0.0025	0.019	0.018	44.876	0.021	5.922	6.200
0.002	0.135	0.800	0.0025	0.019	0.018	43.243	0.021	6.523	6.371
0.002	0.144	0.750	0.0025	0.019	0.018	40.468	0.021	6.950	6.679
0.002	0.148	0.700	0.0025	0.019	0.018	36.377	0.021	7.057	7.173
0.004	0.152	1.040	0.0025	0.025	0.024	40.970	0.024	6.252	6.622
0.004	0.144	1.100	0.0025	0.025	0.024	43.682	0.024	5.973	6.324
0.004	0.144	1.100	0.0025	0.025	0.024	43.682	0.024	5.973	6.324
0.004	0.149	1.070	0.0025	0.025	0.024	42.561	0.024	6.160	6.445
0.004	0.143	1.110	0.0025	0.025	0.024	44.004	0.024	5.903	6.290
0.004	0.165	1.000	0.0025	0.024	0.023	41.152	0.024	6.941	6.601
0.004	0.135	1.180	0.0025	0.025	0.024	47.041	0.024	5.592	5.981
0.003	0.174	0.750	0.0025	0.023	0.022	32.703	0.023	7.646	7.666
0.006	0.152	1.390	0.0025	0.028	0.027	48.914	0.026	5.825	5.800
0.006	0.151	1.390	0.0025	0.029	0.027	48.668	0.026	5.782	5.823
0.006	0.152	1.400	0.0025	0.028	0.027	49.746	0.026	5.866	5.722
0.006	0.169	1.220	0.0025	0.029	0.028	41.809	0.026	6.399	6.528
0.006	0.147	1.400	0.0025	0.029	0.028	48.157	0.026	5.591	5.872
0.006	0.159	1.300	0.0025	0.029	0.028	44.828	0.026	6.052	6.204
0.006	0.164	1.250	0.0025	0.029	0.028	42.691	0.026	6.211	6.431

TABLE A-5.2.5 Slope 0.0026

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.005	0.148	1.330	0.0026	0.025	0.024	52.334	0.025	5.916	5.973
0.005	0.150	1.340	0.0026	0.025	0.024	53.922	0.025	6.069	5.813
0.005	0.148	1.310	0.0026	0.026	0.025	50.923	0.025	5.900	6.120
0.005	0.166	1.200	0.0026	0.025	0.024	47.682	0.025	6.665	6.473
0.005	0.150	1.300	0.0026	0.026	0.025	50.751	0.025	5.984	6.138
0.005	0.171	1.150	0.0026	0.025	0.024	45.291	0.025	6.870	6.750
0.005	0.162	1.200	0.0026	0.026	0.025	46.602	0.025	6.443	6.596

TABLE A-5.2.6 Slopo 0.0027

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.004	0.154	1.040	0.0027	0.025	0.024	41.761	0.025	6.191	6.051
0.004	0.147	1.100	0.0027	0.025	0.024	44.485	0.025	5.908	5.753
0.004	0.139	1.140	0.0027	0.025	0.024	45.125	0.025	5.518	5.685
0.004	0.161	1.000	0.0027	0.025	0.024	40.161	0.025	6.446	6.235
0.004	0.149	1.090	0.0027	0.025	0.024	44.167	0.025	5.980	5.787
0.004	0.161	1.000	0.0027	0.025	0.024	40.161	0.025	6.446	6.235
0.004	0.139	1.150	0.0027	0.025	0.024	46.080	0.025	5.569	5.586
0.002	0.138	0.780	0.0027	0.019	0.018	41.959	0.022	6.399	6.029
0.002	0.132	0.800	0.0027	0.019	0.018	42.384	0.022	6.097	5.981
0.002	0.124	0.860	0.0027	0.019	0.018	45.938	0.022	5.731	5.601
0.002	0.146	0.700	0.0027	0.020	0.019	35.766	0.022	6.626	6.782
0.002	0.137	0.760	0.0027	0.019	0.018	39.562	0.022	6.260	6.306
0.002	0.168	0.600	0.0027	0.020	0.019	30.252	0.022	7.615	7.572
0.002	0.148	0.700	0.0027	0.019	0.018	36.296	0.022	6.772	6.713
0.006	0.154	1.300	0.0027	0.030	0.029	43.445	0.027	5.636	5.864
0.006	0.155	1.300	0.0027	0.030	0.029	43.557	0.027	5.657	5.852
0.006	0.150	1.350	0.0027	0.030	0.028	45.677	0.027	5.522	5.628
0.006	0.170	1.150	0.0027	0.031	0.029	37.571	0.028	6.179	6.550
0.006	0.142	1.450	0.0027	0.029	0.028	49.587	0.027	5.216	5.240
0.006	0.150	1.350	0.0027	0.030	0.028	45.677	0.027	5.522	5.628
0.006	0.154	1.300	0.0027	0.030	0.029	43.445	0.027	5.636	5.864

TABLE A-5.2.7 Slope 0.0028

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.005	0.170	1.110	0.0028	0.026	0.025	41.908	0.026	6.454	6.347
0.005	0.162	1.170	0.0028	0.026	0.025	44.445	0.026	6.172	6.077
0.005	0.158	1.200	0.0028	0.026	0.025	45.570	0.026	6.012	5.963
0.005	0.166	1.120	0.0028	0.027	0.026	41.536	0.027	6.229	6.388
0.005	0.150	1.250	0.0028	0.027	0.026	46.922	0.026	5.668	5.828
0.005	0.157	1.200	0.0028	0.027	0.025	45.141	0.026	5.928	6.006
0.005	0.159	1.200	0.0028	0.026	0.025	45.860	0.026	6.068	5.933

TABLE A-5.2.8 Slope 0.0029

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
0.003	0.146	0.920	0.0029	0.022	0.021	41.288	0.024	5.988	5.819
0.003	0.144	0.930	0.0029	0.022	0.021	41.383	0.025	5.848	5.809
0.003	0.135	0.980	0.0029	0.023	0.022	43.261	0.025	5.478	5.610
0.003	0.146	0.900	0.0029	0.023	0.022	39.320	0.025	5.886	6.037
0.003	0.155	0.860	0.0029	0.023	0.021	38.124	0.025	6.301	6.175
0.003	0.171	0.750	0.0029	0.023	0.022	32.143	0.025	6.900	6.938
0.003	0.140	0.950	0.0029	0.023	0.022	42.173	0.025	5.702	5.724

TABLE.A-5.3 COMPUTATION OF CORRECTION FACTOR (K2) FOR EXPERIMENTAL DATA

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	K2	K2.U/u*
0.003	0.143	0.950	0.0020	0.0221	0.0211	42.976	0.020	7.101	0.867	6.510
0.003	0.140	0.940	0.0020	0.0229	0.0218	41.098	0.020	6.826	0.910	6.257
0.003	0.126	1.080	0.0020	0.0220	0.0212	49.008	0.020	6.258	0.937	5.737
0.003	0.146	0.900	0.0020	0.0228	0.0217	39.512	0.020	7.180	0.968	6.582
0.003	0.133	1.000	0.0020	0.0226	0.0216	44.248	0.020	6.522	0.908	5.979
0.003	0.155	0.850	0.0020	0.0228	0.0216	37.290	0.020	7.605	0.928	6.972
0.003	0.134	1.000	0.0020	0.0224	0.0215	44.563	0.020	6.591	0.898	6.042
0.005	0.158	1.160	0.0023	0.0273	0.0261	42.448	0.024	6.439	0.957	6.347
0.005	0.146	1.270	0.0023	0.0269	0.0258	47.161	0.024	5.999	0.932	5.913
0.005	0.145	1.260	0.0023	0.0273	0.0262	46.151	0.025	5.926	1.042	5.841
0.005	0.166	1.150	0.0023	0.0262	0.0250	43.937	0.024	6.924	0.863	6.825
0.005	0.124	1.550	0.0023	0.0261	0.0252	59.468	0.024	5.140	0.945	5.067
0.005	0.140	1.300	0.0023	0.0274	0.0263	47.472	0.025	5.714	0.979	5.633
0.005	0.152	1.240	0.0023	0.0265	0.0254	46.736	0.024	6.283	1.006	6.194
0.006	0.154	1.300	0.0023	0.0300	0.0287	43.333	0.025	6.076	0.983	5.990
0.006	0.155	1.300	0.0023	0.0298	0.0285	43.669	0.025	6.146	0.972	6.059
0.006	0.150	1.350	0.0023	0.0296	0.0283	45.677	0.025	5.977	1.052	5.892
0.006	0.178	1.150	0.0023	0.0293	0.0279	39.243	0.025	7.131	0.951	7.030
0.006	0.135	1.550	0.0023	0.0288	0.0277	53.868	0.025	5.402	1.123	5.325
0.006	0.143	1.450	0.0023	0.0289	0.0278	50.179	0.025	5.746	1.027	5.664
0.006	0.155	1.300	0.0023	0.0297	0.0284	43.782	0.025	6.170	0.968	6.082
0.004	0.150	1.040	0.0024	0.0256	0.0244	40.585	0.024	6.248	1.001	6.773
0.004	0.146	1.050	0.0024	0.0261	0.0249	40.237	0.024	6.023	1.038	6.529
0.004	0.134	1.150	0.0024	0.0259	0.0248	44.379	0.024	5.545	1.065	6.011
0.004	0.152	1.020	0.0024	0.0259	0.0246	39.409	0.024	6.280	1.107	6.808
0.004	0.133	1.150	0.0024	0.0262	0.0250	43.937	0.024	5.464	1.093	5.923
0.004	0.151	1.000	0.0024	0.0265	0.0252	37.736	0.024	6.190	1.140	6.710
0.004	0.123	1.280	0.0024	0.0254	0.0244	50.412	0.024	5.123	1.145	5.554
0.002	0.128	0.850	0.0025	0.0184	0.0176	46.166	0.021	6.175	1.000	6.175
0.002	0.134	0.800	0.0025	0.0186	0.0178	42.953	0.021	6.459	1.000	6.459
0.002	0.118	0.920	0.0025	0.0185	0.0178	49.788	0.021	5.666	1.000	5.666
0.002	0.131	0.800	0.0025	0.0191	0.0183	41.830	0.021	6.211	1.000	6.211
0.002	0.127	0.850	0.0025	0.0186	0.0178	45.728	0.021	6.089	1.000	6.089
0.002	0.168	0.600	0.0025	0.0198	0.0186	30.252	0.021	7.910	1.000	7.910
0.002	0.153	0.700	0.0025	0.0187	0.0178	37.405	0.021	7.353	1.000	7.353
0.002	0.130	0.840	0.0025	0.0183	0.0176	45.818	0.021	6.290	1.000	6.290
0.002	0.130	0.850	0.0025	0.0181	0.0174	46.916	0.021	6.324	1.000	6.324
0.002	0.117	0.930	0.0025	0.0184	0.0177	50.579	0.021	5.645	1.000	5.645
0.002	0.124	0.850	0.0025	0.0189	0.0181	44.876	0.021	5.922	1.000	5.922
0.002	0.135	0.800	0.0025	0.0185	0.0177	43.243	0.021	6.523	1.000	6.523
0.002	0.144	0.750	0.0025	0.0185	0.0177	40.468	0.021	6.950	1.000	6.950
0.002	0.148	0.700	0.0025	0.0192	0.0182	36.377	0.021	7.057	1.000	7.057
0.004	0.152	1.040	0.0025	0.0254	0.0242	40.970	0.024	6.252	1.000	6.252
0.004	0.144	1.100	0.0025	0.0252	0.0241	43.682	0.024	5.973	1.000	5.973
0.004	0.144	1.100	0.0025	0.0252	0.0241	43.682	0.024	5.973	1.000	5.973
0.004	0.149	1.070	0.0025	0.0251	0.0240	42.561	0.024	6.160	1.000	6.160
0.004	0.143	1.110	0.0025	0.0252	0.0241	44.004	0.024	5.903	1.000	5.903
0.004	0.165	1.000	0.0025	0.0243	0.0232	41.152	0.024	6.941	1.000	6.941
0.004	0.135	1.180	0.0025	0.0251	0.0241	47.041	0.024	5.592	1.000	5.592

0.003	0.174	0.750	0.0025	0.0229	0.0216	32.703	0.023	7.646	1.000	7.646
0.006	0.152	1.390	0.0025	0.0284	0.0273	48.914	0.026	5.825	1.000	5.825
0.006	0.151	1.390	0.0025	0.0286	0.0274	48.668	0.026	5.782	1.000	5.782
0.006	0.152	1.400	0.0025	0.0281	0.0271	49.746	0.026	5.866	1.000	5.866
0.006	0.169	1.220	0.0025	0.0292	0.0278	41.809	0.026	6.399	1.000	6.399
0.006	0.147	1.400	0.0025	0.0291	0.0279	48.157	0.026	5.591	1.000	5.591
0.006	0.159	1.300	0.0025	0.0290	0.0278	44.828	0.026	6.052	1.000	6.052
0.006	0.164	1.250	0.0025	0.0293	0.0280	42.691	0.026	6.211	1.000	6.211
0.005	0.148	1.330	0.0026	0.0254	0.0245	52.334	0.025	5.916	0.915	5.486
0.005	0.150	1.340	0.0026	0.0249	0.0240	53.922	0.025	6.069	0.868	5.628
0.005	0.148	1.310	0.0026	0.0257	0.0248	50.923	0.025	5.900	0.957	5.472
0.005	0.166	1.200	0.0026	0.0252	0.0242	47.682	0.025	6.665	0.839	6.181
0.005	0.150	1.300	0.0026	0.0256	0.0246	50.751	0.025	5.984	0.943	5.550
0.005	0.171	1.150	0.0026	0.0254	0.0243	45.291	0.025	6.870	0.916	6.371
0.005	0.162	1.200	0.0026	0.0258	0.0247	46.602	0.025	6.443	0.982	5.975
0.004	0.154	1.040	0.0027	0.0249	0.0238	41.761	0.025	6.191	1.034	6.646
0.004	0.147	1.100	0.0027	0.0247	0.0237	44.485	0.025	5.908	1.024	6.342
0.004	0.139	1.140	0.0027	0.0253	0.0242	45.125	0.025	5.518	1.140	5.924
0.004	0.161	1.000	0.0027	0.0249	0.0237	40.161	0.025	6.446	1.078	6.920
0.004	0.149	1.090	0.0027	0.0247	0.0236	44.167	0.025	5.980	0.987	6.420
0.004	0.161	1.000	0.0027	0.0249	0.0237	40.161	0.025	6.446	1.078	6.920
0.004	0.139	1.150	0.0027	0.0250	0.0239	46.080	0.025	5.569	1.136	5.978
0.002	0.138	0.780	0.0027	0.0186	0.0177	41.959	0.022	6.399	1.000	6.869
0.002	0.132	0.800	0.0027	0.0189	0.0180	42.384	0.022	6.097	1.010	6.545
0.002	0.124	0.860	0.0027	0.0187	0.0179	45.938	0.022	5.731	1.097	6.153
0.002	0.146	0.700	0.0027	0.0196	0.0185	35.766	0.022	6.626	1.065	7.113
0.002	0.137	0.760	0.0027	0.0192	0.0183	39.562	0.022	6.260	1.073	6.720
0.002	0.168	0.600	0.0027	0.0198	0.0186	30.252	0.022	7.615	1.047	8.174
0.002	0.148	0.700	0.0027	0.0193	0.0183	36.296	0.022	6.772	1.053	7.269
0.006	0.154	1.300	0.0027	0.0299	0.0286	43.445	0.027	5.636	1.060	6.050
0.006	0.155	1.300	0.0027	0.0298	0.0285	43.557	0.027	5.657	1.056	6.073
0.006	0.150	1.350	0.0027	0.0296	0.0283	45.677	0.027	5.522	1.139	5.928
0.006	0.170	1.150	0.0027	0.0306	0.0291	37.571	0.028	6.179	1.142	6.633
0.006	0.142	1.450	0.0027	0.0292	0.0281	49.587	0.027	5.216	1.125	5.599
0.006	0.150	1.350	0.0027	0.0296	0.0283	45.677	0.027	5.522	1.139	5.928
0.006	0.154	1.300	0.0027	0.0299	0.0286	43.445	0.027	5.636	1.060	6.050
0.005	0.170	1.110	0.0028	0.0265	0.0253	41.908	0.026	6.454	0.991	6.656
0.005	0.162	1.170	0.0028	0.0263	0.0252	44.445	0.026	6.172	0.981	6.365
0.005	0.158	1.200	0.0028	0.0263	0.0252	45.570	0.026	6.012	1.046	6.199
0.005	0.166	1.120	0.0028	0.0270	0.0257	41.536	0.027	6.229	1.027	6.424
0.005	0.150	1.250	0.0028	0.0266	0.0256	46.922	0.026	5.668	1.116	5.845
0.005	0.157	1.200	0.0028	0.0266	0.0255	45.141	0.026	5.928	1.021	6.113
0.005	0.159	1.200	0.0028	0.0262	0.0251	45.860	0.026	6.068	1.037	6.258
0.003	0.146	0.920	0.0029	0.0223	0.0213	41.288	0.024	5.988	1.159	7.078
0.003	0.144	0.930	0.0029	0.0225	0.0214	41.383	0.025	5.848	1.187	6.912
0.003	0.135	0.980	0.0029	0.0227	0.0217	43.261	0.025	5.478	1.090	6.475
0.003	0.146	0.900	0.0029	0.0229	0.0218	39.320	0.025	5.886	1.249	6.957
0.003	0.155	0.860	0.0029	0.0226	0.0214	38.124	0.025	6.301	1.167	7.447
0.003	0.171	0.750	0.0029	0.0233	0.0220	32.143	0.025	6.900	1.341	8.155
0.003	0.140	0.950	0.0029	0.0225	0.0215	42.173	0.025	5.702	1.080	6.740

TABLE.A-5.4 COMPUTATION RESISTANCE COEFFICIENT BASE FROM REGRESION ANALYSIS OF EXPERIMENTAL DATA

Equation (without K); U/u* =-3.4874Ln(B/D)+19.339 with K;U/u*=-4.8095.ln(B/D)+24.461

X SECT.	DISCH. M3/S	B/D RATIO	SLOPE	U/u* Obs.	U/u* Cal. without K	Standar Error Est.	U/u* Cal. with K	Standar Error Est.
P # 6 - 1	0.002	46.166	0.0025	6.175	5.976	0.040	6.030	0.021
P # 5 - 1	0.002	42.953	0.0025	6.459	6.228	0.053	6.377	0.007
P # 4 - 1	0.002	49.788	0.0025	5.666	5.713	0.002	5.667	0.000
P # 3 - 1	0.002	41.830	0.0025	6.211	6.320	0.012	6.504	0.086
P # 2 - 1	0.002	45.728	0.0025	6.089	6.009	0.006	6.076	0.000
P # 1 - 1	0.002	30.252	0.0025	7.910	7.450	0.211	8.063	0.023
P # 0 - 1	0.002	37.405	0.0025	7.353	6.710	0.413	7.042	0.097
P # 6 - 1	0.002	45.818	0.0025	6.290	6.002	0.083	6.066	0.050
P # 5 - 1	0.002	46.916	0.0025	6.324	5.920	0.163	5.952	0.138
P # 4 - 1	0.002	50.579	0.0025	5.645	5.658	0.000	5.591	0.003
P # 3 - 1	0.002	44.876	0.0025	5.922	6.075	0.023	6.166	0.060
P # 2 - 1	0.002	43.243	0.0025	6.523	6.204	0.102	6.344	0.032
P # 1 - 1	0.002	40.468	0.0025	6.950	6.435	0.265	6.663	0.082
P # 0 - 1	0.002	36.377	0.0025	7.057	6.807	0.063	7.176	0.014
P # 6 - 1	0.004	40.970	0.0025	6.252	6.392	0.020	6.604	0.124
P # 5 - 1	0.004	43.682	0.0025	5.973	6.169	0.038	6.296	0.104
P # 4 - 1	0.004	43.682	0.0025	5.973	6.169	0.038	6.296	0.104
P # 3 - 1	0.004	42.561	0.0025	6.160	6.259	0.010	6.421	0.068
P # 2 - 1	0.004	44.004	0.0025	5.903	6.143	0.058	6.261	0.128
P # 1 - 1	0.004	41.152	0.0025	6.941	6.377	0.318	6.583	0.128
P # 0 - 1	0.004	47.041	0.0025	5.592	5.911	0.101	5.940	0.121
P # 1 - 1	0.003	32.703	0.0025	7.646	7.178	0.219	7.688	0.002
P # 6 - 1	0.006	48.914	0.0025	5.825	5.774	0.003	5.752	0.005
P # 5 - 1	0.006	48.668	0.0025	5.782	5.792	0.000	5.776	0.000
P # 4 - 1	0.006	49.746	0.0025	5.866	5.716	0.023	5.671	0.038
P # 3 - 1	0.006	41.809	0.0025	6.399	6.322	0.006	6.507	0.012
P # 2 - 1	0.006	48.157	0.0025	5.591	5.829	0.057	5.827	0.056
P # 1 - 1	0.006	44.828	0.0025	6.052	6.079	0.001	6.171	0.014
P # 0 - 1	0.006	42.691	0.0025	6.211	6.249	0.001	6.406	0.038
P # 6 - 1	0.004	40.585	0.0024	6.248	6.425	0.031	6.649	0.161
P # 5 - 1	0.004	40.237	0.0024	6.023	6.455	0.187	6.691	0.446
P # 4 - 1	0.004	44.379	0.0024	5.545	6.114	0.323	6.220	0.455
P # 3 - 1	0.004	39.409	0.0024	6.280	6.528	0.061	6.791	0.261
P # 2 - 1	0.004	43.937	0.0024	5.464	6.149	0.469	6.268	0.647
P # 1 - 1	0.004	37.736	0.0024	6.190	6.679	0.240	7.000	0.656
P # 0 - 1	0.004	50.412	0.0024	5.123	5.669	0.298	5.607	0.234
P # 6 - 1	0.003	42.976	0.0020	7.101	6.226	0.767	6.374	0.529
P # 5 - 1	0.003	41.098	0.0020	6.826	6.381	0.197	6.589	0.056
P # 4 - 1	0.003	49.008	0.0020	6.258	5.768	0.241	5.742	0.266
P # 3 - 1	0.003	39.512	0.0020	7.180	6.519	0.438	6.778	0.161
P # 2 - 1	0.003	44.248	0.0020	6.522	6.124	0.158	6.234	0.083
P # 1 - 1	0.003	37.290	0.0020	7.605	6.720	0.783	7.057	0.301
P # 0 - 1	0.003	44.563	0.0020	6.591	6.099	0.241	6.200	0.153
P # 6 - 1	0.005	42.448	0.0023	6.439	6.269	0.029	6.434	0.000
P # 5 - 1	0.005	47.161	0.0023	5.999	5.902	0.009	5.927	0.005
P # 4 - 1	0.005	46.151	0.0023	5.926	5.977	0.003	6.031	0.011
P # 3 - 1	0.005	43.937	0.0023	6.924	6.149	0.601	6.268	0.430

P # 2 - 1	0.005	59.468	0.0023	5.140	5.093	0.002	4.812	0.107
P # 1 - 1	0.005	47.472	0.0023	5.714	5.879	0.027	5.896	0.033
P # 0 - 1	0.005	46.736	0.0023	6.283	5.933	0.123	5.971	0.098
P # 6 - 1	0.006	43.333	0.0023	6.076	6.197	0.014	6.334	0.067
P # 5 - 1	0.006	43.669	0.0023	6.146	6.170	0.001	6.297	0.023
P # 4 - 1	0.006	45.677	0.0023	5.977	6.013	0.001	6.081	0.011
P # 3 - 1	0.006	39.243	0.0023	7.131	6.542	0.347	6.811	0.103
P # 2 - 1	0.006	53.868	0.0023	5.402	5.438	0.001	5.288	0.013
P # 1 - 1	0.006	50.179	0.0023	5.746	5.685	0.004	5.629	0.014
P # 0 - 1	0.006	43.782	0.0023	6.170	6.161	0.000	6.285	0.013
P # 6 - 1	0.004	41.761	0.0027	6.191	6.326	0.018	6.512	0.103
P # 5 - 1	0.004	44.485	0.0027	5.908	6.105	0.039	6.208	0.090
P # 4 - 1	0.004	45.125	0.0027	5.518	6.055	0.289	6.140	0.386
P # 3 - 1	0.004	40.161	0.0027	6.446	6.462	0.000	6.700	0.065
P # 2 - 1	0.004	44.167	0.0027	5.980	6.130	0.022	6.243	0.069
P # 1 - 1	0.004	40.161	0.0027	6.446	6.462	0.000	6.700	0.065
P # 0 - 1	0.004	46.080	0.0027	5.569	5.982	0.171	6.039	0.221
P # 6 - 1	0.002	41.959	0.0027	6.399	6.309	0.008	6.489	0.008
P # 5 - 1	0.002	42.384	0.0027	6.097	6.274	0.031	6.441	0.119
P # 4 - 1	0.002	45.938	0.0027	5.731	5.993	0.069	6.054	0.104
P # 3 - 1	0.002	35.766	0.0027	6.626	6.866	0.057	7.257	0.398
P # 2 - 1	0.002	39.562	0.0027	6.260	6.514	0.065	6.772	0.262
P # 1 - 1	0.002	30.252	0.0027	7.615	7.450	0.027	8.063	0.201
P # 0 - 1	0.002	36.296	0.0027	6.772	6.815	0.002	7.187	0.172
P # 6 - 1	0.006	43.445	0.0027	5.636	6.188	0.305	6.322	0.471
P # 5 - 1	0.006	43.557	0.0027	5.657	6.179	0.272	6.310	0.426
P # 4 - 1	0.006	45.677	0.0027	5.522	6.013	0.241	6.081	0.312
P # 3 - 1	0.006	37.571	0.0027	6.179	6.694	0.266	7.021	0.708
P # 2 - 1	0.006	49.587	0.0027	5.216	5.727	0.261	5.686	0.221
P # 1 - 1	0.006	45.677	0.0027	5.522	6.013	0.241	6.081	0.312
P # 0 - 1	0.006	43.445	0.0027	5.636	6.188	0.305	6.322	0.471
P # 6 - 1	0.005	52.334	0.0026	5.916	5.539	0.142	5.427	0.239
P # 5 - 1	0.005	53.922	0.0026	6.069	5.434	0.402	5.283	0.617
P # 4 - 1	0.005	50.923	0.0026	5.900	5.634	0.071	5.558	0.117
P # 3 - 1	0.005	47.682	0.0026	6.665	5.863	0.643	5.874	0.625
P # 2 - 1	0.005	50.751	0.0026	5.984	5.646	0.114	5.574	0.168
P # 1 - 1	0.005	45.291	0.0026	6.870	6.043	0.685	6.122	0.560
P # 0 - 1	0.005	46.602	0.0026	6.443	5.943	0.250	5.985	0.210
P # 6 - 1	0.003	41.288	0.0029	5.988	6.365	0.142	6.567	0.335
P # 5 - 1	0.003	41.383	0.0029	5.848	6.357	0.259	6.556	0.501
P # 4 - 1	0.003	43.261	0.0029	5.478	6.203	0.524	6.342	0.746
P # 3 - 1	0.003	39.320	0.0029	5.886	6.536	0.422	6.802	0.838
P # 2 - 1	0.003	38.124	0.0029	6.301	6.643	0.117	6.950	0.422
P # 1 - 1	0.003	32.143	0.0029	6.900	7.238	0.115	7.771	0.759
P # 0 - 1	0.003	42.173	0.0029	5.702	6.291	0.347	6.465	0.581
P # 6 - 1	0.005	41.908	0.0028	6.454	6.313	0.020	6.495	0.002
P # 5 - 1	0.005	44.445	0.0028	6.172	6.108	0.004	6.213	0.002
P # 4 - 1	0.005	45.570	0.0028	6.012	6.021	0.000	6.092	0.007
P # 3 - 1	0.005	41.536	0.0028	6.229	6.344	0.013	6.538	0.096
P # 2 - 1	0.005	46.922	0.0028	5.668	5.919	0.063	5.952	0.080
P # 1 - 1	0.005	45.141	0.0028	5.928	6.054	0.016	6.138	0.044
P # 0 - 1	0.005	45.860	0.0028	6.068	5.999	0.005	6.062	0.000
					TOTAL	14.968	TOTAL	19.021
					Std.Error	0.3949	Std.Error	0.4451

TABLE.A-5.5 COMPUTATION FRICTION FACTOR BASE FROM REGRESION ANALYSIS OF EXPERIMENTAL DATA

without K $\frac{1}{\sqrt{f}} = 6.837 - 1.233 \ln\left(\frac{B}{D}\right)$ with K $\frac{1}{\sqrt{f}} = 8.648 - 1.70 \ln\left(\frac{B}{D}\right)$

X SECT.	DISCH. M3/S	B/D RATIO	SLOPE	$1/\sqrt{f}$ Obs.	$1/\sqrt{f}$ Cal. without K	Standar Error Est.	$1/\sqrt{f}$ Cal. with K	Standar Error Est.
P # 6 - 1	0.002	46.166134	0.0025	2.1832	2.1128	0.005	2.1319	0.003
P # 5 - 1	0.002	42.95302	0.0025	2.2835	2.2018	0.007	2.2545	0.001
P # 4 - 1	0.002	49.788235	0.0025	2.0032	2.0197	0.000	2.0034	0.000
P # 3 - 1	0.002	41.830065	0.0025	2.1959	2.2344	0.001	2.2996	0.011
P # 2 - 1	0.002	45.727848	0.0025	2.1527	2.1246	0.001	2.1481	0.000
P # 1 - 1	0.002	30.252101	0.0025	2.7965	2.6339	0.026	2.8506	0.003
P # 0 - 1	0.002	37.40458	0.0025	2.5996	2.3723	0.052	2.4897	0.012
P # 6 - 1	0.002	45.818182	0.0025	2.2238	2.1221	0.010	2.1447	0.006
P # 5 - 1	0.002	46.915584	0.0025	2.2359	2.0930	0.020	2.1045	0.017
P # 4 - 1	0.002	50.578947	0.0025	1.9958	2.0003	0.000	1.9766	0.000
P # 3 - 1	0.002	44.875776	0.0025	2.0936	2.1478	0.003	2.1801	0.007
P # 2 - 1	0.002	43.243243	0.0025	2.3063	2.1935	0.013	2.2431	0.004
P # 1 - 1	0.002	40.467626	0.0025	2.4572	2.2752	0.033	2.3559	0.010
P # 0 - 1	0.002	36.377134	0.0025	2.4950	2.4066	0.008	2.5371	0.002
P # 6 - 1	0.004	40.969697	0.0025	2.2103	2.2600	0.002	2.3349	0.016
P # 5 - 1	0.004	43.68231	0.0025	2.1119	2.1810	0.005	2.2259	0.013
P # 4 - 1	0.004	43.68231	0.0025	2.1119	2.1810	0.005	2.2259	0.013
P # 3 - 1	0.004	42.561338	0.0025	2.1778	2.2130	0.001	2.2701	0.009
P # 2 - 1	0.004	44.003571	0.0025	2.0872	2.1720	0.007	2.2134	0.016
P # 1 - 1	0.004	41.152263	0.0025	2.4540	2.2546	0.040	2.3274	0.016
P # 0 - 1	0.004	47.040541	0.0025	1.9771	2.0897	0.013	2.1000	0.015
P # 1 - 1	0.003	32.703488	0.0025	2.7033	2.5379	0.027	2.7181	0.000
P # 6 - 1	0.006	48.913924	0.0025	2.0594	2.0415	0.000	2.0335	0.001
P # 5 - 1	0.006	48.667506	0.0025	2.0441	2.0478	0.000	2.0421	0.000
P # 4 - 1	0.006	49.746193	0.0025	2.0740	2.0207	0.003	2.0049	0.005
P # 3 - 1	0.006	41.808989	0.0025	2.2625	2.2350	0.001	2.3004	0.001
P # 2 - 1	0.006	48.157248	0.0025	1.9767	2.0608	0.007	2.0601	0.007
P # 1 - 1	0.006	44.827586	0.0025	2.1398	2.1491	0.000	2.1819	0.002
P # 0 - 1	0.006	42.691257	0.0025	2.1959	2.2093	0.000	2.2649	0.005
P # 6 - 1	0.004	40.585366	0.0024	2.2090	2.2717	0.004	2.3509	0.020
P # 5 - 1	0.004	40.237226	0.0024	2.1295	2.2823	0.023	2.3656	0.056
P # 4 - 1	0.004	44.379195	0.0024	1.9605	2.1615	0.040	2.1990	0.057
P # 3 - 1	0.004	39.409091	0.0024	2.2203	2.3079	0.008	2.4010	0.033
P # 2 - 1	0.004	43.936877	0.0024	1.9317	2.1738	0.059	2.2160	0.081
P # 1 - 1	0.004	37.735849	0.0024	2.1884	2.3614	0.030	2.4747	0.082
P # 0 - 1	0.004	50.412308	0.0024	1.8114	2.0043	0.037	1.9822	0.029
P # 6 - 1	0.003	42.97619	0.0020	2.5107	2.2011	0.096	2.2536	0.066
P # 5 - 1	0.003	41.097674	0.0020	2.4132	2.2562	0.025	2.3296	0.007
P # 4 - 1	0.003	49.008403	0.0020	2.2126	2.0392	0.030	2.0303	0.033
P # 3 - 1	0.003	39.512195	0.0020	2.5386	2.3047	0.055	2.3965	0.020
P # 2 - 1	0.003	44.247788	0.0020	2.3058	2.1651	0.020	2.2040	0.010
P # 1 - 1	0.003	37.290323	0.0020	2.6889	2.3760	0.098	2.4949	0.038
P # 0 - 1	0.003	44.56328	0.0020	2.3301	2.1564	0.030	2.1919	0.019
P # 6 - 1	0.005	42.44795	0.0023	2.2765	2.2163	0.004	2.2746	0.000
P # 5 - 1	0.005	47.160819	0.0023	2.1209	2.0865	0.001	2.0956	0.001
P # 4 - 1	0.005	46.151163	0.0023	2.0951	2.1132	0.000	2.1324	0.001
P # 3 - 1	0.005	43.936877	0.0023	2.4479	2.1738	0.075	2.2160	0.054

P # 2 - 1	0.005	59.467822	0.0023	1.8172	1.8007	0.000	1.7013	0.013
P # 1 - 1	0.005	47.47191	0.0023	2.0202	2.0784	0.003	2.0844	0.004
P # 0 - 1	0.005	46.735562	0.0023	2.2215	2.0977	0.015	2.1110	0.012
P # 6 - 1	0.006	43.333333	0.0023	2.1484	2.1909	0.002	2.2395	0.008
P # 5 - 1	0.006	43.669251	0.0023	2.1730	2.1814	0.000	2.2264	0.003
P # 4 - 1	0.006	45.676692	0.0023	2.1132	2.1260	0.000	2.1500	0.001
P # 3 - 1	0.006	39.243323	0.0023	2.5213	2.3131	0.043	2.4081	0.013
P # 2 - 1	0.006	53.867713	0.0023	1.9099	1.9226	0.000	1.8695	0.002
P # 1 - 1	0.006	50.178998	0.0023	2.0313	2.0101	0.000	1.9901	0.002
P # 0 - 1	0.006	43.782383	0.0023	2.1813	2.1782	0.000	2.2220	0.002
P # 6 - 1	0.004	41.760618	0.0027	2.1888	2.2365	0.002	2.3024	0.013
P # 5 - 1	0.004	44.485294	0.0027	2.0887	2.1585	0.005	2.1949	0.011
P # 4 - 1	0.004	45.125	0.0027	1.9510	2.1409	0.036	2.1706	0.048
P # 3 - 1	0.004	40.160643	0.0027	2.2790	2.2846	0.000	2.3688	0.008
P # 2 - 1	0.004	44.167286	0.0027	2.1144	2.1674	0.003	2.2071	0.009
P # 1 - 1	0.004	40.160643	0.0027	2.2790	2.2846	0.000	2.3688	0.008
P # 0 - 1	0.004	46.080139	0.0027	1.9690	2.1151	0.021	2.1350	0.028
P # 6 - 1	0.002	41.958621	0.0027	2.2624	2.2306	0.001	2.2944	0.001
P # 5 - 1	0.002	42.384106	0.0027	2.1555	2.2182	0.004	2.2772	0.015
P # 4 - 1	0.002	45.937888	0.0027	2.0264	2.1189	0.009	2.1403	0.013
P # 3 - 1	0.002	35.766423	0.0027	2.3428	2.4275	0.007	2.5659	0.050
P # 2 - 1	0.002	39.561644	0.0027	2.2133	2.3032	0.008	2.3944	0.033
P # 1 - 1	0.002	30.252101	0.0027	2.6922	2.6339	0.003	2.8506	0.025
P # 0 - 1	0.002	36.296296	0.0027	2.3941	2.4094	0.000	2.5409	0.022
P # 6 - 1	0.006	43.44473	0.0027	1.9925	2.1877	0.038	2.2352	0.059
P # 5 - 1	0.006	43.556701	0.0027	2.0001	2.1845	0.034	2.2308	0.053
P # 4 - 1	0.006	45.676692	0.0027	1.9525	2.1260	0.030	2.1500	0.039
P # 3 - 1	0.006	37.571023	0.0027	2.1846	2.3668	0.033	2.4822	0.089
P # 2 - 1	0.006	49.587264	0.0027	1.8442	2.0247	0.033	2.0103	0.028
P # 1 - 1	0.006	45.676692	0.0027	1.9525	2.1260	0.030	2.1500	0.039
P # 0 - 1	0.006	43.44473	0.0027	1.9925	2.1877	0.038	2.2352	0.059
P # 6 - 1	0.005	52.33432	0.0026	2.0915	1.9582	0.018	1.9186	0.030
P # 5 - 1	0.005	53.921922	0.0026	2.1456	1.9214	0.050	1.8678	0.077
P # 4 - 1	0.005	50.922849	0.0026	2.0860	1.9919	0.009	1.9651	0.015
P # 3 - 1	0.005	47.682119	0.0026	2.3565	2.0730	0.080	2.0769	0.078
P # 2 - 1	0.005	50.750751	0.0026	2.1157	1.9961	0.014	1.9709	0.021
P # 1 - 1	0.005	45.291096	0.0026	2.4289	2.1364	0.086	2.1644	0.070
P # 0 - 1	0.005	46.601942	0.0026	2.2779	2.1012	0.031	2.1159	0.026
P # 6 - 1	0.003	41.287805	0.0029	2.1171	2.2505	0.018	2.3218	0.042
P # 5 - 1	0.003	41.382775	0.0029	2.0677	2.2477	0.032	2.3179	0.063
P # 4 - 1	0.003	43.261261	0.0029	1.9369	2.1929	0.066	2.2424	0.093
P # 3 - 1	0.003	39.320388	0.0029	2.0812	2.3107	0.053	2.4048	0.105
P # 2 - 1	0.003	38.123711	0.0029	2.2277	2.3488	0.015	2.4573	0.053
P # 1 - 1	0.003	32.142857	0.0029	2.4395	2.5592	0.014	2.7475	0.095
P # 0 - 1	0.003	42.172897	0.0029	2.0161	2.2244	0.043	2.2857	0.073
P # 6 - 1	0.005	41.908163	0.0028	2.2820	2.2321	0.002	2.2964	0.000
P # 5 - 1	0.005	44.444805	0.0028	2.1821	2.1597	0.001	2.1965	0.000
P # 4 - 1	0.005	45.56962	0.0028	2.1254	2.1289	0.000	2.1540	0.001
P # 3 - 1	0.005	41.536424	0.0028	2.2022	2.2431	0.002	2.3116	0.012
P # 2 - 1	0.005	46.921922	0.0028	2.0040	2.0928	0.008	2.1042	0.010
P # 1 - 1	0.005	45.141066	0.0028	2.0959	2.1405	0.002	2.1700	0.005
P # 0 - 1	0.005	45.859873	0.0028	2.1454	2.1210	0.001	2.1432	0.000
					TOTAL	1.871	TOTAL	2.378
					Std.Error	0.1396	Std.Error	0.1574

TABLE A-5.6 COMPUTATION STANDARD ERROR ESTIMATE RESISTANCE COEFFICIENT OF AVAILABLE FIELD DATA

Equation(logaritmic form);U/u*=-1.3571ln(B/D)+22.883 Power form; U/u*=26.598.(B/D)$^{-0.0983}$

X section	Qw m3/s	B/D	Slope	U/u* obs.	U/u* Cal. Log.	Standart Error Estimate	U/u* Cal. Power	Standart Error Estimate
P # 0-1	3730	1001.1	0.000073	14.230	13.507	0.523	13.482	0.559
P # 1-1	3730	328.03	0.000073	15.099	15.021	0.006	15.045	0.003
P # 2-1	3730	312.62	0.000073	15.241	15.086	0.024	15.117	0.015
P # 3-1	3730	722.15	0.000073	14.584	13.950	0.402	13.922	0.438
P # 4-1	3730	310.15	0.000073	15.092	15.097	0.000	15.128	0.001
P # 5-1	3730	200.01	0.000073	15.260	15.693	0.187	15.795	0.287
P # 6-1	3730	1232.3	0.000073	14.070	13.225	0.715	13.210	0.741
P # 0-1	5980	1171.1	0.000085	13.340	13.294	0.002	13.276	0.004
P # 1-1	5980	501.04	0.000085	14.048	14.446	0.159	14.432	0.147
P # 2-1	5980	755.55	0.000085	14.354	13.889	0.216	13.861	0.243
P # 3-1	5980	1212.9	0.000085	13.469	13.247	0.050	13.231	0.057
P # 4-1	5980	645.65	0.000085	14.694	14.102	0.350	14.076	0.382
P # 5-1	5980	418.38	0.000085	14.812	14.691	0.015	14.690	0.015
P # 6-1	5980	2160.6	0.000085	12.946	12.463	0.233	12.500	0.198
P # 0-1	8120	917.54	0.000088	13.496	13.625	0.017	13.598	0.011
P # 1-1	8120	616.95	0.000088	14.180	14.164	0.000	14.139	0.002
P # 2-1	8120	1023.8	0.000088	13.777	13.477	0.090	13.453	0.105
P # 3-1	8120	1238.2	0.000088	13.026	13.219	0.037	13.204	0.032
P # 4-1	8120	824.71	0.000088	13.937	13.770	0.028	13.742	0.038
P # 5-1	8120	769.8	0.000088	14.237	13.864	0.139	13.835	0.161
P # 6-1	8120	1927.2	0.000088	12.861	12.618	0.059	12.642	0.048
P # 0-1	9930	1287.4	0.000091	13.042	13.166	0.015	13.153	0.012
P # 1-1	9930	619.04	0.000091	14.200	14.159	0.002	14.135	0.004
P # 2-1	9930	954.8	0.000091	13.532	13.571	0.002	13.545	0.000
P # 3-1	9930	1447.5	0.000091	12.784	13.007	0.050	13.002	0.048
P # 4-1	9930	814.55	0.000091	13.759	13.787	0.001	13.759	0.000
P # 5-1	9930	922.76	0.000091	13.583	13.618	0.001	13.591	0.000
P # 6-1	9930	1856.6	0.000091	12.830	12.669	0.026	12.688	0.020
P # 0-1	11600	1329.2	0.000095	12.839	13.122	0.080	13.112	0.074
P # 1-1	11600	668.81	0.000095	13.945	14.054	0.012	14.028	0.007
P # 2-1	11600	943.29	0.000095	13.444	13.588	0.021	13.561	0.014
P # 3-1	11600	1543.2	0.000095	12.653	12.920	0.071	12.921	0.072
P # 4-1	11600	843.31	0.000095	13.476	13.740	0.070	13.712	0.055
P # 5-1	11600	1077.5	0.000095	13.179	13.407	0.052	13.385	0.043
P # 6-1	11600	1598.2	0.000095	12.625	12.872	0.061	12.877	0.063
P # 0-1	13800	1247.5	0.000097	12.714	13.208	0.244	13.194	0.230
P # 1-1	13800	558.59	0.000097	14.002	14.299	0.088	14.278	0.076
P # 2-1	13800	837.69	0.000097	13.554	13.749	0.038	13.721	0.028
P # 3-1	13800	2118.4	0.000097	12.093	12.490	0.158	12.525	0.187
P # 4-1	13800	937.09	0.000097	13.309	13.597	0.083	13.570	0.068
P # 5-1	13800	1006	0.000097	13.145	13.500	0.126	13.476	0.110
P # 6-1	13800	1454.4	0.000097	12.538	13.000	0.214	12.996	0.210
					Total	4.6646	Total	4.8081
					Std. Error	0.34584	Std. Error	0.35112

TABLE. A - 5.7 COMPUTATION RESISTANCE COEFFICIENT vs B/D RATIO AT DIFFERENT SLOPE

TABLE A-5.7.1 Slope 0.000073

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
3730	0.599	2496	7.3E-05	2.493	2.488	1001.12	0.042	14.23	14.28
3730	0.784	1249	7.3E-05	3.808	3.784	328.03	0.052	15.10	15.06
3730	0.798	1209	7.3E-05	3.867	3.843	312.62	0.052	15.24	15.09
3730	0.652	2032	7.3E-05	2.814	2.806	722.15	0.045	14.58	14.51
3730	0.793	1208	7.3E-05	3.895	3.870	310.15	0.053	15.09	15.10
3730	0.872	925	7.3E-05	4.625	4.579	200.01	0.057	15.26	15.41
3730	0.570	2840	7.3E-05	2.305	2.301	1232.33	0.041	14.07	14.13

TABLE A-5.7.2 Slope 0.000085

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
5980	0.646	3293	8.5E-05	2.812	2.807	1171.08	0.048	13.34	13.59
5980	0.797	1939	8.5E-05	3.870	3.855	501.04	0.057	14.05	14.54
5980	0.747	2459	8.5E-05	3.255	3.246	755.55	0.052	14.35	14.08
5980	0.646	3350	8.5E-05	2.762	2.758	1212.85	0.048	13.47	13.55
5980	0.786	2217	8.5E-05	3.434	3.423	645.65	0.053	14.69	14.26
5980	0.862	1704	8.5E-05	4.073	4.054	418.38	0.058	14.81	14.75
5980	0.558	4812	8.5E-05	2.227	2.225	2160.56	0.043	12.95	12.90

TABLE A-5.7.3 Slope 0.000088

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
8120	0.738	3178	8.8E-05	3.464	3.456	917.54	0.055	13.50	13.74
8120	0.831	2456	8.8E-05	3.981	3.968	616.95	0.059	14.18	14.27
8120	0.734	3366	8.8E-05	3.288	3.281	1023.82	0.053	13.78	13.59
8120	0.676	3858	8.8E-05	3.116	3.111	1238.22	0.052	13.03	13.33
8120	0.773	2943	8.8E-05	3.569	3.560	824.71	0.055	13.94	13.88
8120	0.797	2800	8.8E-05	3.637	3.628	769.80	0.056	14.24	13.97
8120	0.612	5056	8.8E-05	2.624	2.621	1927.17	0.048	12.86	12.74

TABLE A-5.7.4 Slope 0.000091

Qw m^3/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
9930	0.708	4248	9.1E-05	3.300	3.295	1287.40	0.054	13.04	13.13
9930	0.877	2647	9.1E-05	4.276	4.262	619.04	0.062	14.20	14.13
9930	0.774	3499	9.1E-05	3.665	3.657	954.80	0.057	13.53	13.54
9930	0.681	4594	9.1E-05	3.174	3.169	1447.49	0.053	12.78	12.97
9930	0.810	3160	9.1E-05	3.879	3.870	814.55	0.059	13.76	13.75
9930	0.782	3423	9.1E-05	3.710	3.702	922.76	0.058	13.58	13.58
9930	0.650	5326	9.1E-05	2.869	2.866	1856.61	0.051	12.83	12.63

TABLE A-5.7.5 Slope 0.000095

Qw m³/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
11600	0.729	4598	9.5E-05	3.459	3.454	1329.18	0.057	12.84	12.87
11600	0.893	2947	9.5E-05	4.406	4.393	668.81	0.064	13.94	13.91
11600	0.810	3675	9.5E-05	3.896	3.888	943.29	0.060	13.44	13.39
11600	0.700	5058	9.5E-05	3.278	3.273	1543.16	0.055	12.65	12.65
11600	0.830	3433	9.5E-05	4.071	4.061	843.31	0.062	13.48	13.56
11600	0.777	4012	9.5E-05	3.723	3.717	1077.49	0.059	13.18	13.19
11600	0.694	5170	9.5E-05	3.235	3.231	1598.17	0.055	12.63	12.60

TABLE A-5.7.6 Slope 0.000097

Qw m³/s	Vel. m/s	Width m	Slope	Depth m	R m	B/D ratio	u*	U/u*	Computed U/u* (plot)
13800	0.764	4748	9.7E-05	3.806	3.800	1247.48	0.060	12.71	12.83
13800	0.968	2822	9.7E-05	5.052	5.034	558.59	0.069	14.00	14.05
13800	0.870	3645	9.7E-05	4.351	4.341	837.69	0.064	13.55	13.43
13800	0.660	6655	9.7E-05	3.141	3.139	2118.42	0.055	12.09	12.03
13800	0.839	3927	9.7E-05	4.191	4.182	937.09	0.063	13.31	13.26
13800	0.819	4118	9.7E-05	4.094	4.085	1005.96	0.062	13.15	13.16
13800	0.732	5235	9.7E-05	3.599	3.594	1454.43	0.058	12.54	12.60

TABLE. A-5.8 COMPUTATION OF CORECTION FACTOR (K2) (FIELD DATA)

Qw m^3/s	Width m	Slope	vel. m/s	Depth m	R m	B/D	u*	U/u*	K2	K2.U/u*
3730	2496	7.3E-05	0.599	2.493	2.488	1001.12	0.042	14.230	0.946	14.222
3730	1249	7.3E-05	0.784	3.808	3.784	328.03	0.052	15.099	1.005	15.091
3730	1209	7.3E-05	0.798	3.867	3.843	312.62	0.052	15.241	0.995	15.232
3730	2032	7.3E-05	0.652	2.814	2.806	722.15	0.045	14.584	0.951	14.576
3730	1208	7.3E-05	0.793	3.895	3.870	310.15	0.053	15.092	1.005	15.083
3730	925	7.3E-05	0.872	4.625	4.579	200.01	0.057	15.260	1.040	15.251
3730	2840	7.3E-05	0.570	2.305	2.301	1232.33	0.041	14.070	0.937	14.062
5980	3293	8.5E-05	0.646	2.812	2.807	1171.08	0.048	13.340	0.988	13.333
5980	1939	8.5E-05	0.797	3.870	3.855	501.04	0.057	14.048	1.028	14.040
5980	2459	8.5E-05	0.747	3.255	3.246	755.55	0.052	14.354	0.966	14.346
5980	3350	8.5E-05	0.646	2.762	2.758	1212.85	0.048	13.469	0.979	13.462
5980	2217	8.5E-05	0.786	3.434	3.423	645.65	0.053	14.694	0.966	14.686
5980	1704	8.5E-05	0.862	4.073	4.054	418.38	0.058	14.812	0.994	14.803
5980	4812	8.5E-05	0.558	2.227	2.225	2160.56	0.043	12.946	0.954	12.938
8120	3178	8.8E-05	0.738	3.464	3.456	917.54	0.055	13.496	1.006	13.488
8120	2456	8.8E-05	0.831	3.981	3.968	616.95	0.059	14.180	1.001	14.172
8120	3366	8.8E-05	0.734	3.288	3.281	1023.82	0.053	13.777	0.977	13.769
8120	3858	8.8E-05	0.676	3.116	3.111	1238.22	0.052	13.026	1.012	13.019
8120	2943	8.8E-05	0.773	3.569	3.560	824.71	0.055	13.937	0.987	13.929
8120	2800	8.8E-05	0.797	3.637	3.628	769.80	0.056	14.237	0.974	14.228
8120	5056	8.8E-05	0.612	2.624	2.621	1927.17	0.048	12.861	0.998	12.853
9930	4248	9.1E-05	0.708	3.300	3.295	1287.40	0.054	13.042	1.000	13.035
9930	2647	9.1E-05	0.877	4.276	4.262	619.04	0.062	14.200	1.000	14.192
9930	3499	9.1E-05	0.774	3.665	3.657	954.80	0.057	13.532	1.000	13.524
9930	4594	9.1E-05	0.681	3.174	3.169	1447.49	0.053	12.784	1.000	12.776
9930	3160	9.1E-05	0.810	3.879	3.870	814.55	0.059	13.759	1.000	13.752
9930	3423	9.1E-05	0.782	3.710	3.702	922.76	0.058	13.583	1.000	13.575
9930	5326	9.1E-05	0.650	2.869	2.866	1856.61	0.051	12.830	1.000	12.822
11600	4598	9.5E-05	0.729	3.459	3.454	1329.18	0.057	12.839	1.019	12.832
11600	2947	9.5E-05	0.893	4.406	4.393	668.81	0.064	13.945	0.995	13.937
11600	3675	9.5E-05	0.810	3.896	3.888	943.29	0.060	13.444	1.010	13.437
11600	5058	9.5E-05	0.700	3.278	3.273	1543.16	0.055	12.653	1.018	12.646
11600	3433	9.5E-05	0.830	4.071	4.061	843.31	0.062	13.476	1.017	13.468
11600	4012	9.5E-05	0.777	3.723	3.717	1077.49	0.059	13.179	1.022	13.171
11600	5170	9.5E-05	0.694	3.235	3.231	1598.17	0.055	12.625	1.020	12.618
13800	4748	9.7E-05	0.764	3.806	3.800	1247.48	0.060	12.714	1.037	12.707
13800	2822	9.7E-05	0.968	5.052	5.034	558.59	0.069	14.002	1.020	13.994
13800	3645	9.7E-05	0.870	4.351	4.341	837.69	0.064	13.554	1.011	13.546
13800	6655	9.7E-05	0.660	3.141	3.139	2118.42	0.055	12.093	1.021	12.086
13800	3927	9.7E-05	0.839	4.191	4.182	937.09	0.063	13.309	1.020	13.302
13800	4118	9.7E-05	0.819	4.094	4.085	1005.96	0.062	13.145	1.024	13.137
13800	5235	9.7E-05	0.732	3.599	3.594	1454.43	0.058	12.538	1.034	12.531
								Average	0.9994	

TABLE A-5.9 COMPUTATION RESISTANCE COEFFICIENT BASE FROM REGRESION ANALYSIS OF AVAILABLE FIELD DATA

Equation(without K);U/u*=-1.3571ln(B/D)+22.883 with K; U/u*=-1.3203ln(B/D)+22.598

X section	Qw m3/s	B/D	Slope	U/u* observed	U/u* Calculted without K	Standart Error Estimate	U/u* Calculted with K	Standart Error Estimate
J # 0-1	3730	1001.1	0.000073	14.2302	13.5070	0.5231	13.4762	0.5685
J # 1-1	3730	328.03	0.000073	15.0992	15.0212	0.0061	14.9493	0.0224
J # 2-1	3730	312.62	0.000073	15.2408	15.0865	0.0238	15.0129	0.0519
J # 3-1	3730	722.15	0.000073	14.5845	13.9503	0.4023	13.9075	0.4584
J # 4-1	3730	310.15	0.000073	15.0920	15.0972	0.0000	15.0234	0.0047
J # 5-1	3730	200.01	0.000073	15.2597	15.6926	0.1874	15.6026	0.1176
J # 6-1	3730	1232.3	0.000073	14.0704	13.2250	0.7148	13.2019	0.7544
J # 0-1	5980	1171.1	0.000085	13.3402	13.2942	0.0021	13.2692	0.0050
J # 1-1	5980	501.04	0.000085	14.0481	14.4463	0.1586	14.3901	0.1170
J # 2-1	5980	755.55	0.000085	14.3538	13.8889	0.2161	13.8478	0.2560
J # 3-1	5980	1212.9	0.000085	13.4694	13.2466	0.0497	13.2229	0.0608
J # 4-1	5980	645.65	0.000085	14.6942	14.1022	0.3505	14.0553	0.4082
J # 5-1	5980	418.38	0.000085	14.8117	14.6910	0.0146	14.6282	0.0337
J # 6-1	5980	2160.6	0.000085	12.9457	12.4630	0.2330	12.4606	0.2354
J # 0-1	8120	917.54	0.000088	13.4959	13.6253	0.0167	13.5913	0.0091
J # 1-1	8120	616.95	0.000088	14.1800	14.1639	0.0003	14.1154	0.0042
J # 2-1	8120	1023.8	0.000088	13.7766	13.4765	0.0901	13.4466	0.1089
J # 3-1	8120	1238.2	0.000088	13.0261	13.2185	0.0370	13.1956	0.0287
J # 4-1	8120	824.71	0.000088	13.9371	13.7700	0.0279	13.7321	0.0420
J # 5-1	8120	769.8	0.000088	14.2366	13.8635	0.1392	13.8231	0.1710
J # 6-1	8120	1927.2	0.000088	12.8605	12.6182	0.0588	12.6115	0.0620
J # 0-1	9930	1287.4	0.000091	13.0422	13.1656	0.0152	13.1441	0.0104
J # 1-1	9930	619.04	0.000091	14.2004	14.1593	0.0017	14.1109	0.0080
J # 2-1	9930	954.8	0.000091	13.5322	13.5713	0.0015	13.5388	0.0000
J # 3-1	9930	1447.5	0.000091	12.7835	13.0066	0.0498	12.9894	0.0424
J # 4-1	9930	814.55	0.000091	13.7594	13.7868	0.0008	13.7485	0.0001
J # 5-1	9930	922.76	0.000091	13.5828	13.6176	0.0012	13.5838	0.0000
J # 6-1	9930	1856.6	0.000091	12.8298	12.6688	0.0259	12.6607	0.0286
J # 0-1	11600	1329.2	0.000095	12.8392	13.1223	0.0801	13.1020	0.0691
J # 1-1	11600	668.81	0.000095	13.9448	14.0544	0.0120	14.0088	0.0041
J # 2-1	11600	943.29	0.000095	13.4445	13.5877	0.0205	13.5548	0.0122
J # 3-1	11600	1543.2	0.000095	12.6533	12.9197	0.0710	12.9049	0.0633
J # 4-1	11600	843.31	0.000095	13.4761	13.7398	0.0695	13.7027	0.0513
J # 5-1	11600	1077.5	0.000095	13.1789	13.4072	0.0521	13.3791	0.0401
J # 6-1	11600	1598.2	0.000095	12.6251	12.8722	0.0610	12.8587	0.0545
J # 0-1	13800	1247.5	0.000097	12.7143	13.2084	0.2442	13.1857	0.2223
J # 1-1	13800	558.59	0.000097	14.0023	14.2988	0.0879	14.2465	0.0597
J # 2-1	13800	837.69	0.000097	13.5541	13.7488	0.0379	13.7115	0.0248
J # 3-1	13800	2118.4	0.000097	12.0928	12.4897	0.1576	12.4866	0.1551
J # 4-1	13800	937.09	0.000097	13.3094	13.5967	0.0825	13.5635	0.0646
J # 5-1	13800	1006	0.000097	13.1450	13.5004	0.1263	13.4698	0.1055
J # 6-1	13800	1454.4	0.000097	12.5377	13.0001	0.2138	12.9831	0.1984
					Total	4.6646	Total	4.7343
					Std. Error	0.3458	Std. Error	0.3484

TABLE A-5.10 COMPUTATION FRICTION FACTOR BASE FROM REGRESION ANALYSIS OF AVAILABLE FIELD DATA

without K $\frac{1}{\sqrt{f}} = 8.09 - 0.48 \ln . \left(\frac{B}{D}\right)$ with K $\frac{1}{\sqrt{f}} = 7.99 - 0.467 \ln . \left(\frac{B}{D}\right)$

X section	Qw m3/s	B/D	Slope	$1/\sqrt{f}$ observed	$1/\sqrt{f}$ Calculted without K	Standart Error Estimate	$1/\sqrt{f}$ Calculted with K	Standart Error Estimate
P # 0-1	3730	1001.1	0.000073	5.0311	4.7754	0.0654	4.7646	0.0711
P # 1-1	3730	328.03	0.000073	5.3384	5.3108	0.0008	5.2854	0.0028
P # 2-1	3730	312.62	0.000073	5.3884	5.3339	0.0030	5.3079	0.0065
P # 3-1	3730	722.15	0.000073	5.1564	4.9322	0.0503	4.9170	0.0573
P # 4-1	3730	310.15	0.000073	5.3358	5.3377	0.0000	5.3116	0.0006
P # 5-1	3730	200.01	0.000073	5.3951	5.5482	0.0234	5.5163	0.0147
P # 6-1	3730	1232.3	0.000073	4.9746	4.6757	0.0893	4.6676	0.0943
P # 0-1	5980	1171.1	0.000085	4.7165	4.7002	0.0003	4.6914	0.0006
P # 1-1	5980	501.04	0.000085	4.9667	5.1076	0.0198	5.0877	0.0146
P # 2-1	5980	755.55	0.000085	5.0748	4.9105	0.0270	4.8959	0.0320
P # 3-1	5980	1212.9	0.000085	4.7622	4.6834	0.0062	4.6750	0.0076
P # 4-1	5980	645.65	0.000085	5.1952	4.9859	0.0438	4.9693	0.0510
P # 5-1	5980	418.38	0.000085	5.2367	5.1941	0.0018	5.1718	0.0042
P # 6-1	5980	2160.6	0.000085	4.5770	4.4063	0.0291	4.4055	0.0294
P # 0-1	8120	917.54	0.000088	4.7715	4.8173	0.0021	4.8053	0.0011
P # 1-1	8120	616.95	0.000088	5.0134	5.0077	0.0000	4.9905	0.0005
P # 2-1	8120	1023.8	0.000088	4.8708	4.7647	0.0113	4.7541	0.0136
P # 3-1	8120	1238.2	0.000088	4.6054	4.6734	0.0046	4.6653	0.0036
P # 4-1	8120	824.71	0.000088	4.9275	4.8684	0.0035	4.8550	0.0053
P # 5-1	8120	769.8	0.000088	5.0334	4.9015	0.0174	4.8872	0.0214
P # 6-1	8120	1927.2	0.000088	4.5469	4.4612	0.0073	4.4588	0.0078
P # 0-1	9930	1287.4	0.000091	4.6111	4.6548	0.0019	4.6472	0.0013
P # 1-1	9930	619.04	0.000091	5.0206	5.0061	0.0002	4.9890	0.0010
P # 2-1	9930	954.8	0.000091	4.7843	4.7982	0.0002	4.7867	0.0000
P # 3-1	9930	1447.5	0.000091	4.5197	4.5985	0.0062	4.5924	0.0053
P # 4-1	9930	814.55	0.000091	4.8647	4.8744	0.0001	4.8608	0.0000
P # 5-1	9930	922.76	0.000091	4.8023	4.8145	0.0002	4.8026	0.0000
P # 6-1	9930	1856.6	0.000091	4.5360	4.4791	0.0032	4.4763	0.0036
P # 0-1	11600	1329.2	0.000095	4.5393	4.6394	0.0100	4.6322	0.0086
P # 1-1	11600	668.81	0.000095	4.9302	4.9690	0.0015	4.9529	0.0005
P # 2-1	11600	943.29	0.000095	4.7533	4.8040	0.0026	4.7923	0.0015
P # 3-1	11600	1543.2	0.000095	4.4736	4.5678	0.0089	4.5626	0.0079
P # 4-1	11600	843.31	0.000095	4.7645	4.8577	0.0087	4.8446	0.0064
P # 5-1	11600	1077.5	0.000095	4.6594	4.7402	0.0065	4.7302	0.0050
P # 6-1	11600	1598.2	0.000095	4.4637	4.5510	0.0076	4.5462	0.0068
P # 0-1	13800	1247.5	0.000097	4.4952	4.6699	0.0305	4.6619	0.0278
P # 1-1	13800	558.59	0.000097	4.9505	5.0554	0.0110	5.0369	0.0075
P # 2-1	13800	837.69	0.000097	4.7921	4.8609	0.0047	4.8478	0.0031
P # 3-1	13800	2118.4	0.000097	4.2754	4.4158	0.0197	4.4147	0.0194
P # 4-1	13800	937.09	0.000097	4.7056	4.8071	0.0103	4.7954	0.0081
P # 5-1	13800	1006	0.000097	4.6475	4.7731	0.0158	4.7623	0.0132
P # 6-1	13800	1454.4	0.000097	4.4327	4.5962	0.0267	4.5902	0.0248
					Total	0.5831	Total	0.5918
					Std. Error	0.1207	Std. Error	0.1216

APPENDIX - VI

COMPARISON OF f STUDY MODEL WITH AVIALABLE f EQUATION AND DIFFERENT DATA

TABLE A-6.1 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f1 study

$$\frac{1}{\sqrt{f}} = 1.113 \ln\left(\frac{R}{d50}\right) - 5.92$$

f by White and Collebrock

$$\frac{1}{\sqrt{f}} = 1.14 - 2.0 \log\left(\frac{ks}{4R} + \frac{21.25}{Re^{0.9}}\right)$$

Disch. Qw m3/s	Vel. m/s	R m	Slope S	D84 m	Reynolds number Re	f study	f White - Colle.	Std. Error Est.
3730	0.599	2.488	7.3E-05	0.00029	1491411.543	0.049	0.014	0.001
3730	0.784	3.784	7.3E-05	0.00029	2968291.677	0.040	0.015	0.001
3730	0.798	3.843	7.3E-05	0.00029	3065582.28	0.040	0.015	0.001
3730	0.652	2.806	7.3E-05	0.00029	1830560.164	0.046	0.014	0.001
3730	0.793	3.870	7.3E-05	0.00029	3067964.625	0.040	0.015	0.001
3730	0.872	4.579	7.3E-05	0.00029	3992509.438	0.037	0.015	0.000
3730	0.570	2.301	7.3E-05	0.00029	1311252.196	0.051	0.014	0.001
5980	0.646	2.807	8.5E-05	0.00029	1812877.199	0.046	0.014	0.001
5980	0.797	3.855	8.5E-05	0.00029	3071802.187	0.040	0.015	0.001
5980	0.747	3.246	8.5E-05	0.00029	2425462.513	0.043	0.015	0.001
5980	0.646	2.758	8.5E-05	0.00029	1782135.876	0.047	0.014	0.001
5980	0.786	3.423	8.5E-05	0.00029	2689009.162	0.042	0.015	0.001
5980	0.862	4.054	8.5E-05	0.00029	3492693.256	0.039	0.015	0.001
5980	0.558	2.225	8.5E-05	0.00029	1241577.205	0.052	0.014	0.001
8120	0.738	3.456	8.8E-05	0.00029	2549508.834	0.042	0.015	0.001
8120	0.831	3.968	8.8E-05	0.00029	3295505.67	0.039	0.015	0.001
8120	0.734	3.281	8.8E-05	0.00029	2407655.585	0.043	0.015	0.001
8120	0.676	3.111	8.8E-05	0.00029	2101323.371	0.044	0.015	0.001
8120	0.773	3.560	8.8E-05	0.00029	2752414.476	0.041	0.015	0.001
8120	0.797	3.628	8.8E-05	0.00029	2892485.102	0.041	0.015	0.001
8120	0.612	2.621	8.8E-05	0.00029	1604347.68	0.048	0.014	0.001
9930	0.708	3.295	9.1E-05	0.00029	2333944.798	0.043	0.015	0.001
9930	0.877	4.262	9.1E-05	0.00029	3739335.627	0.038	0.015	0.001
9930	0.774	3.657	9.1E-05	0.00029	2832021.515	0.041	0.015	0.001
9930	0.681	3.169	9.1E-05	0.00029	2158532.57	0.044	0.015	0.001
9930	0.810	3.870	9.1E-05	0.00029	3134708.308	0.040	0.015	0.001
9930	0.782	3.702	9.1E-05	0.00029	2894690.074	0.041	0.015	0.001
9930	0.650	2.866	9.1E-05	0.00029	1862432.335	0.046	0.014	0.001
11600	0.694	3.455	9.5E-05	0.00029	2396087.566	0.042	0.015	0.001
11600	0.893	4.393	9.5E-05	0.00029	3924470.689	0.038	0.015	0.000
11600	0.810	3.888	9.5E-05	0.00029	3149784.325	0.040	0.015	0.001
11600	0.700	3.273	9.5E-05	0.00029	2290428.101	0.043	0.015	0.001
11600	0.830	4.061	9.5E-05	0.00029	3370974.185	0.039	0.015	0.001
11600	0.777	3.717	9.5E-05	0.00029	2885969.198	0.041	0.015	0.001
11600	0.694	3.231	9.5E-05	0.00029	2240909.387	0.043	0.015	0.001
13800	0.764	3.800	9.7E-05	0.00029	2901834.611	0.040	0.015	0.001
13800	0.968	5.034	9.7E-05	0.00029	4872702.469	0.036	0.016	0.000
13800	0.870	4.341	9.7E-05	0.00029	3776990.604	0.038	0.015	0.001
13800	0.660	3.139	9.7E-05	0.00029	2071672.987	0.044	0.015	0.001
13800	0.839	4.182	9.7E-05	0.00029	3506648.836	0.039	0.015	0.001
13800	0.819	4.085	9.7E-05	0.00029	3344491.998	0.039	0.015	0.001
13800	0.732	3.594	9.7E-05	0.00029	2632483.198	0.041	0.015	0.001
							Total	0.0316
							Std.error	0.0285

TABLE A - 6.2 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f1 study

$$\frac{1}{\sqrt{f}} = 1.113 \ln\left(\frac{R}{d50}\right) - 5.92$$

f by Leopold, Wolman & Miller

$$\frac{1}{\sqrt{f}} = 1.00 - 2.03 \log\left(\frac{D}{d84}\right)$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D84 m	f study	f Leopold et,al	Standart Error Estimate
3730	2.493	2.488	7.3E-05	0.00029	0.049	0.0205	0.0008
3730	3.808	3.784	7.3E-05	0.00029	0.040	0.0185	0.0005
3730	3.867	3.843	7.3E-05	0.00029	0.040	0.0184	0.0005
3730	2.814	2.806	7.3E-05	0.00029	0.046	0.0199	0.0007
3730	3.895	3.870	7.3E-05	0.00029	0.040	0.0184	0.0005
3730	4.625	4.579	7.3E-05	0.00029	0.037	0.0176	0.0004
3730	2.305	2.301	7.3E-05	0.00029	0.051	0.0209	0.0009
5980	2.812	2.807	8.5E-05	0.00029	0.046	0.0199	0.0007
5980	3.870	3.855	8.5E-05	0.00029	0.040	0.0184	0.0005
5980	3.255	3.246	8.5E-05	0.00029	0.043	0.0192	0.0006
5980	2.762	2.758	8.5E-05	0.00029	0.047	0.0200	0.0007
5980	3.434	3.423	8.5E-05	0.00029	0.042	0.0189	0.0005
5980	4.073	4.054	8.5E-05	0.00029	0.039	0.0182	0.0004
5980	2.227	2.225	8.5E-05	0.00029	0.052	0.0211	0.0009
8120	3.464	3.456	8.8E-05	0.00029	0.042	0.0189	0.0005
8120	3.981	3.968	8.8E-05	0.00029	0.039	0.0183	0.0004
8120	3.288	3.281	8.8E-05	0.00029	0.043	0.0191	0.0006
8120	3.116	3.111	8.8E-05	0.00029	0.044	0.0194	0.0006
8120	3.569	3.560	8.8E-05	0.00029	0.041	0.0188	0.0005
8120	3.637	3.628	8.8E-05	0.00029	0.041	0.0187	0.0005
8120	2.624	2.621	8.8E-05	0.00029	0.048	0.0202	0.0008
9930	3.300	3.295	9.1E-05	0.00029	0.043	0.0191	0.0006
9930	4.276	4.262	9.1E-05	0.00029	0.038	0.0180	0.0004
9930	3.665	3.657	9.1E-05	0.00029	0.041	0.0186	0.0005
9930	3.174	3.169	9.1E-05	0.00029	0.044	0.0193	0.0006
9930	3.879	3.870	9.1E-05	0.00029	0.040	0.0184	0.0005
9930	3.710	3.702	9.1E-05	0.00029	0.041	0.0186	0.0005
9930	2.869	2.866	9.1E-05	0.00029	0.046	0.0198	0.0007
11600	3.077	3.455	9.5E-05	0.00029	0.042	0.0194	0.0005
11600	4.406	4.393	9.5E-05	0.00029	0.038	0.0178	0.0004
11600	3.896	3.888	9.5E-05	0.00029	0.040	0.0184	0.0005
11600	3.278	3.273	9.5E-05	0.00029	0.043	0.0191	0.0006
11600	4.071	4.061	9.5E-05	0.00029	0.039	0.0182	0.0004
11600	3.723	3.717	9.5E-05	0.00029	0.041	0.0186	0.0005
11600	3.235	3.231	9.5E-05	0.00029	0.043	0.0192	0.0006
13800	3.806	3.800	9.7E-05	0.00029	0.040	0.0185	0.0005
13800	5.052	5.034	9.7E-05	0.00029	0.036	0.0173	0.0003
13800	4.351	4.341	9.7E-05	0.00029	0.038	0.0179	0.0004
13800	3.141	3.139	9.7E-05	0.00029	0.044	0.0193	0.0006
13800	4.191	4.182	9.7E-05	0.00029	0.039	0.0180	0.0004
13800	4.094	4.085	9.7E-05	0.00029	0.039	0.0181	0.0004
13800	3.599	3.594	9.7E-05	0.00029	0.041	0.0187	0.0005
						Total	0.0227
						Std.error	0.0241

TABLE.A-6.3 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f1 study

$$\frac{1}{\sqrt{f}} = 1.113 \ln.\left(\frac{R}{d50}\right) - 5.92$$

f by limerinos (d84)

$$\frac{1}{\sqrt{f}} = 1.16 - 2.03 \log\left(\frac{R}{d84}\right)$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D84 m	f study	f Limerinos	Standart Error Estimate
3730	2.493	2.488	7.3E-05	0.00029	0.049	0.0215	0.0008
3730	3.808	3.784	7.3E-05	0.00029	0.040	0.0193	0.0004
3730	3.867	3.843	7.3E-05	0.00029	0.040	0.0192	0.0004
3730	2.814	2.806	7.3E-05	0.00029	0.046	0.0208	0.0006
3730	3.895	3.870	7.3E-05	0.00029	0.040	0.0192	0.0004
3730	4.625	4.579	7.3E-05	0.00029	0.037	0.0184	0.0003
3730	2.305	2.301	7.3E-05	0.00029	0.051	0.0219	0.0008
5980	2.812	2.807	8.5E-05	0.00029	0.046	0.0208	0.0006
5980	3.870	3.855	8.5E-05	0.00029	0.040	0.0192	0.0004
5980	3.255	3.246	8.5E-05	0.00029	0.043	0.0201	0.0005
5980	2.762	2.758	8.5E-05	0.00029	0.047	0.0209	0.0007
5980	3.434	3.423	8.5E-05	0.00029	0.042	0.0198	0.0005
5980	4.073	4.054	8.5E-05	0.00029	0.039	0.0190	0.0004
5980	2.227	2.225	8.5E-05	0.00029	0.052	0.0221	0.0009
8120	3.464	3.456	8.8E-05	0.00029	0.042	0.0198	0.0005
8120	3.981	3.968	8.8E-05	0.00029	0.039	0.0191	0.0004
8120	3.288	3.281	8.8E-05	0.00029	0.043	0.0200	0.0005
8120	3.116	3.111	8.8E-05	0.00029	0.044	0.0203	0.0006
8120	3.569	3.560	8.8E-05	0.00029	0.041	0.0196	0.0005
8120	3.637	3.628	8.8E-05	0.00029	0.041	0.0195	0.0005
8120	2.624	2.621	8.8E-05	0.00029	0.048	0.0212	0.0007
9930	3.300	3.295	9.1E-05	0.00029	0.043	0.0200	0.0005
9930	4.276	4.262	9.1E-05	0.00029	0.038	0.0188	0.0004
9930	3.665	3.657	9.1E-05	0.00029	0.041	0.0195	0.0005
9930	3.174	3.169	9.1E-05	0.00029	0.044	0.0202	0.0005
9930	3.879	3.870	9.1E-05	0.00029	0.040	0.0192	0.0004
9930	3.710	3.702	9.1E-05	0.00029	0.041	0.0194	0.0005
9930	2.869	2.866	9.1E-05	0.00029	0.046	0.0207	0.0006
11600	3.077	3.455	9.5E-05	0.00029	0.042	0.0198	0.0005
11600	4.406	4.393	9.5E-05	0.00029	0.038	0.0186	0.0004
11600	3.896	3.888	9.5E-05	0.00029	0.040	0.0192	0.0004
11600	3.278	3.273	9.5E-05	0.00029	0.043	0.0200	0.0005
11600	4.071	4.061	9.5E-05	0.00029	0.039	0.0190	0.0004
11600	3.723	3.717	9.5E-05	0.00029	0.041	0.0194	0.0004
11600	3.235	3.231	9.5E-05	0.00029	0.043	0.0201	0.0005
13800	3.806	3.800	9.7E-05	0.00029	0.040	0.0193	0.0004
13800	5.052	5.034	9.7E-05	0.00029	0.036	0.0180	0.0003
13800	4.351	4.341	9.7E-05	0.00029	0.038	0.0187	0.0004
13800	3.141	3.139	9.7E-05	0.00029	0.044	0.0202	0.0006
13800	4.191	4.182	9.7E-05	0.00029	0.039	0.0189	0.0004
13800	4.094	4.085	9.7E-05	0.00029	0.039	0.0190	0.0004
13800	3.599	3.594	9.7E-05	0.00029	0.041	0.0196	0.0005
						Total	0.0211
						Std.error	0.0232

TABLE.A-6.4 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f1 Study

$$\frac{1}{\sqrt{f}} = 1.113 \ln\left(\frac{R}{d50}\right) - 5.92$$

f by Limerinos(d50)

$$\frac{1}{\sqrt{f}} = 0.35 - 2.03 \log\left(\frac{R}{d50}\right)$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D50 m	f study	f Lime rinos	Standart Error Estimate
3730	2.493	2.488	7.3E-05	0.00021	0.049	0.0159	0.0011
3730	3.808	3.784	7.3E-05	0.00021	0.040	0.0146	0.0007
3730	3.867	3.843	7.3E-05	0.00021	0.040	0.0145	0.0006
3730	2.814	2.806	7.3E-05	0.00021	0.046	0.0155	0.0009
3730	3.895	3.870	7.3E-05	0.00021	0.040	0.0145	0.0006
3730	4.625	4.579	7.3E-05	0.00021	0.037	0.0140	0.0005
3730	2.305	2.301	7.3E-05	0.00021	0.051	0.0162	0.0012
5980	2.812	2.807	8.5E-05	0.00021	0.046	0.0155	0.0009
5980	3.870	3.855	8.5E-05	0.00021	0.040	0.0145	0.0006
5980	3.255	3.246	8.5E-05	0.00021	0.043	0.0150	0.0008
5980	2.762	2.758	8.5E-05	0.00021	0.047	0.0156	0.0010
5980	3.434	3.423	8.5E-05	0.00021	0.042	0.0149	0.0007
5980	4.073	4.054	8.5E-05	0.00021	0.039	0.0143	0.0006
5980	2.227	2.225	8.5E-05	0.00021	0.052	0.0163	0.0013
8120	3.464	3.456	8.8E-05	0.00021	0.042	0.0148	0.0007
8120	3.981	3.968	8.8E-05	0.00021	0.039	0.0144	0.0006
8120	3.288	3.281	8.8E-05	0.00021	0.043	0.0150	0.0008
8120	3.116	3.111	8.8E-05	0.00021	0.044	0.0152	0.0008
8120	3.569	3.560	8.8E-05	0.00021	0.041	0.0147	0.0007
8120	3.637	3.628	8.8E-05	0.00021	0.041	0.0147	0.0007
8120	2.624	2.621	8.8E-05	0.00021	0.048	0.0158	0.0010
9930	3.300	3.295	9.1E-05	0.00021	0.043	0.0150	0.0008
9930	4.276	4.262	9.1E-05	0.00021	0.038	0.0142	0.0006
9930	3.665	3.657	9.1E-05	0.00021	0.041	0.0147	0.0007
9930	3.174	3.169	9.1E-05	0.00021	0.044	0.0151	0.0008
9930	3.879	3.870	9.1E-05	0.00021	0.040	0.0145	0.0006
9930	3.710	3.702	9.1E-05	0.00021	0.041	0.0146	0.0007
9930	2.869	2.866	9.1E-05	0.00021	0.046	0.0155	0.0009
11600	3.077	3.455	9.5E-05	0.00021	0.042	0.0148	0.0007
11600	4.406	4.393	9.5E-05	0.00021	0.038	0.0141	0.0006
11600	3.896	3.888	9.5E-05	0.00021	0.040	0.0145	0.0006
11600	3.278	3.273	9.5E-05	0.00021	0.043	0.0150	0.0008
11600	4.071	4.061	9.5E-05	0.00021	0.039	0.0143	0.0006
11600	3.723	3.717	9.5E-05	0.00021	0.041	0.0146	0.0007
11600	3.235	3.231	9.5E-05	0.00021	0.043	0.0151	0.0008
13800	3.806	3.800	9.7E-05	0.00021	0.040	0.0145	0.0007
13800	5.052	5.034	9.7E-05	0.00021	0.036	0.0137	0.0005
13800	4.351	4.341	9.7E-05	0.00021	0.038	0.0141	0.0006
13800	3.141	3.139	9.7E-05	0.00021	0.044	0.0152	0.0008
13800	4.191	4.182	9.7E-05	0.00021	0.039	0.0142	0.0006
13800	4.094	4.085	9.7E-05	0.00021	0.039	0.0143	0.0006
13800	3.599	3.594	9.7E-05	0.00021	0.041	0.0147	0.0007
						Total	0.0314
						Std.error	0.0284

TABLE.A-6.5 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f2 Study

$$\frac{1}{\sqrt{f}} = -0.582 \ln\left(\frac{R}{d50}\right) + 4.80$$

f by Limerinos

$$\frac{1}{\sqrt{f}} = 0.35 - 2.03 \log\left(\frac{R}{d50}\right)$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D50 m	f Study	f Limerinos d50	Standart Error Estimate
0.003	0.0221	0.0211	0.0020	0.000225	0.2150	0.0749	0.0196
0.003	0.0229	0.0218	0.0020	0.000225	0.2188	0.0737	0.0210
0.003	0.0220	0.0212	0.0020	0.000225	0.2153	0.0748	0.0197
0.003	0.0228	0.0217	0.0020	0.000225	0.2181	0.0740	0.0208
0.003	0.0226	0.0216	0.0020	0.000225	0.2178	0.0740	0.0207
0.003	0.0228	0.0216	0.0020	0.000225	0.2178	0.0740	0.0207
0.003	0.0224	0.0215	0.0020	0.000225	0.2170	0.0743	0.0204
0.005	0.0273	0.0261	0.0023	0.000225	0.2418	0.0678	0.0303
0.005	0.0269	0.0258	0.0023	0.000225	0.2404	0.0681	0.0297
0.005	0.0273	0.0262	0.0023	0.000225	0.2422	0.0677	0.0305
0.005	0.0262	0.0250	0.0023	0.000225	0.2362	0.0691	0.0279
0.005	0.0261	0.0252	0.0023	0.000225	0.2372	0.0689	0.0283
0.005	0.0274	0.0263	0.0023	0.000225	0.2428	0.0676	0.0307
0.005	0.0265	0.0254	0.0023	0.000225	0.2384	0.0686	0.0288
0.006	0.0300	0.0287	0.0023	0.000225	0.2554	0.0649	0.0363
0.006	0.0298	0.0285	0.0023	0.000225	0.2543	0.0652	0.0358
0.006	0.0296	0.0283	0.0023	0.000225	0.2535	0.0653	0.0354
0.006	0.0293	0.0279	0.0023	0.000225	0.2513	0.0658	0.0344
0.006	0.0288	0.0277	0.0023	0.000225	0.2505	0.0659	0.0341
0.006	0.0289	0.0278	0.0023	0.000225	0.2508	0.0659	0.0342
0.006	0.0297	0.0284	0.0023	0.000225	0.2540	0.0652	0.0356
0.004	0.0256	0.0244	0.0024	0.000225	0.2329	0.0699	0.0266
0.004	0.0261	0.0249	0.0024	0.000225	0.2352	0.0693	0.0275
0.004	0.0259	0.0248	0.0024	0.000225	0.2349	0.0694	0.0274
0.004	0.0259	0.0246	0.0024	0.000225	0.2340	0.0696	0.0270
0.004	0.0262	0.0250	0.0024	0.000225	0.2362	0.0691	0.0279
0.004	0.0265	0.0252	0.0024	0.000225	0.2369	0.0689	0.0282
0.004	0.0254	0.0244	0.0024	0.000225	0.2329	0.0699	0.0266
0.002	0.0184	0.0176	0.0025	0.000225	0.1956	0.0818	0.0129
0.002	0.0186	0.0178	0.0025	0.000225	0.1964	0.0815	0.0132
0.002	0.0185	0.0178	0.0025	0.000225	0.1963	0.0816	0.0132
0.002	0.0191	0.0183	0.0025	0.000225	0.1990	0.0805	0.0141
0.002	0.0186	0.0178	0.0025	0.000225	0.1965	0.0815	0.0132
0.002	0.0198	0.0186	0.0025	0.000225	0.2010	0.0797	0.0147
0.002	0.0187	0.0178	0.0025	0.000225	0.1963	0.0816	0.0132
0.002	0.0183	0.0176	0.0025	0.000225	0.1951	0.0820	0.0128
0.002	0.0181	0.0174	0.0025	0.000225	0.1940	0.0825	0.0124
0.002	0.0184	0.0177	0.0025	0.000225	0.1958	0.0817	0.0130
0.002	0.0189	0.0181	0.0025	0.000225	0.1983	0.0807	0.0138
0.002	0.0185	0.0177	0.0025	0.000225	0.1958	0.0817	0.0130
0.002	0.0185	0.0177	0.0025	0.000225	0.1957	0.0818	0.0130
0.002	0.0192	0.0182	0.0025	0.000225	0.1990	0.0805	0.0140
0.004	0.0254	0.0242	0.0025	0.000225	0.2317	0.0702	0.0261
0.004	0.0252	0.0241	0.0025	0.000225	0.2311	0.0704	0.0258
0.004	0.0252	0.0241	0.0025	0.000225	0.2311	0.0704	0.0258
0.004	0.0251	0.0240	0.0025	0.000225	0.2307	0.0705	0.0257

0.004	0.0252	0.0241	0.0025	0.000225	0.2313	0.0703	0.0259
0.004	0.0243	0.0232	0.0025	0.000225	0.2262	0.0716	0.0239
0.004	0.0251	0.0241	0.0025	0.000225	0.2310	0.0704	0.0258
0.003	0.0229	0.0216	0.0025	0.000225	0.2177	0.0741	0.0206
0.006	0.0284	0.0273	0.0025	0.000225	0.2482	0.0664	0.0330
0.006	0.0286	0.0274	0.0025	0.000225	0.2489	0.0663	0.0334
0.006	0.0281	0.0271	0.0025	0.000225	0.2469	0.0667	0.0325
0.006	0.0292	0.0278	0.0025	0.000225	0.2511	0.0658	0.0343
0.006	0.0291	0.0279	0.0025	0.000225	0.2514	0.0657	0.0345
0.006	0.0290	0.0278	0.0025	0.000225	0.2506	0.0659	0.0341
0.006	0.0293	0.0280	0.0025	0.000225	0.2517	0.0657	0.0346
0.005	0.0254	0.0245	0.0026	0.000225	0.2332	0.0698	0.0267
0.005	0.0249	0.0240	0.0026	0.000225	0.2304	0.0705	0.0256
0.005	0.0257	0.0248	0.0026	0.000225	0.2347	0.0695	0.0273
0.005	0.0252	0.0242	0.0026	0.000225	0.2315	0.0703	0.0260
0.005	0.0256	0.0246	0.0026	0.000225	0.2341	0.0696	0.0271
0.005	0.0254	0.0243	0.0026	0.000225	0.2323	0.0700	0.0263
0.005	0.0258	0.0247	0.0026	0.000225	0.2343	0.0695	0.0272
0.004	0.0249	0.0238	0.0027	0.000225	0.2294	0.0708	0.0251
0.004	0.0247	0.0237	0.0027	0.000225	0.2288	0.0709	0.0249
0.004	0.0253	0.0242	0.0027	0.000225	0.2317	0.0702	0.0261
0.004	0.0249	0.0237	0.0027	0.000225	0.2291	0.0709	0.0250
0.004	0.0247	0.0236	0.0027	0.000225	0.2285	0.0710	0.0248
0.004	0.0249	0.0237	0.0027	0.000225	0.2291	0.0709	0.0250
0.004	0.0250	0.0239	0.0027	0.000225	0.2302	0.0706	0.0255
0.002	0.0186	0.0177	0.0027	0.000225	0.1961	0.0816	0.0131
0.002	0.0189	0.0180	0.0027	0.000225	0.1977	0.0810	0.0136
0.002	0.0187	0.0179	0.0027	0.000225	0.1972	0.0812	0.0135
0.002	0.0196	0.0185	0.0027	0.000225	0.2006	0.0798	0.0146
0.002	0.0192	0.0183	0.0027	0.000225	0.1992	0.0804	0.0141
0.002	0.0198	0.0186	0.0027	0.000225	0.2010	0.0797	0.0147
0.002	0.0193	0.0183	0.0027	0.000225	0.1992	0.0804	0.0141
0.006	0.0299	0.0286	0.0027	0.000225	0.2551	0.0650	0.0361
0.006	0.0298	0.0285	0.0027	0.000225	0.2547	0.0651	0.0359
0.006	0.0296	0.0283	0.0027	0.000225	0.2535	0.0653	0.0354
0.006	0.0306	0.0291	0.0027	0.000225	0.2574	0.0646	0.0372
0.006	0.0292	0.0281	0.0027	0.000225	0.2524	0.0655	0.0349
0.006	0.0296	0.0283	0.0027	0.000225	0.2535	0.0653	0.0354
0.006	0.0299	0.0286	0.0027	0.000225	0.2551	0.0650	0.0361
0.005	0.0265	0.0253	0.0028	0.000225	0.2375	0.0688	0.0285
0.005	0.0263	0.0252	0.0028	0.000225	0.2370	0.0689	0.0283
0.005	0.0263	0.0252	0.0028	0.000225	0.2372	0.0689	0.0283
0.005	0.0270	0.0257	0.0028	0.000225	0.2399	0.0682	0.0295
0.005	0.0266	0.0256	0.0028	0.000225	0.2389	0.0685	0.0291
0.005	0.0266	0.0255	0.0028	0.000225	0.2384	0.0686	0.0289
0.005	0.0262	0.0251	0.0028	0.000225	0.2364	0.0691	0.0280
0.003	0.0223	0.0213	0.0029	0.000225	0.2157	0.0747	0.0199
0.003	0.0225	0.0214	0.0029	0.000225	0.2167	0.0744	0.0203
0.003	0.0227	0.0217	0.0029	0.000225	0.2179	0.0740	0.0207
0.003	0.0229	0.0218	0.0029	0.000225	0.2186	0.0738	0.0210
0.003	0.0226	0.0214	0.0029	0.000225	0.2167	0.0744	0.0203
0.003	0.0233	0.0220	0.0029	0.000225	0.2196	0.0735	0.0214
0.003	0.0225	0.0215	0.0029	0.000225	0.2171	0.0742	0.0204
						Total	2.465
						Std.error	0.160

TABLE.A-6.6 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f2 Study

$$\frac{1}{\sqrt{f}} = -0.582 \ln\left(\frac{R}{d50}\right) + 4.80$$

f by Limerinos

$$\frac{1}{\sqrt{f}} = 1.16 - 2.03 \log\left(\frac{R}{d84}\right)$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D84 m	f Study	f Lime-rinos	Standart Error Estimate
0.003	0.0221	0.0211	0.0020	0.00029	0.215	0.146	0.005
0.003	0.0229	0.0218	0.0020	0.00029	0.219	0.143	0.006
0.003	0.0220	0.0212	0.0020	0.00029	0.215	0.145	0.005
0.003	0.0228	0.0217	0.0020	0.00029	0.218	0.143	0.006
0.003	0.0226	0.0216	0.0020	0.00029	0.218	0.143	0.006
0.003	0.0228	0.0216	0.0020	0.00029	0.218	0.143	0.006
0.003	0.0224	0.0215	0.0020	0.00029	0.217	0.144	0.005
0.005	0.0273	0.0261	0.0023	0.00029	0.242	0.127	0.013
0.005	0.0269	0.0258	0.0023	0.00029	0.240	0.128	0.013
0.005	0.0273	0.0262	0.0023	0.00029	0.242	0.127	0.013
0.005	0.0262	0.0250	0.0023	0.00029	0.236	0.130	0.011
0.005	0.0261	0.0252	0.0023	0.00029	0.237	0.130	0.012
0.005	0.0274	0.0263	0.0023	0.00029	0.243	0.126	0.014
0.005	0.0265	0.0254	0.0023	0.00029	0.238	0.129	0.012
0.006	0.0300	0.0287	0.0023	0.00029	0.255	0.120	0.018
0.006	0.0298	0.0285	0.0023	0.00029	0.254	0.120	0.018
0.006	0.0296	0.0283	0.0023	0.00029	0.254	0.121	0.018
0.006	0.0293	0.0279	0.0023	0.00029	0.251	0.122	0.017
0.006	0.0288	0.0277	0.0023	0.00029	0.251	0.122	0.016
0.006	0.0289	0.0278	0.0023	0.00029	0.251	0.122	0.017
0.006	0.0297	0.0284	0.0023	0.00029	0.254	0.120	0.018
0.004	0.0256	0.0244	0.0024	0.00029	0.233	0.132	0.010
0.004	0.0261	0.0249	0.0024	0.00029	0.235	0.131	0.011
0.004	0.0259	0.0248	0.0024	0.00029	0.235	0.131	0.011
0.004	0.0259	0.0246	0.0024	0.00029	0.234	0.132	0.010
0.004	0.0262	0.0250	0.0024	0.00029	0.236	0.130	0.011
0.004	0.0265	0.0252	0.0024	0.00029	0.237	0.130	0.011
0.004	0.0254	0.0244	0.0024	0.00029	0.233	0.132	0.010
0.002	0.0184	0.0176	0.0025	0.00029	0.196	0.165	0.001
0.002	0.0186	0.0178	0.0025	0.00029	0.196	0.164	0.001
0.002	0.0185	0.0178	0.0025	0.00029	0.196	0.164	0.001
0.002	0.0191	0.0183	0.0025	0.00029	0.199	0.161	0.001
0.002	0.0186	0.0178	0.0025	0.00029	0.197	0.164	0.001
0.002	0.0198	0.0186	0.0025	0.00029	0.201	0.159	0.002
0.002	0.0187	0.0178	0.0025	0.00029	0.196	0.164	0.001
0.002	0.0183	0.0176	0.0025	0.00029	0.195	0.166	0.001
0.002	0.0181	0.0174	0.0025	0.00029	0.194	0.167	0.001
0.002	0.0184	0.0177	0.0025	0.00029	0.196	0.165	0.001
0.002	0.0189	0.0181	0.0025	0.00029	0.198	0.162	0.001
0.002	0.0185	0.0177	0.0025	0.00029	0.196	0.165	0.001
0.002	0.0185	0.0177	0.0025	0.00029	0.196	0.165	0.001
0.002	0.0192	0.0182	0.0025	0.00029	0.199	0.161	0.001
0.004	0.0254	0.0242	0.0025	0.00029	0.232	0.133	0.010
0.004	0.0252	0.0241	0.0025	0.00029	0.231	0.134	0.010
0.004	0.0252	0.0241	0.0025	0.00029	0.231	0.134	0.010
0.004	0.0251	0.0240	0.0025	0.00029	0.231	0.134	0.009

0.004	0.0252	0.0241	0.0025	0.00029	0.231	0.133	0.010
0.004	0.0243	0.0232	0.0025	0.00029	0.226	0.137	0.008
0.004	0.0251	0.0241	0.0025	0.00029	0.231	0.134	0.009
0.003	0.0229	0.0216	0.0025	0.00029	0.218	0.143	0.006
0.006	0.0284	0.0273	0.0025	0.00029	0.248	0.123	0.016
0.006	0.0286	0.0274	0.0025	0.00029	0.249	0.123	0.016
0.006	0.0281	0.0271	0.0025	0.00029	0.247	0.124	0.015
0.006	0.0292	0.0278	0.0025	0.00029	0.251	0.122	0.017
0.006	0.0291	0.0279	0.0025	0.00029	0.251	0.122	0.017
0.006	0.0290	0.0278	0.0025	0.00029	0.251	0.122	0.017
0.006	0.0293	0.0280	0.0025	0.00029	0.252	0.122	0.017
0.005	0.0254	0.0245	0.0026	0.00029	0.233	0.132	0.010
0.005	0.0249	0.0240	0.0026	0.00029	0.230	0.134	0.009
0.005	0.0257	0.0248	0.0026	0.00029	0.235	0.131	0.011
0.005	0.0252	0.0242	0.0026	0.00029	0.231	0.133	0.010
0.005	0.0256	0.0246	0.0026	0.00029	0.234	0.132	0.011
0.005	0.0254	0.0243	0.0026	0.00029	0.232	0.133	0.010
0.005	0.0258	0.0247	0.0026	0.00029	0.234	0.131	0.011
0.004	0.0249	0.0238	0.0027	0.00029	0.229	0.135	0.009
0.004	0.0247	0.0237	0.0027	0.00029	0.229	0.135	0.009
0.004	0.0253	0.0242	0.0027	0.00029	0.232	0.133	0.010
0.004	0.0249	0.0237	0.0027	0.00029	0.229	0.135	0.009
0.004	0.0247	0.0236	0.0027	0.00029	0.229	0.135	0.009
0.004	0.0249	0.0237	0.0027	0.00029	0.229	0.135	0.009
0.004	0.0250	0.0239	0.0027	0.00029	0.230	0.134	0.009
0.002	0.0186	0.0177	0.0027	0.00029	0.196	0.164	0.001
0.002	0.0189	0.0180	0.0027	0.00029	0.198	0.162	0.001
0.002	0.0187	0.0179	0.0027	0.00029	0.197	0.163	0.001
0.002	0.0196	0.0185	0.0027	0.00029	0.201	0.159	0.002
0.002	0.0192	0.0183	0.0027	0.00029	0.199	0.161	0.001
0.002	0.0198	0.0186	0.0027	0.00029	0.201	0.159	0.002
0.002	0.0193	0.0183	0.0027	0.00029	0.199	0.161	0.001
0.006	0.0299	0.0286	0.0027	0.00029	0.255	0.120	0.018
0.006	0.0298	0.0285	0.0027	0.00029	0.255	0.120	0.018
0.006	0.0296	0.0283	0.0027	0.00029	0.254	0.121	0.018
0.006	0.0306	0.0291	0.0027	0.00029	0.257	0.119	0.019
0.006	0.0292	0.0281	0.0027	0.00029	0.252	0.121	0.017
0.006	0.0296	0.0283	0.0027	0.00029	0.254	0.121	0.018
0.006	0.0299	0.0286	0.0027	0.00029	0.255	0.120	0.018
0.005	0.0265	0.0253	0.0028	0.00029	0.237	0.129	0.012
0.005	0.0263	0.0252	0.0028	0.00029	0.237	0.130	0.012
0.005	0.0263	0.0252	0.0028	0.00029	0.237	0.130	0.012
0.005	0.0270	0.0257	0.0028	0.00029	0.240	0.128	0.012
0.005	0.0266	0.0256	0.0028	0.00029	0.239	0.129	0.012
0.005	0.0266	0.0255	0.0028	0.00029	0.238	0.129	0.012
0.005	0.0262	0.0251	0.0028	0.00029	0.236	0.130	0.011
0.003	0.0223	0.0213	0.0029	0.00029	0.216	0.145	0.005
0.003	0.0225	0.0214	0.0029	0.00029	0.217	0.144	0.005
0.003	0.0227	0.0217	0.0029	0.00029	0.218	0.143	0.006
0.003	0.0229	0.0218	0.0029	0.00029	0.219	0.143	0.006
0.003	0.0226	0.0214	0.0029	0.00029	0.217	0.144	0.005
0.003	0.0233	0.0220	0.0029	0.00029	0.220	0.142	0.006
0.003	0.0225	0.0215	0.0029	0.00029	0.217	0.144	0.005
						Total	0.913
						Std.error	0.098

TABLE.A-6.7 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f2 Study

$$\frac{1}{\sqrt{f}} = -0.582\ln\left(\frac{R}{d50}\right) + 4.80$$

f by White & Collebrock

$$\frac{1}{\sqrt{f}} = 1.14 - 2.0\log\left(\frac{ks}{4R} + \frac{21.25}{Re^{0.9}}\right)$$

Disch. Qw m3/s	Vel. m/s	R m	Slope S	D84 m	Reynolds number Re	f Study	f White - Colle.	Std. Error Est.
0.003	0.143	0.021	0.001953	0.00029	3017.47	0.215	0.044	0.029
0.003	0.140	0.022	0.001953	0.00029	3043.384	0.219	0.044	0.030
0.003	0.126	0.021	0.001953	0.00029	2668.863	0.215	0.046	0.029
0.003	0.146	0.022	0.001953	0.00029	3172.738	0.218	0.044	0.030
0.003	0.133	0.022	0.001953	0.00029	2870.264	0.218	0.045	0.030
0.003	0.155	0.022	0.001953	0.00029	3349.754	0.218	0.043	0.031
0.003	0.134	0.021	0.001953	0.00029	2871.143	0.217	0.045	0.030
0.005	0.158	0.026	0.002344	0.00029	4116.395	0.242	0.040	0.041
0.005	0.146	0.026	0.002344	0.00029	3776.839	0.240	0.041	0.040
0.005	0.145	0.026	0.002344	0.00029	3803.429	0.242	0.041	0.040
0.005	0.166	0.025	0.002344	0.00029	4158.53	0.236	0.040	0.038
0.005	0.124	0.025	0.002344	0.00029	3120.847	0.237	0.044	0.037
0.005	0.140	0.026	0.002344	0.00029	3690.665	0.243	0.042	0.040
0.005	0.152	0.025	0.002344	0.00029	3866.783	0.238	0.041	0.039
0.006	0.154	0.029	0.002279	0.00029	4411.765	0.255	0.039	0.047
0.006	0.155	0.028	0.002279	0.00029	4413.262	0.254	0.039	0.046
0.006	0.150	0.028	0.002279	0.00029	4258.003	0.254	0.040	0.046
0.006	0.178	0.028	0.002279	0.00029	4964.386	0.251	0.038	0.046
0.006	0.135	0.028	0.002279	0.00029	3732.392	0.251	0.041	0.044
0.006	0.143	0.028	0.002279	0.00029	3979.326	0.251	0.041	0.044
0.006	0.155	0.028	0.002279	0.00029	4413.762	0.254	0.039	0.046
0.004	0.150	0.024	0.002409	0.00029	3665.521	0.233	0.042	0.037
0.004	0.146	0.025	0.002409	0.00029	3629.137	0.235	0.042	0.037
0.004	0.134	0.025	0.002409	0.00029	3328.269	0.235	0.043	0.037
0.004	0.152	0.025	0.002409	0.00029	3732.162	0.234	0.041	0.037
0.004	0.133	0.025	0.002409	0.00029	3326.824	0.236	0.043	0.037
0.004	0.151	0.025	0.002409	0.00029	3798.67	0.237	0.041	0.038
0.004	0.123	0.024	0.002409	0.00029	3005.753	0.233	0.044	0.036
0.002	0.128	0.018	0.002474	0.00029	2255.24	0.196	0.049	0.022
0.002	0.134	0.018	0.002474	0.00029	2388.773	0.196	0.048	0.022
0.002	0.118	0.018	0.002474	0.00029	2089.959	0.196	0.050	0.021
0.002	0.131	0.018	0.002474	0.00029	2385.923	0.199	0.048	0.023
0.002	0.127	0.018	0.002474	0.00029	2254.343	0.197	0.049	0.022
0.002	0.168	0.019	0.002474	0.00029	3126.628	0.201	0.044	0.025
0.002	0.153	0.018	0.002474	0.00029	2712.127	0.196	0.046	0.023
0.002	0.130	0.018	0.002474	0.00029	2281.369	0.195	0.049	0.021
0.002	0.130	0.017	0.002474	0.00029	2256.737	0.194	0.049	0.021
0.002	0.117	0.018	0.002474	0.00029	2068.735	0.196	0.050	0.021
0.002	0.124	0.018	0.002474	0.00029	2252.551	0.198	0.049	0.022
0.002	0.135	0.018	0.002474	0.00029	2389.486	0.196	0.048	0.022
0.002	0.144	0.018	0.002474	0.00029	2541.081	0.196	0.047	0.022
0.002	0.148	0.018	0.002474	0.00029	2708.245	0.199	0.046	0.023
0.004	0.152	0.024	0.002474	0.00029	3667.137	0.232	0.042	0.036
0.004	0.144	0.024	0.002474	0.00029	3477.161	0.231	0.042	0.036
0.004	0.144	0.024	0.002474	0.00029	3477.161	0.231	0.042	0.036
0.004	0.149	0.024	0.002474	0.00029	3570.535	0.231	0.042	0.036

0.004	0.143	0.024	0.002474	0.00029	3446.937	0.231	0.042	0.036
0.004	0.165	0.023	0.002474	0.00029	3814.61	0.226	0.041	0.034
0.004	0.135	0.024	0.002474	0.00029	3251.584	0.231	0.043	0.035
0.003	0.152	0.022	0.002454	0.00029	3282.784	0.218	0.043	0.030
0.006	0.151	0.027	0.002539	0.00029	4126.093	0.248	0.040	0.043
0.006	0.152	0.027	0.002539	0.00029	4177.729	0.249	0.040	0.044
0.006	0.169	0.027	0.002539	0.00029	4559.853	0.247	0.039	0.043
0.006	0.147	0.028	0.002539	0.00029	4105.381	0.251	0.040	0.044
0.006	0.159	0.028	0.002539	0.00029	4442.263	0.251	0.039	0.045
0.006	0.164	0.028	0.002539	0.00029	4551.051	0.251	0.039	0.045
0.006	0.148	0.028	0.002539	0.00029	4137.526	0.252	0.040	0.045
0.005	0.150	0.024	0.002604	0.00029	3675.388	0.233	0.042	0.037
0.005	0.148	0.024	0.002604	0.00029	3555.19	0.230	0.042	0.035
0.005	0.166	0.025	0.002604	0.00029	4098.181	0.235	0.040	0.038
0.005	0.150	0.024	0.002604	0.00029	3626.661	0.231	0.042	0.036
0.005	0.171	0.025	0.002604	0.00029	4219.897	0.234	0.040	0.038
0.005	0.162	0.024	0.002604	0.00029	3934.866	0.232	0.041	0.037
0.005	0.154	0.025	0.002604	0.00029	3813.185	0.234	0.041	0.037
0.004	0.147	0.024	0.002669	0.00029	3494.95	0.229	0.042	0.035
0.004	0.139	0.024	0.002669	0.00029	3286.583	0.229	0.043	0.034
0.004	0.161	0.024	0.002669	0.00029	3886.101	0.232	0.041	0.036
0.004	0.149	0.024	0.002669	0.00029	3526.96	0.229	0.042	0.035
0.004	0.161	0.024	0.002669	0.00029	3792.738	0.229	0.041	0.035
0.004	0.139	0.024	0.002669	0.00029	3305.757	0.229	0.043	0.035
0.004	0.138	0.024	0.002669	0.00029	3299.09	0.230	0.043	0.035
0.002	0.132	0.018	0.002669	0.00029	2350.193	0.196	0.048	0.022
0.002	0.124	0.018	0.002669	0.00029	2239.065	0.198	0.049	0.022
0.002	0.146	0.018	0.002669	0.00029	2618.961	0.197	0.046	0.023
0.002	0.137	0.019	0.002669	0.00029	2539.039	0.201	0.047	0.024
0.002	0.168	0.018	0.002669	0.00029	3073.293	0.199	0.044	0.024
0.002	0.148	0.019	0.002669	0.00029	2756.065	0.201	0.046	0.024
0.002	0.154	0.018	0.002669	0.00029	2819.311	0.199	0.045	0.024
0.006	0.155	0.029	0.002669	0.00029	4423.636	0.255	0.039	0.047
0.006	0.150	0.029	0.002669	0.00029	4291.108	0.255	0.040	0.046
0.006	0.170	0.028	0.002669	0.00029	4826.544	0.254	0.038	0.046
0.006	0.142	0.029	0.002669	0.00029	4112.5	0.257	0.040	0.047
0.006	0.150	0.028	0.002669	0.00029	4226.724	0.252	0.040	0.045
0.006	0.154	0.028	0.002669	0.00029	4367.464	0.254	0.039	0.046
0.006	0.170	0.029	0.002669	0.00029	4864.996	0.255	0.038	0.047
0.005	0.162	0.025	0.002799	0.00029	4103.902	0.237	0.040	0.039
0.005	0.158	0.025	0.002799	0.00029	3985.948	0.237	0.041	0.039
0.005	0.166	0.025	0.002799	0.00029	4176.521	0.237	0.040	0.039
0.005	0.150	0.026	0.002799	0.00029	3862.701	0.240	0.041	0.040
0.005	0.157	0.026	0.002799	0.00029	4004.846	0.239	0.040	0.039
0.005	0.159	0.025	0.002799	0.00029	4053.426	0.238	0.040	0.039
0.005	0.146	0.025	0.002799	0.00029	3669.248	0.236	0.042	0.038
0.003	0.144	0.021	0.002865	0.00029	3050.684	0.216	0.044	0.029
0.003	0.135	0.021	0.002865	0.00029	2896.903	0.217	0.045	0.030
0.003	0.146	0.022	0.002865	0.00029	3153.214	0.218	0.044	0.030
0.003	0.155	0.022	0.002865	0.00029	3368.198	0.219	0.043	0.031
0.003	0.171	0.021	0.002865	0.00029	3674.35	0.217	0.042	0.031
0.003	0.140	0.022	0.002865	0.00029	3079.42	0.220	0.044	0.031

Total	3.405
Std.error	0.188

TABLE.A-6.8 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f2 Study

$$\frac{1}{\sqrt{f}} = -0.582\ln\left(\frac{R}{d50}\right) + 4.80$$

f by Leopold et, al

$$\frac{1}{\sqrt{f}} = 1.00 - 2.03\log\left(\frac{D}{d84}\right)$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D50 m	D84 m	f Study	f Leopold et,al	Standart Error Estimate
0.003	0.022	0.021	0.001953	0.000225	0.00029	0.215	0.126	0.089
0.003	0.023	0.022	0.001953	0.000225	0.00029	0.219	0.123	0.096
0.003	0.022	0.021	0.001953	0.000225	0.00029	0.215	0.126	0.089
0.003	0.023	0.022	0.001953	0.000225	0.00029	0.218	0.123	0.095
0.003	0.023	0.022	0.001953	0.000225	0.00029	0.218	0.124	0.094
0.003	0.023	0.022	0.001953	0.000225	0.00029	0.218	0.123	0.095
0.003	0.022	0.021	0.001953	0.000225	0.00029	0.217	0.125	0.092
0.005	0.027	0.026	0.002344	0.000225	0.00029	0.242	0.111	0.131
0.005	0.027	0.026	0.002344	0.000225	0.00029	0.240	0.112	0.129
0.005	0.027	0.026	0.002344	0.000225	0.00029	0.242	0.111	0.132
0.005	0.026	0.025	0.002344	0.000225	0.00029	0.236	0.113	0.123
0.005	0.026	0.025	0.002344	0.000225	0.00029	0.237	0.114	0.123
0.005	0.027	0.026	0.002344	0.000225	0.00029	0.243	0.110	0.132
0.005	0.027	0.025	0.002344	0.000225	0.00029	0.238	0.112	0.126
0.006	0.030	0.029	0.002279	0.000225	0.00029	0.255	0.105	0.151
0.006	0.030	0.028	0.002279	0.000225	0.00029	0.254	0.105	0.149
0.006	0.030	0.028	0.002279	0.000225	0.00029	0.254	0.106	0.148
0.006	0.029	0.028	0.002279	0.000225	0.00029	0.251	0.106	0.145
0.006	0.029	0.028	0.002279	0.000225	0.00029	0.251	0.107	0.143
0.006	0.029	0.028	0.002279	0.000225	0.00029	0.251	0.107	0.144
0.006	0.030	0.028	0.002279	0.000225	0.00029	0.254	0.105	0.149
0.004	0.026	0.024	0.002409	0.000225	0.00029	0.233	0.115	0.118
0.004	0.026	0.025	0.002409	0.000225	0.00029	0.235	0.114	0.122
0.004	0.026	0.025	0.002409	0.000225	0.00029	0.235	0.114	0.121
0.004	0.026	0.025	0.002409	0.000225	0.00029	0.234	0.114	0.120
0.004	0.026	0.025	0.002409	0.000225	0.00029	0.236	0.113	0.123
0.004	0.027	0.025	0.002409	0.000225	0.00029	0.237	0.113	0.124
0.004	0.025	0.024	0.002409	0.000225	0.00029	0.233	0.115	0.117
0.002	0.018	0.018	0.002474	0.000225	0.00029	0.196	0.141	0.054
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.196	0.140	0.056
0.002	0.018	0.018	0.002474	0.000225	0.00029	0.196	0.141	0.055
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.199	0.138	0.061
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.197	0.140	0.056
0.002	0.020	0.019	0.002474	0.000225	0.00029	0.201	0.135	0.066
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.196	0.140	0.056
0.002	0.018	0.018	0.002474	0.000225	0.00029	0.195	0.142	0.053
0.002	0.018	0.017	0.002474	0.000225	0.00029	0.194	0.143	0.051
0.002	0.018	0.018	0.002474	0.000225	0.00029	0.196	0.142	0.054
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.198	0.139	0.060
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.196	0.141	0.055
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.196	0.141	0.055
0.002	0.019	0.018	0.002474	0.000225	0.00029	0.199	0.137	0.062
0.004	0.025	0.024	0.002474	0.000225	0.00029	0.232	0.115	0.116
0.004	0.025	0.024	0.002474	0.000225	0.00029	0.231	0.116	0.115
0.004	0.025	0.024	0.002474	0.000225	0.00029	0.231	0.116	0.115
0.004	0.025	0.024	0.002474	0.000225	0.00029	0.231	0.116	0.115

0.004	0.025	0.024	0.002474	0.000225	0.00029	0.231	0.116	0.115
0.004	0.024	0.023	0.002474	0.000225	0.00029	0.226	0.119	0.108
0.004	0.025	0.024	0.002474	0.000225	0.00029	0.231	0.116	0.115
0.003	0.023	0.022	0.002454	0.000225	0.00029	0.218	0.123	0.095
0.006	0.028	0.027	0.002539	0.000225	0.00029	0.248	0.108	0.140
0.006	0.029	0.027	0.002539	0.000225	0.00029	0.249	0.108	0.141
0.006	0.028	0.027	0.002539	0.000225	0.00029	0.247	0.109	0.138
0.006	0.029	0.028	0.002539	0.000225	0.00029	0.251	0.106	0.145
0.006	0.029	0.028	0.002539	0.000225	0.00029	0.251	0.107	0.145
0.006	0.029	0.028	0.002539	0.000225	0.00029	0.251	0.107	0.144
0.006	0.029	0.028	0.002539	0.000225	0.00029	0.252	0.106	0.146
0.005	0.025	0.024	0.002604	0.000225	0.00029	0.233	0.115	0.118
0.005	0.025	0.024	0.002604	0.000225	0.00029	0.230	0.117	0.113
0.005	0.026	0.025	0.002604	0.000225	0.00029	0.235	0.115	0.120
0.005	0.025	0.024	0.002604	0.000225	0.00029	0.231	0.116	0.115
0.005	0.026	0.025	0.002604	0.000225	0.00029	0.234	0.115	0.119
0.005	0.025	0.024	0.002604	0.000225	0.00029	0.232	0.115	0.117
0.005	0.026	0.025	0.002604	0.000225	0.00029	0.234	0.115	0.120
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.229	0.117	0.113
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.229	0.117	0.112
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.232	0.116	0.116
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.229	0.117	0.112
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.229	0.117	0.111
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.229	0.117	0.112
0.004	0.025	0.024	0.002669	0.000225	0.00029	0.230	0.117	0.114
0.002	0.019	0.018	0.002669	0.000225	0.00029	0.196	0.140	0.056
0.002	0.019	0.018	0.002669	0.000225	0.00029	0.198	0.139	0.059
0.002	0.019	0.018	0.002669	0.000225	0.00029	0.197	0.140	0.057
0.002	0.020	0.019	0.002669	0.000225	0.00029	0.201	0.136	0.065
0.002	0.019	0.018	0.002669	0.000225	0.00029	0.199	0.137	0.062
0.002	0.020	0.019	0.002669	0.000225	0.00029	0.201	0.135	0.066
0.002	0.019	0.018	0.002669	0.000225	0.00029	0.199	0.137	0.062
0.006	0.030	0.029	0.002669	0.000225	0.00029	0.255	0.105	0.150
0.006	0.030	0.029	0.002669	0.000225	0.00029	0.255	0.105	0.150
0.006	0.030	0.028	0.002669	0.000225	0.00029	0.254	0.106	0.148
0.006	0.031	0.029	0.002669	0.000225	0.00029	0.257	0.104	0.154
0.006	0.029	0.028	0.002669	0.000225	0.00029	0.252	0.106	0.146
0.006	0.030	0.028	0.002669	0.000225	0.00029	0.254	0.106	0.148
0.006	0.030	0.029	0.002669	0.000225	0.00029	0.255	0.105	0.150
0.005	0.026	0.025	0.002799	0.000225	0.00029	0.237	0.113	0.125
0.005	0.026	0.025	0.002799	0.000225	0.00029	0.237	0.113	0.124
0.005	0.026	0.025	0.002799	0.000225	0.00029	0.237	0.113	0.124
0.005	0.027	0.026	0.002799	0.000225	0.00029	0.240	0.111	0.128
0.005	0.027	0.026	0.002799	0.000225	0.00029	0.239	0.112	0.127
0.005	0.027	0.025	0.002799	0.000225	0.00029	0.238	0.112	0.126
0.005	0.026	0.025	0.002799	0.000225	0.00029	0.236	0.113	0.123
0.003	0.022	0.021	0.002865	0.000225	0.00029	0.216	0.125	0.091
0.003	0.022	0.021	0.002865	0.000225	0.00029	0.217	0.124	0.092
0.003	0.023	0.022	0.002865	0.000225	0.00029	0.218	0.124	0.094
0.003	0.023	0.022	0.002865	0.000225	0.00029	0.219	0.123	0.096
0.003	0.023	0.021	0.002865	0.000225	0.00029	0.217	0.124	0.093
0.003	0.023	0.022	0.002865	0.000225	0.00029	0.220	0.122	0.098
0.003	0.023	0.022	0.002865	0.000225	0.00029	0.217	0.124	0.093
							Total	10.724
							Std.error	0.334

TABLE.A-6.9 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f3 Study

$$\frac{1}{\sqrt{f}} = 8.648 - 1.70 \ln\left(\frac{B}{D}\right)$$

f by Leopold,Wolman and Miller

$$\frac{1}{\sqrt{f}} = 1.00 - 2.03 \log\left(\frac{D}{d84}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	D84 m	f Study	f Leopold et,al	Standart Error Estimate
0.003	0.950	0.0221	0.0211	0.0020	0.00029	0.1967	0.1257	0.0050
0.003	0.940	0.0229	0.0218	0.0020	0.00029	0.1841	0.1231	0.0037
0.003	1.080	0.0220	0.0212	0.0020	0.00029	0.2423	0.1259	0.0135
0.003	0.900	0.0228	0.0217	0.0020	0.00029	0.1739	0.1234	0.0026
0.003	1.000	0.0226	0.0216	0.0020	0.00029	0.2056	0.1240	0.0067
0.003	0.850	0.0228	0.0216	0.0020	0.00029	0.1605	0.1233	0.0014
0.003	1.000	0.0224	0.0215	0.0020	0.00029	0.2079	0.1245	0.0070
0.005	1.160	0.0273	0.0261	0.0023	0.00029	0.1931	0.1105	0.0068
0.005	1.270	0.0269	0.0258	0.0023	0.00029	0.2274	0.1115	0.0134
0.005	1.260	0.0273	0.0262	0.0023	0.00029	0.2196	0.1106	0.0119
0.005	1.150	0.0262	0.0250	0.0023	0.00029	0.2034	0.1134	0.0081
0.005	1.550	0.0261	0.0252	0.0023	0.00029	0.3449	0.1137	0.0535
0.005	1.300	0.0274	0.0263	0.0023	0.00029	0.2299	0.1104	0.0143
0.005	1.240	0.0265	0.0254	0.0023	0.00029	0.2241	0.1125	0.0125
0.006	1.300	0.0300	0.0287	0.0023	0.00029	0.1992	0.1047	0.0089
0.006	1.300	0.0298	0.0285	0.0023	0.00029	0.2015	0.1052	0.0093
0.006	1.350	0.0296	0.0283	0.0023	0.00029	0.2161	0.1056	0.0122
0.006	1.150	0.0293	0.0279	0.0023	0.00029	0.1723	0.1062	0.0044
0.006	1.550	0.0288	0.0277	0.0023	0.00029	0.2857	0.1073	0.0318
0.006	1.450	0.0289	0.0278	0.0023	0.00029	0.2521	0.1070	0.0211
0.006	1.300	0.0297	0.0284	0.0023	0.00029	0.2023	0.1054	0.0094
0.004	1.040	0.0256	0.0244	0.0024	0.00029	0.1807	0.1148	0.0043
0.004	1.050	0.0261	0.0249	0.0024	0.00029	0.1785	0.1136	0.0042
0.004	1.150	0.0259	0.0248	0.0024	0.00029	0.2066	0.1141	0.0086
0.004	1.020	0.0259	0.0246	0.0024	0.00029	0.1733	0.1142	0.0035
0.004	1.150	0.0262	0.0250	0.0024	0.00029	0.2034	0.1134	0.0081
0.004	1.000	0.0265	0.0252	0.0024	0.00029	0.1631	0.1126	0.0026
0.004	1.280	0.0254	0.0244	0.0024	0.00029	0.2542	0.1155	0.0192
0.002	0.850	0.0184	0.0176	0.0025	0.00029	0.2198	0.1414	0.0061
0.002	0.800	0.0186	0.0178	0.0025	0.00029	0.1965	0.1403	0.0032
0.002	0.920	0.0185	0.0178	0.0025	0.00029	0.2488	0.1410	0.0116
0.002	0.800	0.0191	0.0183	0.0025	0.00029	0.1889	0.1379	0.0026
0.002	0.850	0.0186	0.0178	0.0025	0.00029	0.2165	0.1405	0.0058
0.002	0.600	0.0198	0.0186	0.0025	0.00029	0.1230	0.1347	0.0001
0.002	0.700	0.0187	0.0178	0.0025	0.00029	0.1612	0.1399	0.0005
0.002	0.840	0.0183	0.0176	0.0025	0.00029	0.2171	0.1418	0.0057
0.002	0.850	0.0181	0.0174	0.0025	0.00029	0.2255	0.1429	0.0068
0.002	0.930	0.0184	0.0177	0.0025	0.00029	0.2556	0.1415	0.0130
0.002	0.850	0.0189	0.0181	0.0025	0.00029	0.2102	0.1388	0.0051
0.002	0.800	0.0185	0.0177	0.0025	0.00029	0.1985	0.1409	0.0033
0.002	0.750	0.0185	0.0177	0.0025	0.00029	0.1800	0.1408	0.0015
0.002	0.700	0.0192	0.0182	0.0025	0.00029	0.1552	0.1373	0.0003
0.004	1.040	0.0254	0.0242	0.0025	0.00029	0.1832	0.1155	0.0046
0.004	1.100	0.0252	0.0241	0.0025	0.00029	0.2016	0.1160	0.0073
0.004	1.100	0.0252	0.0241	0.0025	0.00029	0.2016	0.1160	0.0073
0.004	1.070	0.0251	0.0240	0.0025	0.00029	0.1938	0.1162	0.0060

0.004	1.110	0.0252	0.0241	0.0025	0.00029	0.2039	0.1159	0.0077
0.004	1.000	0.0243	0.0232	0.0025	0.00029	0.1844	0.1186	0.0043
0.004	1.180	0.0251	0.0241	0.0025	0.00029	0.2265	0.1163	0.0121
0.003	0.750	0.0229	0.0216	0.0025	0.00029	0.1352	0.1228	0.0002
0.006	1.390	0.0284	0.0273	0.0025	0.00029	0.2415	0.1081	0.0178
0.006	1.390	0.0286	0.0274	0.0025	0.00029	0.2395	0.1077	0.0174
0.006	1.400	0.0281	0.0271	0.0025	0.00029	0.2485	0.1087	0.0195
0.006	1.220	0.0292	0.0278	0.0025	0.00029	0.1888	0.1064	0.0068
0.006	1.400	0.0291	0.0279	0.0025	0.00029	0.2353	0.1066	0.0166
0.006	1.300	0.0290	0.0278	0.0025	0.00029	0.2098	0.1068	0.0106
0.006	1.250	0.0293	0.0280	0.0025	0.00029	0.1947	0.1062	0.0078
0.005	1.330	0.0254	0.0245	0.0026	0.00029	0.2713	0.1154	0.0243
0.005	1.340	0.0249	0.0240	0.0026	0.00029	0.2862	0.1170	0.0286
0.005	1.310	0.0257	0.0248	0.0026	0.00029	0.2586	0.1146	0.0207
0.005	1.200	0.0252	0.0242	0.0026	0.00029	0.2315	0.1161	0.0133
0.005	1.300	0.0256	0.0246	0.0026	0.00029	0.2571	0.1149	0.0202
0.005	1.150	0.0254	0.0243	0.0026	0.00029	0.2132	0.1155	0.0096
0.005	1.200	0.0258	0.0247	0.0026	0.00029	0.2231	0.1145	0.0118
0.004	1.040	0.0249	0.0238	0.0027	0.00029	0.1884	0.1168	0.0051
0.004	1.100	0.0247	0.0237	0.0027	0.00029	0.2073	0.1173	0.0081
0.004	1.140	0.0253	0.0242	0.0027	0.00029	0.2120	0.1158	0.0092
0.004	1.000	0.0249	0.0237	0.0027	0.00029	0.1780	0.1168	0.0037
0.004	1.090	0.0247	0.0236	0.0027	0.00029	0.2050	0.1175	0.0077
0.004	1.000	0.0249	0.0237	0.0027	0.00029	0.1780	0.1168	0.0037
0.004	1.150	0.0250	0.0239	0.0027	0.00029	0.2191	0.1167	0.0105
0.002	0.780	0.0186	0.0177	0.0027	0.00029	0.1898	0.1405	0.0024
0.002	0.800	0.0189	0.0180	0.0027	0.00029	0.1926	0.1391	0.0029
0.002	0.860	0.0187	0.0179	0.0027	0.00029	0.2180	0.1398	0.0061
0.002	0.700	0.0196	0.0185	0.0027	0.00029	0.1517	0.1358	0.0003
0.002	0.760	0.0192	0.0183	0.0027	0.00029	0.1742	0.1375	0.0014
0.002	0.600	0.0198	0.0186	0.0027	0.00029	0.1230	0.1347	0.0001
0.002	0.700	0.0193	0.0183	0.0027	0.00029	0.1547	0.1371	0.0003
0.006	1.300	0.0299	0.0286	0.0027	0.00029	0.1999	0.1049	0.0090
0.006	1.300	0.0298	0.0285	0.0027	0.00029	0.2007	0.1050	0.0092
0.006	1.350	0.0296	0.0283	0.0027	0.00029	0.2161	0.1056	0.0122
0.006	1.150	0.0306	0.0291	0.0027	0.00029	0.1621	0.1036	0.0034
0.006	1.450	0.0292	0.0281	0.0027	0.00029	0.2471	0.1063	0.0198
0.006	1.350	0.0296	0.0283	0.0027	0.00029	0.2161	0.1056	0.0122
0.006	1.300	0.0299	0.0286	0.0027	0.00029	0.1999	0.1049	0.0090
0.005	1.110	0.0265	0.0253	0.0028	0.00029	0.1894	0.1126	0.0059
0.005	1.170	0.0263	0.0252	0.0028	0.00029	0.2070	0.1130	0.0088
0.005	1.200	0.0263	0.0252	0.0028	0.00029	0.2153	0.1130	0.0105
0.005	1.120	0.0270	0.0257	0.0028	0.00029	0.1869	0.1114	0.0057
0.005	1.250	0.0266	0.0256	0.0028	0.00029	0.2256	0.1122	0.0128
0.005	1.200	0.0266	0.0255	0.0028	0.00029	0.2121	0.1124	0.0099
0.005	1.200	0.0262	0.0251	0.0028	0.00029	0.2174	0.1134	0.0108
0.003	0.920	0.0223	0.0213	0.0029	0.00029	0.1853	0.1251	0.0036
0.003	0.930	0.0225	0.0214	0.0029	0.00029	0.1859	0.1244	0.0038
0.003	0.980	0.0227	0.0217	0.0029	0.00029	0.1986	0.1238	0.0056
0.003	0.900	0.0229	0.0218	0.0029	0.00029	0.1727	0.1230	0.0025
0.003	0.860	0.0226	0.0214	0.0029	0.00029	0.1654	0.1241	0.0017
0.003	0.750	0.0233	0.0220	0.0029	0.00029	0.1324	0.1215	0.0001
0.003	0.950	0.0225	0.0215	0.0029	0.00029	0.1912	0.1242	0.0045
							Total	0.0088
							Std. Err	0.0095

TABLE.A-6.10 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f3 Study

$$\frac{1}{\sqrt{f}} = 8.648 - 1.70 \ln\left(\frac{B}{D}\right)$$

f by White - Collebrock

$$\frac{1}{\sqrt{f}} = 1.14 - 2.0\log\left(\frac{ks}{4R} + \frac{21.25}{Re^{0.9}}\right)$$

Disch. Qw m3/s	Velo city m/s	Width m	Depth m2	R m	Slope S	D84 m	f Study	f White Colle.	Standart Error Estimate
0.003	0.143	0.950	0.022	0.021	0.0020	0.00029	0.1967	0.0385	0.0250
0.003	0.140	0.940	0.023	0.022	0.0020	0.00029	0.1841	0.0382	0.0213
0.003	0.126	1.080	0.022	0.021	0.0020	0.00029	0.2423	0.0396	0.0411
0.003	0.146	0.900	0.023	0.022	0.0020	0.00029	0.1739	0.0379	0.0185
0.003	0.133	1.000	0.023	0.022	0.0020	0.00029	0.2056	0.0388	0.0278
0.003	0.155	0.850	0.023	0.022	0.0020	0.00029	0.1605	0.0375	0.0151
0.003	0.134	1.000	0.022	0.021	0.0020	0.00029	0.2079	0.0388	0.0286
0.005	0.158	1.160	0.027	0.026	0.0023	0.00029	0.1931	0.0351	0.0250
0.005	0.146	1.270	0.027	0.026	0.0023	0.00029	0.2274	0.0358	0.0367
0.005	0.145	1.260	0.027	0.026	0.0023	0.00029	0.2196	0.0357	0.0339
0.005	0.166	1.150	0.026	0.025	0.0023	0.00029	0.2034	0.0352	0.0283
0.005	0.124	1.550	0.026	0.025	0.0023	0.00029	0.3449	0.0374	0.0945
0.005	0.140	1.300	0.027	0.026	0.0023	0.00029	0.2299	0.0359	0.0376
0.005	0.152	1.240	0.027	0.025	0.0023	0.00029	0.2241	0.0356	0.0355
0.006	0.154	1.300	0.030	0.029	0.0023	0.00029	0.1992	0.0342	0.0272
0.006	0.155	1.300	0.030	0.028	0.0023	0.00029	0.2015	0.0342	0.0280
0.006	0.150	1.350	0.030	0.028	0.0023	0.00029	0.2161	0.0345	0.0330
0.006	0.178	1.150	0.029	0.028	0.0023	0.00029	0.1723	0.0335	0.0193
0.006	0.135	1.550	0.029	0.028	0.0023	0.00029	0.2857	0.0356	0.0626
0.006	0.143	1.450	0.029	0.028	0.0023	0.00029	0.2521	0.0351	0.0471
0.006	0.155	1.300	0.030	0.028	0.0023	0.00029	0.2023	0.0342	0.0282
0.004	0.150	1.040	0.026	0.024	0.0024	0.00029	0.1807	0.0362	0.0209
0.004	0.146	1.050	0.026	0.025	0.0024	0.00029	0.1785	0.0362	0.0202
0.004	0.134	1.150	0.026	0.025	0.0024	0.00029	0.2066	0.0370	0.0288
0.004	0.152	1.020	0.026	0.025	0.0024	0.00029	0.1733	0.0360	0.0188
0.004	0.133	1.150	0.026	0.025	0.0024	0.00029	0.2034	0.0369	0.0277
0.004	0.151	1.000	0.027	0.025	0.0024	0.00029	0.1631	0.0358	0.0162
0.004	0.123	1.280	0.025	0.024	0.0024	0.00029	0.2542	0.0379	0.0468
0.002	0.128	0.850	0.018	0.018	0.0025	0.00029	0.2198	0.0420	0.0316
0.002	0.134	0.800	0.019	0.018	0.0025	0.00029	0.1965	0.0414	0.0241
0.002	0.118	0.920	0.018	0.018	0.0025	0.00029	0.2488	0.0428	0.0424
0.002	0.131	0.800	0.019	0.018	0.0025	0.00029	0.1889	0.0413	0.0218
0.002	0.127	0.850	0.019	0.018	0.0025	0.00029	0.2165	0.0420	0.0304
0.002	0.168	0.600	0.020	0.019	0.0025	0.00029	0.1230	0.0387	0.0071
0.002	0.153	0.700	0.019	0.018	0.0025	0.00029	0.1612	0.0402	0.0146
0.002	0.130	0.840	0.018	0.018	0.0025	0.00029	0.2171	0.0419	0.0307
0.002	0.130	0.850	0.018	0.017	0.0025	0.00029	0.2255	0.0421	0.0336
0.002	0.117	0.930	0.018	0.018	0.0025	0.00029	0.2556	0.0430	0.0452
0.002	0.124	0.850	0.019	0.018	0.0025	0.00029	0.2102	0.0419	0.0283
0.002	0.135	0.800	0.019	0.018	0.0025	0.00029	0.1985	0.0414	0.0247
0.002	0.144	0.750	0.019	0.018	0.0025	0.00029	0.1800	0.0408	0.0194
0.002	0.148	0.700	0.019	0.018	0.0025	0.00029	0.1552	0.0401	0.0133
0.004	0.152	1.040	0.025	0.024	0.0025	0.00029	0.1832	0.0363	0.0216
0.004	0.144	1.100	0.025	0.024	0.0025	0.00029	0.2016	0.0367	0.0272
0.004	0.144	1.100	0.025	0.024	0.0025	0.00029	0.2016	0.0367	0.0272
0.004	0.149	1.070	0.025	0.024	0.0025	0.00029	0.1938	0.0365	0.0248

0.004	0.143	1.110	0.025	0.024	0.0025	0.00029	0.2039	0.0368	0.0279
0.004	0.165	1.000	0.024	0.023	0.0025	0.00029	0.1844	0.0361	0.0220
0.004	0.135	1.180	0.025	0.024	0.0025	0.00029	0.2265	0.0373	0.0358
0.003	0.174	0.750	0.023	0.022	0.0025	0.00029	0.1352	0.0365	0.0097
0.006	0.152	1.390	0.028	0.027	0.0025	0.00029	0.2415	0.0348	0.0427
0.006	0.151	1.390	0.029	0.027	0.0025	0.00029	0.2395	0.0348	0.0419
0.006	0.152	1.400	0.028	0.027	0.0025	0.00029	0.2485	0.0349	0.0456
0.006	0.169	1.220	0.029	0.028	0.0025	0.00029	0.1888	0.0339	0.0240
0.006	0.147	1.400	0.029	0.028	0.0025	0.00029	0.2353	0.0348	0.0402
0.006	0.159	1.300	0.029	0.028	0.0025	0.00029	0.2098	0.0343	0.0308
0.006	0.164	1.250	0.029	0.028	0.0025	0.00029	0.1947	0.0340	0.0258
0.005	0.148	1.330	0.025	0.024	0.0026	0.00029	0.2713	0.0363	0.0552
0.005	0.150	1.340	0.025	0.024	0.0026	0.00029	0.2862	0.0364	0.0624
0.005	0.148	1.310	0.026	0.025	0.0026	0.00029	0.2586	0.0362	0.0495
0.005	0.166	1.200	0.025	0.024	0.0026	0.00029	0.2315	0.0356	0.0384
0.005	0.150	1.300	0.026	0.025	0.0026	0.00029	0.2571	0.0361	0.0488
0.005	0.171	1.150	0.025	0.024	0.0026	0.00029	0.2132	0.0353	0.0317
0.005	0.162	1.200	0.026	0.025	0.0026	0.00029	0.2231	0.0355	0.0352
0.004	0.154	1.040	0.025	0.024	0.0027	0.00029	0.1884	0.0363	0.0231
0.004	0.147	1.100	0.025	0.024	0.0027	0.00029	0.2073	0.0368	0.0291
0.004	0.139	1.140	0.025	0.024	0.0027	0.00029	0.2120	0.0370	0.0306
0.004	0.161	1.000	0.025	0.024	0.0027	0.00029	0.1780	0.0360	0.0202
0.004	0.149	1.090	0.025	0.024	0.0027	0.00029	0.2050	0.0367	0.0283
0.004	0.161	1.000	0.025	0.024	0.0027	0.00029	0.1780	0.0360	0.0202
0.004	0.139	1.150	0.025	0.024	0.0027	0.00029	0.2191	0.0371	0.0331
0.002	0.138	0.780	0.019	0.018	0.0027	0.00029	0.1898	0.0412	0.0221
0.002	0.132	0.800	0.019	0.018	0.0027	0.00029	0.1926	0.0414	0.0229
0.002	0.124	0.860	0.019	0.018	0.0027	0.00029	0.2180	0.0421	0.0310
0.002	0.146	0.700	0.020	0.019	0.0027	0.00029	0.1517	0.0400	0.0125
0.002	0.137	0.760	0.019	0.018	0.0027	0.00029	0.1742	0.0408	0.0178
0.002	0.168	0.600	0.020	0.019	0.0027	0.00029	0.1230	0.0387	0.0071
0.002	0.148	0.700	0.019	0.018	0.0027	0.00029	0.1547	0.0401	0.0131
0.006	0.154	1.300	0.030	0.029	0.0027	0.00029	0.1999	0.0342	0.0275
0.006	0.155	1.300	0.030	0.029	0.0027	0.00029	0.2007	0.0342	0.0277
0.006	0.150	1.350	0.030	0.028	0.0027	0.00029	0.2161	0.0345	0.0330
0.006	0.170	1.150	0.031	0.029	0.0027	0.00029	0.1621	0.0333	0.0166
0.006	0.142	1.450	0.029	0.028	0.0027	0.00029	0.2471	0.0350	0.0450
0.006	0.150	1.350	0.030	0.028	0.0027	0.00029	0.2161	0.0345	0.0330
0.006	0.154	1.300	0.030	0.029	0.0027	0.00029	0.1999	0.0342	0.0275
0.005	0.170	1.110	0.026	0.025	0.0028	0.00029	0.1894	0.0349	0.0239
0.005	0.162	1.170	0.026	0.025	0.0028	0.00029	0.2070	0.0353	0.0295
0.005	0.158	1.200	0.026	0.025	0.0028	0.00029	0.2153	0.0354	0.0323
0.005	0.166	1.120	0.027	0.026	0.0028	0.00029	0.1869	0.0349	0.0231
0.005	0.150	1.250	0.027	0.026	0.0028	0.00029	0.2256	0.0357	0.0361
0.005	0.157	1.200	0.027	0.025	0.0028	0.00029	0.2121	0.0354	0.0312
0.005	0.159	1.200	0.026	0.025	0.0028	0.00029	0.2174	0.0355	0.0331
0.003	0.146	0.920	0.022	0.021	0.0029	0.00029	0.1853	0.0382	0.0217
0.003	0.144	0.930	0.022	0.021	0.0029	0.00029	0.1859	0.0382	0.0218
0.003	0.135	0.980	0.023	0.022	0.0029	0.00029	0.1986	0.0386	0.0256
0.003	0.146	0.900	0.023	0.022	0.0029	0.00029	0.1727	0.0379	0.0182
0.003	0.155	0.860	0.023	0.021	0.0029	0.00029	0.1654	0.0376	0.0163
0.003	0.171	0.750	0.023	0.022	0.0029	0.00029	0.1324	0.0365	0.0092
0.003	0.140	0.950	0.023	0.022	0.0029	0.00029	0.1912	0.0384	0.0234
								Total	0.0293
								Std. Err	0.0174

TABLE.A-6.11 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f3 Study

$$\frac{1}{\sqrt{f}} = 8.648 - 1.70 \ln\left(\frac{B}{D}\right)$$

f by Limerinos

$$\frac{1}{\sqrt{f}} = 0.35 - 2.03 \log\left(\frac{R}{d50}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	D50 m	f Study	f Limerinos d50	Standart Error Estimate
0.003	0.950	0.0221	0.0211	0.0020	0.000225	0.1967	0.0749	0.0148
0.003	0.940	0.0229	0.0218	0.0020	0.000225	0.1841	0.0737	0.0122
0.003	1.080	0.0220	0.0212	0.0020	0.000225	0.2423	0.0748	0.0281
0.003	0.900	0.0228	0.0217	0.0020	0.000225	0.1739	0.0740	0.0100
0.003	1.000	0.0226	0.0216	0.0020	0.000225	0.2056	0.0740	0.0173
0.003	0.850	0.0228	0.0216	0.0020	0.000225	0.1605	0.0740	0.0075
0.003	1.000	0.0224	0.0215	0.0020	0.000225	0.2079	0.0743	0.0178
0.005	1.160	0.0273	0.0261	0.0023	0.000225	0.1931	0.0678	0.0157
0.005	1.270	0.0269	0.0258	0.0023	0.000225	0.2274	0.0681	0.0254
0.005	1.260	0.0273	0.0262	0.0023	0.000225	0.2196	0.0677	0.0231
0.005	1.150	0.0262	0.0250	0.0023	0.000225	0.2034	0.0691	0.0180
0.005	1.550	0.0261	0.0252	0.0023	0.000225	0.3449	0.0689	0.0762
0.005	1.300	0.0274	0.0263	0.0023	0.000225	0.2299	0.0676	0.0263
0.005	1.240	0.0265	0.0254	0.0023	0.000225	0.2241	0.0686	0.0242
0.006	1.300	0.0300	0.0287	0.0023	0.000225	0.1992	0.0649	0.0180
0.006	1.300	0.0298	0.0285	0.0023	0.000225	0.2015	0.0652	0.0186
0.006	1.350	0.0296	0.0283	0.0023	0.000225	0.2161	0.0653	0.0227
0.006	1.150	0.0293	0.0279	0.0023	0.000225	0.1723	0.0658	0.0113
0.006	1.550	0.0288	0.0277	0.0023	0.000225	0.2857	0.0659	0.0483
0.006	1.450	0.0289	0.0278	0.0023	0.000225	0.2521	0.0659	0.0347
0.006	1.300	0.0297	0.0284	0.0023	0.000225	0.2023	0.0652	0.0188
0.004	1.040	0.0256	0.0244	0.0024	0.000225	0.1807	0.0699	0.0123
0.004	1.050	0.0261	0.0249	0.0024	0.000225	0.1785	0.0693	0.0119
0.004	1.150	0.0259	0.0248	0.0024	0.000225	0.2066	0.0694	0.0188
0.004	1.020	0.0259	0.0246	0.0024	0.000225	0.1733	0.0696	0.0107
0.004	1.150	0.0262	0.0250	0.0024	0.000225	0.2034	0.0691	0.0180
0.004	1.000	0.0265	0.0252	0.0024	0.000225	0.1631	0.0689	0.0089
0.004	1.280	0.0254	0.0244	0.0024	0.000225	0.2542	0.0699	0.0339
0.002	0.850	0.0184	0.0176	0.0025	0.000225	0.2198	0.0818	0.0190
0.002	0.800	0.0186	0.0178	0.0025	0.000225	0.1965	0.0815	0.0132
0.002	0.920	0.0185	0.0178	0.0025	0.000225	0.2488	0.0816	0.0280
0.002	0.800	0.0191	0.0183	0.0025	0.000225	0.1889	0.0805	0.0118
0.002	0.850	0.0186	0.0178	0.0025	0.000225	0.2165	0.0815	0.0182
0.002	0.600	0.0198	0.0186	0.0025	0.000225	0.1230	0.0797	0.0019
0.002	0.700	0.0187	0.0178	0.0025	0.000225	0.1612	0.0816	0.0063
0.002	0.840	0.0183	0.0176	0.0025	0.000225	0.2171	0.0820	0.0183
0.002	0.850	0.0181	0.0174	0.0025	0.000225	0.2255	0.0825	0.0205
0.002	0.930	0.0184	0.0177	0.0025	0.000225	0.2556	0.0817	0.0302
0.002	0.850	0.0189	0.0181	0.0025	0.000225	0.2102	0.0807	0.0168
0.002	0.800	0.0185	0.0177	0.0025	0.000225	0.1985	0.0817	0.0136
0.002	0.750	0.0185	0.0177	0.0025	0.000225	0.1800	0.0818	0.0096
0.002	0.700	0.0192	0.0182	0.0025	0.000225	0.1552	0.0805	0.0056
0.004	1.040	0.0254	0.0242	0.0025	0.000225	0.1832	0.0702	0.0128
0.004	1.100	0.0252	0.0241	0.0025	0.000225	0.2016	0.0704	0.0172
0.004	1.100	0.0252	0.0241	0.0025	0.000225	0.2016	0.0704	0.0172
0.004	1.070	0.0251	0.0240	0.0025	0.000225	0.1938	0.0705	0.0152

0.004	1.110	0.0252	0.0241	0.0025	0.000225	0.2039	0.0703	0.0178
0.004	1.000	0.0243	0.0232	0.0025	0.000225	0.1844	0.0716	0.0127
0.004	1.180	0.0251	0.0241	0.0025	0.000225	0.2265	0.0704	0.0244
0.003	0.750	0.0229	0.0216	0.0025	0.000225	0.1352	0.0741	0.0037
0.006	1.390	0.0284	0.0273	0.0025	0.000225	0.2415	0.0664	0.0307
0.006	1.390	0.0286	0.0274	0.0025	0.000225	0.2395	0.0663	0.0300
0.006	1.400	0.0281	0.0271	0.0025	0.000225	0.2485	0.0667	0.0330
0.006	1.220	0.0292	0.0278	0.0025	0.000225	0.1888	0.0658	0.0151
0.006	1.400	0.0291	0.0279	0.0025	0.000225	0.2353	0.0657	0.0288
0.006	1.300	0.0290	0.0278	0.0025	0.000225	0.2098	0.0659	0.0207
0.006	1.250	0.0293	0.0280	0.0025	0.000225	0.1947	0.0657	0.0166
0.005	1.330	0.0254	0.0245	0.0026	0.000225	0.2713	0.0698	0.0406
0.005	1.340	0.0249	0.0240	0.0026	0.000225	0.2862	0.0705	0.0465
0.005	1.310	0.0257	0.0248	0.0026	0.000225	0.2586	0.0695	0.0358
0.005	1.200	0.0252	0.0242	0.0026	0.000225	0.2315	0.0703	0.0260
0.005	1.300	0.0256	0.0246	0.0026	0.000225	0.2571	0.0696	0.0351
0.005	1.150	0.0254	0.0243	0.0026	0.000225	0.2132	0.0700	0.0205
0.005	1.200	0.0258	0.0247	0.0026	0.000225	0.2231	0.0695	0.0236
0.004	1.040	0.0249	0.0238	0.0027	0.000225	0.1884	0.0708	0.0138
0.004	1.100	0.0247	0.0237	0.0027	0.000225	0.2073	0.0709	0.0186
0.004	1.140	0.0253	0.0242	0.0027	0.000225	0.2120	0.0702	0.0201
0.004	1.000	0.0249	0.0237	0.0027	0.000225	0.1780	0.0709	0.0115
0.004	1.090	0.0247	0.0236	0.0027	0.000225	0.2050	0.0710	0.0180
0.004	1.000	0.0249	0.0237	0.0027	0.000225	0.1780	0.0709	0.0115
0.004	1.150	0.0250	0.0239	0.0027	0.000225	0.2191	0.0706	0.0221
0.002	0.780	0.0186	0.0177	0.0027	0.000225	0.1898	0.0816	0.0117
0.002	0.800	0.0189	0.0180	0.0027	0.000225	0.1926	0.0810	0.0125
0.002	0.860	0.0187	0.0179	0.0027	0.000225	0.2180	0.0812	0.0187
0.002	0.700	0.0196	0.0185	0.0027	0.000225	0.1517	0.0798	0.0052
0.002	0.760	0.0192	0.0183	0.0027	0.000225	0.1742	0.0804	0.0088
0.002	0.600	0.0198	0.0186	0.0027	0.000225	0.1230	0.0797	0.0019
0.002	0.700	0.0193	0.0183	0.0027	0.000225	0.1547	0.0804	0.0055
0.006	1.300	0.0299	0.0286	0.0027	0.000225	0.1999	0.0650	0.0182
0.006	1.300	0.0298	0.0285	0.0027	0.000225	0.2007	0.0651	0.0184
0.006	1.350	0.0296	0.0283	0.0027	0.000225	0.2161	0.0653	0.0227
0.006	1.150	0.0306	0.0291	0.0027	0.000225	0.1621	0.0646	0.0095
0.006	1.450	0.0292	0.0281	0.0027	0.000225	0.2471	0.0655	0.0330
0.006	1.350	0.0296	0.0283	0.0027	0.000225	0.2161	0.0653	0.0227
0.006	1.300	0.0299	0.0286	0.0027	0.000225	0.1999	0.0650	0.0182
0.005	1.110	0.0265	0.0253	0.0028	0.000225	0.1894	0.0688	0.0146
0.005	1.170	0.0263	0.0252	0.0028	0.000225	0.2070	0.0689	0.0191
0.005	1.200	0.0263	0.0252	0.0028	0.000225	0.2153	0.0689	0.0214
0.005	1.120	0.0270	0.0257	0.0028	0.000225	0.1869	0.0682	0.0141
0.005	1.250	0.0266	0.0256	0.0028	0.000225	0.2256	0.0685	0.0247
0.005	1.200	0.0266	0.0255	0.0028	0.000225	0.2121	0.0686	0.0206
0.005	1.200	0.0262	0.0251	0.0028	0.000225	0.2174	0.0691	0.0220
0.003	0.920	0.0223	0.0213	0.0029	0.000225	0.1853	0.0747	0.0122
0.003	0.930	0.0225	0.0214	0.0029	0.000225	0.1859	0.0744	0.0124
0.003	0.980	0.0227	0.0217	0.0029	0.000225	0.1986	0.0740	0.0155
0.003	0.900	0.0229	0.0218	0.0029	0.000225	0.1727	0.0738	0.0098
0.003	0.860	0.0226	0.0214	0.0029	0.000225	0.1654	0.0744	0.0083
0.003	0.750	0.0233	0.0220	0.0029	0.000225	0.1324	0.0735	0.0035
0.003	0.950	0.0225	0.0215	0.0029	0.000225	0.1912	0.0742	0.0137
							Total	0.0189
							Std. Err	0.0140

TABLE.A-6.12 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f3 Study

$$\frac{1}{\sqrt{f}} = 8.648 - 1.70 \ln\left(\frac{B}{D}\right)$$

f by Limerinos

$$\frac{1}{\sqrt{f}} = 1.16 - 2.03 \log\left(\frac{R}{d84}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	D84 m	f Study	f Limerinos d84	Standart Error Estimate
0.003	0.950	0.0221	0.0211	0.0020	0.00029	0.1967	0.1456	0.0026
0.003	0.940	0.0229	0.0218	0.0020	0.00029	0.1841	0.1425	0.0017
0.003	1.080	0.0220	0.0212	0.0020	0.00029	0.2423	0.1454	0.0094
0.003	0.900	0.0228	0.0217	0.0020	0.00029	0.1739	0.1431	0.0010
0.003	1.000	0.0226	0.0216	0.0020	0.00029	0.2056	0.1434	0.0039
0.003	0.850	0.0228	0.0216	0.0020	0.00029	0.1605	0.1433	0.0003
0.003	1.000	0.0224	0.0215	0.0020	0.00029	0.2079	0.1440	0.0041
0.005	1.160	0.0273	0.0261	0.0023	0.00029	0.1931	0.1269	0.0044
0.005	1.270	0.0269	0.0258	0.0023	0.00029	0.2274	0.1277	0.0099
0.005	1.260	0.0273	0.0262	0.0023	0.00029	0.2196	0.1267	0.0086
0.005	1.150	0.0262	0.0250	0.0023	0.00029	0.2034	0.1303	0.0053
0.005	1.550	0.0261	0.0252	0.0023	0.00029	0.3449	0.1297	0.0463
0.005	1.300	0.0274	0.0263	0.0023	0.00029	0.2299	0.1264	0.0107
0.005	1.240	0.0265	0.0254	0.0023	0.00029	0.2241	0.1290	0.0091
0.006	1.300	0.0300	0.0287	0.0023	0.00029	0.1992	0.1197	0.0063
0.006	1.300	0.0298	0.0285	0.0023	0.00029	0.2015	0.1203	0.0066
0.006	1.350	0.0296	0.0283	0.0023	0.00029	0.2161	0.1207	0.0091
0.006	1.150	0.0293	0.0279	0.0023	0.00029	0.1723	0.1218	0.0025
0.006	1.550	0.0288	0.0277	0.0023	0.00029	0.2857	0.1222	0.0267
0.006	1.450	0.0289	0.0278	0.0023	0.00029	0.2521	0.1221	0.0169
0.006	1.300	0.0297	0.0284	0.0023	0.00029	0.2023	0.1204	0.0067
0.004	1.040	0.0256	0.0244	0.0024	0.00029	0.1807	0.1324	0.0023
0.004	1.050	0.0261	0.0249	0.0024	0.00029	0.1785	0.1309	0.0023
0.004	1.150	0.0259	0.0248	0.0024	0.00029	0.2066	0.1311	0.0057
0.004	1.020	0.0259	0.0246	0.0024	0.00029	0.1733	0.1316	0.0017
0.004	1.150	0.0262	0.0250	0.0024	0.00029	0.2034	0.1303	0.0053
0.004	1.000	0.0265	0.0252	0.0024	0.00029	0.1631	0.1299	0.0011
0.004	1.280	0.0254	0.0244	0.0024	0.00029	0.2542	0.1324	0.0148
0.002	0.850	0.0184	0.0176	0.0025	0.00029	0.2198	0.1650	0.0030
0.002	0.800	0.0186	0.0178	0.0025	0.00029	0.1965	0.1640	0.0011
0.002	0.920	0.0185	0.0178	0.0025	0.00029	0.2488	0.1642	0.0072
0.002	0.800	0.0191	0.0183	0.0025	0.00029	0.1889	0.1611	0.0008
0.002	0.850	0.0186	0.0178	0.0025	0.00029	0.2165	0.1639	0.0028
0.002	0.600	0.0198	0.0186	0.0025	0.00029	0.1230	0.1589	0.0013
0.002	0.700	0.0187	0.0178	0.0025	0.00029	0.1612	0.1642	0.0000
0.002	0.840	0.0183	0.0176	0.0025	0.00029	0.2171	0.1655	0.0027
0.002	0.850	0.0181	0.0174	0.0025	0.00029	0.2255	0.1668	0.0034
0.002	0.930	0.0184	0.0177	0.0025	0.00029	0.2556	0.1647	0.0083
0.002	0.850	0.0189	0.0181	0.0025	0.00029	0.2102	0.1618	0.0023
0.002	0.800	0.0185	0.0177	0.0025	0.00029	0.1985	0.1647	0.0011
0.002	0.750	0.0185	0.0177	0.0025	0.00029	0.1800	0.1649	0.0002
0.002	0.700	0.0192	0.0182	0.0025	0.00029	0.1552	0.1611	0.0000
0.004	1.040	0.0254	0.0242	0.0025	0.00029	0.1832	0.1331	0.0025
0.004	1.100	0.0252	0.0241	0.0025	0.00029	0.2016	0.1336	0.0046
0.004	1.100	0.0252	0.0241	0.0025	0.00029	0.2016	0.1336	0.0046
0.004	1.070	0.0251	0.0240	0.0025	0.00029	0.1938	0.1338	0.0036

0.004	1.110	0.0252	0.0241	0.0025	0.00029	0.2039	0.1334	0.0050
0.004	1.000	0.0243	0.0232	0.0025	0.00029	0.1844	0.1369	0.0023
0.004	1.180	0.0251	0.0241	0.0025	0.00029	0.2265	0.1336	0.0086
0.003	0.750	0.0229	0.0216	0.0025	0.00029	0.1352	0.1434	0.0001
0.006	1.390	0.0284	0.0273	0.0025	0.00029	0.2415	0.1234	0.0139
0.006	1.390	0.0286	0.0274	0.0025	0.00029	0.2395	0.1230	0.0136
0.006	1.400	0.0281	0.0271	0.0025	0.00029	0.2485	0.1241	0.0155
0.006	1.220	0.0292	0.0278	0.0025	0.00029	0.1888	0.1219	0.0045
0.006	1.400	0.0291	0.0279	0.0025	0.00029	0.2353	0.1217	0.0129
0.006	1.300	0.0290	0.0278	0.0025	0.00029	0.2098	0.1221	0.0077
0.006	1.250	0.0293	0.0280	0.0025	0.00029	0.1947	0.1216	0.0054
0.005	1.330	0.0254	0.0245	0.0026	0.00029	0.2713	0.1322	0.0193
0.005	1.340	0.0249	0.0240	0.0026	0.00029	0.2862	0.1340	0.0232
0.005	1.310	0.0257	0.0248	0.0026	0.00029	0.2586	0.1312	0.0162
0.005	1.200	0.0252	0.0242	0.0026	0.00029	0.2315	0.1333	0.0096
0.005	1.300	0.0256	0.0246	0.0026	0.00029	0.2571	0.1316	0.0157
0.005	1.150	0.0254	0.0243	0.0026	0.00029	0.2132	0.1327	0.0065
0.005	1.200	0.0258	0.0247	0.0026	0.00029	0.2231	0.1314	0.0084
0.004	1.040	0.0249	0.0238	0.0027	0.00029	0.1884	0.1347	0.0029
0.004	1.100	0.0247	0.0237	0.0027	0.00029	0.2073	0.1351	0.0052
0.004	1.140	0.0253	0.0242	0.0027	0.00029	0.2120	0.1332	0.0062
0.004	1.000	0.0249	0.0237	0.0027	0.00029	0.1780	0.1349	0.0019
0.004	1.090	0.0247	0.0236	0.0027	0.00029	0.2050	0.1353	0.0049
0.004	1.000	0.0249	0.0237	0.0027	0.00029	0.1780	0.1349	0.0019
0.004	1.150	0.0250	0.0239	0.0027	0.00029	0.2191	0.1342	0.0072
0.002	0.780	0.0186	0.0177	0.0027	0.00029	0.1898	0.1643	0.0006
0.002	0.800	0.0189	0.0180	0.0027	0.00029	0.1926	0.1625	0.0009
0.002	0.860	0.0187	0.0179	0.0027	0.00029	0.2180	0.1630	0.0030
0.002	0.700	0.0196	0.0185	0.0027	0.00029	0.1517	0.1593	0.0001
0.002	0.760	0.0192	0.0183	0.0027	0.00029	0.1742	0.1608	0.0002
0.002	0.600	0.0198	0.0186	0.0027	0.00029	0.1230	0.1589	0.0013
0.002	0.700	0.0193	0.0183	0.0027	0.00029	0.1547	0.1609	0.0000
0.006	1.300	0.0299	0.0286	0.0027	0.00029	0.1999	0.1199	0.0064
0.006	1.300	0.0298	0.0285	0.0027	0.00029	0.2007	0.1201	0.0065
0.006	1.350	0.0296	0.0283	0.0027	0.00029	0.2161	0.1207	0.0091
0.006	1.150	0.0306	0.0291	0.0027	0.00029	0.1621	0.1188	0.0019
0.006	1.450	0.0292	0.0281	0.0027	0.00029	0.2471	0.1212	0.0159
0.006	1.350	0.0296	0.0283	0.0027	0.00029	0.2161	0.1207	0.0091
0.006	1.300	0.0299	0.0286	0.0027	0.00029	0.1999	0.1199	0.0064
0.005	1.110	0.0265	0.0253	0.0028	0.00029	0.1894	0.1295	0.0036
0.005	1.170	0.0263	0.0252	0.0028	0.00029	0.2070	0.1298	0.0060
0.005	1.200	0.0263	0.0252	0.0028	0.00029	0.2153	0.1297	0.0073
0.005	1.120	0.0270	0.0257	0.0028	0.00029	0.1869	0.1281	0.0035
0.005	1.250	0.0266	0.0256	0.0028	0.00029	0.2256	0.1286	0.0094
0.005	1.200	0.0266	0.0255	0.0028	0.00029	0.2121	0.1289	0.0069
0.005	1.200	0.0262	0.0251	0.0028	0.00029	0.2174	0.1302	0.0076
0.003	0.920	0.0223	0.0213	0.0029	0.00029	0.1853	0.1450	0.0016
0.003	0.930	0.0225	0.0214	0.0029	0.00029	0.1859	0.1442	0.0017
0.003	0.980	0.0227	0.0217	0.0029	0.00029	0.1986	0.1432	0.0031
0.003	0.900	0.0229	0.0218	0.0029	0.00029	0.1727	0.1427	0.0009
0.003	0.860	0.0226	0.0214	0.0029	0.00029	0.1654	0.1442	0.0005
0.003	0.750	0.0233	0.0220	0.0029	0.00029	0.1324	0.1419	0.0001
0.003	0.950	0.0225	0.0215	0.0029	0.00029	0.1912	0.1439	0.0022
							Total	0.0062
							Std. Err	0.0080

TABLE.A-6.13 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f4 Study

$$\frac{1}{\sqrt{f}} = 7.99 - 0.467\ln.\left(\frac{B}{D}\right)$$

f by Leopold,Wolman and Miller

$$\frac{1}{\sqrt{f}} = 1.00 - 2.03\log\left(\frac{D}{d84}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	D84 m	f Study	f Leopold et,al	Standart Error Estimate
3730	2496	2.493	2.488	7.3E-05	0.00029	0.0441	0.0205	0.0006
3730	1249	3.808	3.784	7.3E-05	0.00029	0.0358	0.0185	0.0003
3730	1209	3.867	3.843	7.3E-05	0.00029	0.0355	0.0184	0.0003
3730	2032	2.814	2.806	7.3E-05	0.00029	0.0414	0.0199	0.0005
3730	1208	3.895	3.870	7.3E-05	0.00029	0.0355	0.0184	0.0003
3730	925	4.625	4.579	7.3E-05	0.00029	0.0329	0.0176	0.0002
3730	2840	2.305	2.301	7.3E-05	0.00029	0.0459	0.0209	0.0006
5980	3293	2.812	2.807	8.5E-05	0.00029	0.0455	0.0199	0.0007
5980	1939	3.870	3.855	8.5E-05	0.00029	0.0386	0.0184	0.0004
5980	2459	3.255	3.246	8.5E-05	0.00029	0.0417	0.0192	0.0005
5980	3350	2.762	2.758	8.5E-05	0.00029	0.0458	0.0200	0.0007
5980	2217	3.434	3.423	8.5E-05	0.00029	0.0405	0.0189	0.0005
5980	1704	4.073	4.054	8.5E-05	0.00029	0.0374	0.0182	0.0004
5980	4812	2.227	2.225	8.5E-05	0.00029	0.0516	0.0211	0.0009
8120	3178	3.464	3.456	8.8E-05	0.00029	0.0433	0.0189	0.0006
8120	2456	3.981	3.968	8.8E-05	0.00029	0.0402	0.0183	0.0005
8120	3366	3.288	3.281	8.8E-05	0.00029	0.0443	0.0191	0.0006
8120	3858	3.116	3.111	8.8E-05	0.00029	0.0460	0.0194	0.0007
8120	2943	3.569	3.560	8.8E-05	0.00029	0.0424	0.0188	0.0006
8120	2800	3.637	3.628	8.8E-05	0.00029	0.0419	0.0187	0.0005
8120	5056	2.624	2.621	8.8E-05	0.00029	0.0503	0.0202	0.0009
9930	4248	3.300	3.295	9.1E-05	0.00029	0.0463	0.0191	0.0007
9930	2647	4.276	4.262	9.1E-05	0.00029	0.0402	0.0180	0.0005
9930	3499	3.665	3.657	9.1E-05	0.00029	0.0437	0.0186	0.0006
9930	4594	3.174	3.169	9.1E-05	0.00029	0.0474	0.0193	0.0008
9930	3160	3.879	3.870	9.1E-05	0.00029	0.0423	0.0184	0.0006
9930	3423	3.710	3.702	9.1E-05	0.00029	0.0434	0.0186	0.0006
9930	5326	2.869	2.866	9.1E-05	0.00029	0.0499	0.0198	0.0009
11600	4598	3.077	3.455	9.5E-05	0.00029	0.0477	0.0194	0.0008
11600	2947	4.406	4.393	9.5E-05	0.00029	0.0408	0.0178	0.0005
11600	3675	3.896	3.888	9.5E-05	0.00029	0.0436	0.0184	0.0006
11600	5058	3.278	3.273	9.5E-05	0.00029	0.0481	0.0191	0.0008
11600	3433	4.071	4.061	9.5E-05	0.00029	0.0426	0.0182	0.0006
11600	4012	3.723	3.717	9.5E-05	0.00029	0.0447	0.0186	0.0007
11600	5170	3.235	3.231	9.5E-05	0.00029	0.0484	0.0192	0.0009
13800	4748	3.806	3.800	9.7E-05	0.00029	0.0460	0.0185	0.0008
13800	2822	5.052	5.034	9.7E-05	0.00029	0.0394	0.0173	0.0005
13800	3645	4.351	4.341	9.7E-05	0.00029	0.0426	0.0179	0.0006
13800	6655	3.141	3.139	9.7E-05	0.00029	0.0513	0.0193	0.0010
13800	3927	4.191	4.182	9.7E-05	0.00029	0.0435	0.0180	0.0006
13800	4118	4.094	4.085	9.7E-05	0.00029	0.0441	0.0181	0.0007
13800	5235	3.599	3.594	9.7E-05	0.00029	0.0475	0.0187	0.0008
							Total	0.0259
							Std. Error	0.0255

TABLE.A-6.14 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f4 Study

$$\frac{1}{\sqrt{f}} = 7.99 - 0.467 \ln.\left(\frac{B}{D}\right)$$

f by Limerinos

$$\frac{1}{\sqrt{f}} = 0.35 - 2.03 \log\left(\frac{R}{d50}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	D50 m	f calc.	f Limerinos D50	Standart Error Estimate
3730	2496	2.493	2.488	7.3E-05	0.00021	0.0441	0.0159	0.0008
3730	1249	3.808	3.784	7.3E-05	0.00021	0.0358	0.0146	0.0005
3730	1209	3.867	3.843	7.3E-05	0.00021	0.0355	0.0145	0.0004
3730	2032	2.814	2.806	7.3E-05	0.00021	0.0414	0.0155	0.0007
3730	1208	3.895	3.870	7.3E-05	0.00021	0.0355	0.0145	0.0004
3730	925	4.625	4.579	7.3E-05	0.00021	0.0329	0.0140	0.0004
3730	2840	2.305	2.301	7.3E-05	0.00021	0.0459	0.0162	0.0009
5980	3293	2.812	2.807	8.5E-05	0.00021	0.0455	0.0155	0.0009
5980	1939	3.870	3.855	8.5E-05	0.00021	0.0386	0.0145	0.0006
5980	2459	3.255	3.246	8.5E-05	0.00021	0.0417	0.0150	0.0007
5980	3350	2.762	2.758	8.5E-05	0.00021	0.0458	0.0156	0.0009
5980	2217	3.434	3.423	8.5E-05	0.00021	0.0405	0.0149	0.0007
5980	1704	4.073	4.054	8.5E-05	0.00021	0.0374	0.0143	0.0005
5980	4812	2.227	2.225	8.5E-05	0.00021	0.0516	0.0163	0.0012
8120	3178	3.464	3.456	8.8E-05	0.00021	0.0433	0.0148	0.0008
8120	2456	3.981	3.968	8.8E-05	0.00021	0.0402	0.0144	0.0007
8120	3366	3.288	3.281	8.8E-05	0.00021	0.0443	0.0150	0.0009
8120	3858	3.116	3.111	8.8E-05	0.00021	0.0460	0.0152	0.0009
8120	2943	3.569	3.560	8.8E-05	0.00021	0.0424	0.0147	0.0008
8120	2800	3.637	3.628	8.8E-05	0.00021	0.0419	0.0147	0.0007
8120	5056	2.624	2.621	8.8E-05	0.00021	0.0503	0.0158	0.0012
9930	4248	3.300	3.295	9.1E-05	0.00021	0.0463	0.0150	0.0010
9930	2647	4.276	4.262	9.1E-05	0.00021	0.0402	0.0142	0.0007
9930	3499	3.665	3.657	9.1E-05	0.00021	0.0437	0.0147	0.0008
9930	4594	3.174	3.169	9.1E-05	0.00021	0.0474	0.0151	0.0010
9930	3160	3.879	3.870	9.1E-05	0.00021	0.0423	0.0145	0.0008
9930	3423	3.710	3.702	9.1E-05	0.00021	0.0434	0.0146	0.0008
9930	5326	2.869	2.866	9.1E-05	0.00021	0.0499	0.0155	0.0012
11600	4598	3.077	3.455	9.5E-05	0.00021	0.0477	0.0148	0.0011
11600	2947	4.406	4.393	9.5E-05	0.00021	0.0408	0.0141	0.0007
11600	3675	3.896	3.888	9.5E-05	0.00021	0.0436	0.0145	0.0008
11600	5058	3.278	3.273	9.5E-05	0.00021	0.0481	0.0150	0.0011
11600	3433	4.071	4.061	9.5E-05	0.00021	0.0426	0.0143	0.0008
11600	4012	3.723	3.717	9.5E-05	0.00021	0.0447	0.0146	0.0009
11600	5170	3.235	3.231	9.5E-05	0.00021	0.0484	0.0151	0.0011
13800	4748	3.806	3.800	9.7E-05	0.00021	0.0460	0.0145	0.0010
13800	2822	5.052	5.034	9.7E-05	0.00021	0.0394	0.0137	0.0007
13800	3645	4.351	4.341	9.7E-05	0.00021	0.0426	0.0141	0.0008
13800	6655	3.141	3.139	9.7E-05	0.00021	0.0513	0.0152	0.0013
13800	3927	4.191	4.182	9.7E-05	0.00021	0.0435	0.0142	0.0009
13800	4118	4.094	4.085	9.7E-05	0.00021	0.0441	0.0143	0.0009
13800	5235	3.599	3.594	9.7E-05	0.00021	0.0475	0.0147	0.0011
							Total	0.0350
							Std. Error	0.0296

TABLE.A-6.15 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f4 Study

$$\frac{1}{\sqrt{f}} = 7.99 - 0.467 \ln.\left(\frac{B}{D}\right)$$

f by Limerinos

$$\frac{1}{\sqrt{f}} = 1.16 - 2.03 \log\left(\frac{R}{d84}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	d84 m	f calc.	f Limerinos d84	Standart Error Estimate
3730	2496	2.493	2.488	7.3E-05	0.00029	0.0441	0.0215	0.0005
3730	1249	3.808	3.784	7.3E-05	0.00029	0.0358	0.0193	0.0003
3730	1209	3.867	3.843	7.3E-05	0.00029	0.0355	0.0192	0.0003
3730	2032	2.814	2.806	7.3E-05	0.00029	0.0414	0.0208	0.0004
3730	1208	3.895	3.870	7.3E-05	0.00029	0.0355	0.0192	0.0003
3730	925	4.625	4.579	7.3E-05	0.00029	0.0329	0.0184	0.0002
3730	2840	2.305	2.301	7.3E-05	0.00029	0.0459	0.0219	0.0006
5980	3293	2.812	2.807	8.5E-05	0.00029	0.0455	0.0208	0.0006
5980	1939	3.870	3.855	8.5E-05	0.00029	0.0386	0.0192	0.0004
5980	2459	3.255	3.246	8.5E-05	0.00029	0.0417	0.0201	0.0005
5980	3350	2.762	2.758	8.5E-05	0.00029	0.0458	0.0209	0.0006
5980	2217	3.434	3.423	8.5E-05	0.00029	0.0405	0.0198	0.0004
5980	1704	4.073	4.054	8.5E-05	0.00029	0.0374	0.0190	0.0003
5980	4812	2.227	2.225	8.5E-05	0.00029	0.0516	0.0221	0.0009
8120	3178	3.464	3.456	8.8E-05	0.00029	0.0433	0.0198	0.0006
8120	2456	3.981	3.968	8.8E-05	0.00029	0.0402	0.0191	0.0004
8120	3366	3.288	3.281	8.8E-05	0.00029	0.0443	0.0200	0.0006
8120	3858	3.116	3.111	8.8E-05	0.00029	0.0460	0.0203	0.0007
8120	2943	3.569	3.560	8.8E-05	0.00029	0.0424	0.0196	0.0005
8120	2800	3.637	3.628	8.8E-05	0.00029	0.0419	0.0195	0.0005
8120	5056	2.624	2.621	8.8E-05	0.00029	0.0503	0.0212	0.0008
9930	4248	3.300	3.295	9.1E-05	0.00029	0.0463	0.0200	0.0007
9930	2647	4.276	4.262	9.1E-05	0.00029	0.0402	0.0188	0.0005
9930	3499	3.665	3.657	9.1E-05	0.00029	0.0437	0.0195	0.0006
9930	4594	3.174	3.169	9.1E-05	0.00029	0.0474	0.0202	0.0007
9930	3160	3.879	3.870	9.1E-05	0.00029	0.0423	0.0192	0.0005
9930	3423	3.710	3.702	9.1E-05	0.00029	0.0434	0.0194	0.0006
9930	5326	2.869	2.866	9.1E-05	0.00029	0.0499	0.0207	0.0009
11600	4598	3.077	3.455	9.5E-05	0.00029	0.0477	0.0198	0.0008
11600	2947	4.406	4.393	9.5E-05	0.00029	0.0408	0.0186	0.0005
11600	3675	3.896	3.888	9.5E-05	0.00029	0.0436	0.0192	0.0006
11600	5058	3.278	3.273	9.5E-05	0.00029	0.0481	0.0200	0.0008
11600	3433	4.071	4.061	9.5E-05	0.00029	0.0426	0.0190	0.0006
11600	4012	3.723	3.717	9.5E-05	0.00029	0.0447	0.0194	0.0006
11600	5170	3.235	3.231	9.5E-05	0.00029	0.0484	0.0201	0.0008
13800	4748	3.806	3.800	9.7E-05	0.00029	0.0460	0.0193	0.0007
13800	2822	5.052	5.034	9.7E-05	0.00029	0.0394	0.0180	0.0005
13800	3645	4.351	4.341	9.7E-05	0.00029	0.0426	0.0187	0.0006
13800	6655	3.141	3.139	9.7E-05	0.00029	0.0513	0.0202	0.0010
13800	3927	4.191	4.182	9.7E-05	0.00029	0.0435	0.0189	0.0006
13800	4118	4.094	4.085	9.7E-05	0.00029	0.0441	0.0190	0.0006
13800	5235	3.599	3.594	9.7E-05	0.00029	0.0475	0.0196	0.0008
							Total	0.0242
							Std. Error	0.0246

TABLE.A-6.17 TEST OF DIFFERENT EQUATIONS OF FRICTION FACTOR

f4 Study

$$\frac{1}{\sqrt{f}} = 7.99 - 0.467\ln.\left(\frac{B}{D}\right)$$

f by White and Collebrock

$$\frac{1}{\sqrt{f}} = 1.14 - 2.0\log\left(\frac{ks}{4R} + \frac{21.25}{\mathrm{Re}^{0.9}}\right)$$

Disch. Qw m3/s	Velo city m/s	R m	Slope S	D84 m	Reynolds number Re	f calc.	f White - Collebrock	Standart Error Estimate
3730	0.599	2.488	7.3E-05	0.00029	1491412	0.0441	0.0117	0.0010
3730	0.784	3.784	7.3E-05	0.00029	2968292	0.0358	0.0106	0.0006
3730	0.798	3.843	7.3E-05	0.00029	3065582	0.0355	0.0105	0.0006
3730	0.652	2.806	7.3E-05	0.00029	1830560	0.0414	0.0113	0.0009
3730	0.793	3.870	7.3E-05	0.00029	3067965	0.0355	0.0105	0.0006
3730	0.872	4.579	7.3E-05	0.00029	3992509	0.0329	0.0101	0.0005
3730	0.570	2.301	7.3E-05	0.00029	1311252	0.0459	0.0119	0.0012
5980	0.646	2.807	8.5E-05	0.00029	1812877	0.0455	0.0114	0.0012
5980	0.797	3.855	8.5E-05	0.00029	3071802	0.0386	0.0105	0.0008
5980	0.747	3.246	8.5E-05	0.00029	2425463	0.0417	0.0109	0.0010
5980	0.646	2.758	8.5E-05	0.00029	1782136	0.0458	0.0114	0.0012
5980	0.786	3.423	8.5E-05	0.00029	2689009	0.0405	0.0107	0.0009
5980	0.862	4.054	8.5E-05	0.00029	3492693	0.0374	0.0104	0.0007
5980	0.558	2.225	8.5E-05	0.00029	1241577	0.0516	0.0120	0.0016
8120	0.738	3.456	8.8E-05	0.00029	2549509	0.0433	0.0108	0.0011
8120	0.831	3.968	8.8E-05	0.00029	3295506	0.0402	0.0104	0.0009
8120	0.734	3.281	8.8E-05	0.00029	2407656	0.0443	0.0109	0.0011
8120	0.676	3.111	8.8E-05	0.00029	2101323	0.0460	0.0111	0.0012
8120	0.773	3.560	8.8E-05	0.00029	2752414	0.0424	0.0107	0.0010
8120	0.797	3.628	8.8E-05	0.00029	2892485	0.0419	0.0106	0.0010
8120	0.612	2.621	8.8E-05	0.00029	1604348	0.0503	0.0116	0.0015
9930	0.708	3.295	9.1E-05	0.00029	2333945	0.0463	0.0109	0.0013
9930	0.877	4.262	9.1E-05	0.00029	3739336	0.0402	0.0103	0.0009
9930	0.774	3.657	9.1E-05	0.00029	2832022	0.0437	0.0106	0.0011
9930	0.681	3.169	9.1E-05	0.00029	2158533	0.0474	0.0111	0.0013
9930	0.810	3.870	9.1E-05	0.00029	3134708	0.0423	0.0105	0.0010
9930	0.782	3.702	9.1E-05	0.00029	2894690	0.0434	0.0106	0.0011
9930	0.650	2.866	9.1E-05	0.00029	1862432	0.0499	0.0113	0.0015
11600	0.694	3.455	9.5E-05	0.00029	2396088	0.0477	0.0109	0.0014
11600	0.893	4.393	9.5E-05	0.00029	3924471	0.0408	0.0102	0.0009
11600	0.810	3.888	9.5E-05	0.00029	3149784	0.0436	0.0105	0.0011
11600	0.700	3.273	9.5E-05	0.00029	2290428	0.0481	0.0110	0.0014
11600	0.830	4.061	9.5E-05	0.00029	3370974	0.0426	0.0104	0.0010
11600	0.777	3.717	9.5E-05	0.00029	2885969	0.0447	0.0106	0.0012
11600	0.694	3.231	9.5E-05	0.00029	2240909	0.0484	0.0110	0.0014
13800	0.764	3.800	9.7E-05	0.00029	2901835	0.0460	0.0106	0.0013
13800	0.968	5.034	9.7E-05	0.00029	4872702	0.0394	0.0099	0.0009
13800	0.870	4.341	9.7E-05	0.00029	3776991	0.0426	0.0102	0.0010
13800	0.660	3.139	9.7E-05	0.00029	2071673	0.0513	0.0111	0.0016
13800	0.839	4.182	9.7E-05	0.00029	3506649	0.0435	0.0103	0.0011
13800	0.819	4.085	9.7E-05	0.00029	3344492	0.0441	0.0104	0.0011
13800	0.732	3.594	9.7E-05	0.00029	2632483	0.0475	0.0107	0.0014
							Total	0.0454
							Std. Error	0.0337

TABLE . A-6.17 TEST OF EQUATIONS USED FIELD DATA

f1 study from field **f2 study from experimental**

$$\frac{1}{\sqrt{f}} = 1.113 \ln . \left(\frac{R}{d50} \right) - 5.92$$

$$\frac{1}{\sqrt{f}} = -0.582 \ln . \left(\frac{R}{d50} \right) + 4.80$$

Disch. Qw m3/s	Depth m2	R m	Slope S	D84 m	f study field	f study exp.	Standart Error Estimate
3730	2.493	2.488	7.3E-05	0.00021	0.049	2.3016	5.0744
3730	3.808	3.784	7.3E-05	0.00021	0.040	1.2258	1.4057
3730	3.867	3.843	7.3E-05	0.00021	0.040	1.2021	1.3505
3730	2.814	2.806	7.3E-05	0.00021	0.046	1.8811	3.3669
3730	3.895	3.870	7.3E-05	0.00021	0.040	1.1913	1.3259
3730	4.625	4.579	7.3E-05	0.00021	0.037	0.9724	0.8749
3730	2.305	2.301	7.3E-05	0.00021	0.051	2.6562	6.7875
5980	2.812	2.807	8.5E-05	0.00021	0.046	1.8800	3.3627
5980	3.870	3.855	8.5E-05	0.00021	0.040	1.1973	1.3396
5980	3.255	3.246	8.5E-05	0.00021	0.043	1.5097	2.1508
5980	2.762	2.758	8.5E-05	0.00021	0.047	1.9346	3.5646
5980	3.434	3.423	8.5E-05	0.00021	0.042	1.4012	1.8471
5980	4.073	4.054	8.5E-05	0.00021	0.039	1.1241	1.1775
5980	2.227	2.225	8.5E-05	0.00021	0.052	2.8332	7.7360
8120	3.464	3.456	8.8E-05	0.00021	0.042	1.3829	1.7982
8120	3.981	3.968	8.8E-05	0.00021	0.039	1.1543	1.2430
8120	3.288	3.281	8.8E-05	0.00021	0.043	1.4866	2.0842
8120	3.116	3.111	8.8E-05	0.00021	0.044	1.6060	2.4397
8120	3.569	3.560	8.8E-05	0.00021	0.041	1.3285	1.6567
8120	3.637	3.628	8.8E-05	0.00021	0.041	1.2954	1.5736
8120	2.624	2.621	8.8E-05	0.00021	0.048	2.1043	4.2294
9930	3.300	3.295	9.1E-05	0.00021	0.043	1.4781	2.0600
9930	4.276	4.262	9.1E-05	0.00021	0.038	1.0576	1.0392
9930	3.665	3.657	9.1E-05	0.00021	0.041	1.2818	1.5400
9930	3.174	3.169	9.1E-05	0.00021	0.044	1.5626	2.3073
9930	3.879	3.870	9.1E-05	0.00021	0.040	1.1913	1.3259
9930	3.710	3.702	9.1E-05	0.00021	0.041	1.2616	1.4908
9930	2.869	2.866	9.1E-05	0.00021	0.046	1.8196	3.1467
11600	3.077	3.455	9.5E-05	0.00021	0.042	1.3837	1.8002
11600	4.406	4.393	9.5E-05	0.00021	0.038	1.0203	0.9655
11600	3.896	3.888	9.5E-05	0.00021	0.040	1.1844	1.3102
11600	3.278	3.273	9.5E-05	0.00021	0.043	1.4917	2.0987
11600	4.071	4.061	9.5E-05	0.00021	0.039	1.1215	1.1718
11600	3.723	3.717	9.5E-05	0.00021	0.041	1.2550	1.4747
11600	3.235	3.231	9.5E-05	0.00021	0.043	1.5198	2.1802
13800	3.806	3.800	9.7E-05	0.00021	0.040	1.2194	1.3906
13800	5.052	5.034	9.7E-05	0.00021	0.036	0.8747	0.7041
13800	4.351	4.341	9.7E-05	0.00021	0.038	1.0348	0.9939
13800	3.141	3.139	9.7E-05	0.00021	0.044	1.5851	2.3755
13800	4.191	4.182	9.7E-05	0.00021	0.039	1.0822	1.0892
13800	4.094	4.085	9.7E-05	0.00021	0.039	1.1133	1.1544
13800	3.599	3.594	9.7E-05	0.00021	0.041	1.3115	1.6137
						Total	89.6216
						Std.error	1.5159

TABLE.A-6.18 TEST OF EQUATIONS USED AVAILABLE FIELD DATA

f3 Study from experimental data

$$\frac{1}{\sqrt{f}} = 8.648 - 1.70 \ln .\left(\frac{B}{D}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	D84 m	B/D	f Study
3730	2496	2.493	2.488	7.3E-05	0.00029	1001.12	0.104
3730	1249	3.808	3.784	7.3E-05	0.00029	328.03	0.036
3730	1209	3.867	3.843	7.3E-05	0.00029	312.62	0.036
3730	2032	2.814	2.806	7.3E-05	0.00029	722.15	0.041
3730	1208	3.895	3.870	7.3E-05	0.00029	310.15	0.035
3730	925	4.625	4.579	7.3E-05	0.00029	200.01	0.033
3730	2840	2.305	2.301	7.3E-05	0.00029	1232.33	0.046
5980	3293	2.812	2.807	8.5E-05	0.00029	1171.08	0.045
5980	1939	3.870	3.855	8.5E-05	0.00029	501.04	0.039
5980	2459	3.255	3.246	8.5E-05	0.00029	755.55	0.042
5980	3350	2.762	2.758	8.5E-05	0.00029	1212.85	0.046
5980	2217	3.434	3.423	8.5E-05	0.00029	645.65	0.041
5980	1704	4.073	4.054	8.5E-05	0.00029	418.38	0.037
5980	4812	2.227	2.225	8.5E-05	0.00029	2160.56	0.052
8120	3178	3.464	3.456	8.8E-05	0.00029	917.54	0.043
8120	2456	3.981	3.968	8.8E-05	0.00029	616.95	0.040
8120	3366	3.288	3.281	8.8E-05	0.00029	1023.82	0.044
8120	3858	3.116	3.111	8.8E-05	0.00029	1238.22	0.046
8120	2943	3.569	3.560	8.8E-05	0.00029	824.71	0.042
8120	2800	3.637	3.628	8.8E-05	0.00029	769.80	0.042
8120	5056	2.624	2.621	8.8E-05	0.00029	1927.17	0.050
9930	4248	3.300	3.295	9.1E-05	0.00029	1287.40	0.046
9930	2647	4.276	4.262	9.1E-05	0.00029	619.04	0.040
9930	3499	3.665	3.657	9.1E-05	0.00029	954.80	0.044
9930	4594	3.174	3.169	9.1E-05	0.00029	1447.49	0.047
9930	3160	3.879	3.870	9.1E-05	0.00029	814.55	0.042
9930	3423	3.710	3.702	9.1E-05	0.00029	922.76	0.043
9930	5326	2.869	2.866	9.1E-05	0.00029	1856.61	0.050
11600	4598	3.077	3.455	9.5E-05	0.00029	1494.54	0.048
11600	2947	4.406	4.393	9.5E-05	0.00029	668.81	0.041
11600	3675	3.896	3.888	9.5E-05	0.00029	943.29	0.044
11600	5058	3.278	3.273	9.5E-05	0.00029	1543.16	0.048
11600	3433	4.071	4.061	9.5E-05	0.00029	843.31	0.043
11600	4012	3.723	3.717	9.5E-05	0.00029	1077.49	0.045
11600	5170	3.235	3.231	9.5E-05	0.00029	1598.17	0.048
13800	4748	3.806	3.800	9.7E-05	0.00029	1247.48	0.046
13800	2822	5.052	5.034	9.7E-05	0.00029	558.59	0.039
13800	3645	4.351	4.341	9.7E-05	0.00029	837.69	0.043
13800	6655	3.141	3.139	9.7E-05	0.00029	2118.42	0.051
13800	3927	4.191	4.182	9.7E-05	0.00029	937.09	0.044
13800	4118	4.094	4.085	9.7E-05	0.00029	1005.96	0.044
13800	5235	3.599	3.594	9.7E-05	0.00029	1454.43	0.047

TABLE.A-6.19 TEST OF EQUATIONS USED AVAILABLE EXPERIMENTAL DATA

f4 Study from field data

$$\frac{1}{\sqrt{f}} = 7.99 - 0.467 \ln\left(\frac{B}{D}\right)$$

Disch. Qw m3/s	Width m	Depth m2	R m	Slope S	B/D	f Study
0.003	0.950	0.0221	0.0211	0.0020	0.00029	0.0257
0.003	0.940	0.0229	0.0218	0.0020	0.00029	0.0256
0.003	1.080	0.0220	0.0212	0.0020	0.00029	0.0262
0.003	0.900	0.0228	0.0217	0.0020	0.00029	0.0254
0.003	1.000	0.0226	0.0216	0.0020	0.00029	0.0258
0.003	0.850	0.0228	0.0216	0.0020	0.00029	0.0252
0.003	1.000	0.0224	0.0215	0.0020	0.00029	0.0259
0.005	1.160	0.0273	0.0261	0.0023	0.00029	0.0257
0.005	1.270	0.0269	0.0258	0.0023	0.00029	0.0261
0.005	1.260	0.0273	0.0262	0.0023	0.00029	0.0260
0.005	1.150	0.0262	0.0250	0.0023	0.00029	0.0258
0.005	1.550	0.0261	0.0252	0.0023	0.00029	0.0270
0.005	1.300	0.0274	0.0263	0.0023	0.00029	0.0261
0.005	1.240	0.0265	0.0254	0.0023	0.00029	0.0261
0.006	1.300	0.0300	0.0287	0.0023	0.00029	0.0258
0.006	1.300	0.0298	0.0285	0.0023	0.00029	0.0258
0.006	1.350	0.0296	0.0283	0.0023	0.00029	0.0260
0.006	1.150	0.0293	0.0279	0.0023	0.00029	0.0254
0.006	1.550	0.0288	0.0277	0.0023	0.00029	0.0266
0.006	1.450	0.0289	0.0278	0.0023	0.00029	0.0263
0.006	1.300	0.0297	0.0284	0.0023	0.00029	0.0258
0.004	1.040	0.0256	0.0244	0.0024	0.00029	0.0255
0.004	1.050	0.0261	0.0249	0.0024	0.00029	0.0255
0.004	1.150	0.0259	0.0248	0.0024	0.00029	0.0259
0.004	1.020	0.0259	0.0246	0.0024	0.00029	0.0254
0.004	1.150	0.0262	0.0250	0.0024	0.00029	0.0258
0.004	1.000	0.0265	0.0252	0.0024	0.00029	0.0252
0.004	1.280	0.0254	0.0244	0.0024	0.00029	0.0264
0.002	0.850	0.0184	0.0176	0.0025	0.00029	0.0260
0.002	0.800	0.0186	0.0178	0.0025	0.00029	0.0257
0.002	0.920	0.0185	0.0178	0.0025	0.00029	0.0263
0.002	0.800	0.0191	0.0183	0.0025	0.00029	0.0256
0.002	0.850	0.0186	0.0178	0.0025	0.00029	0.0260
0.002	0.600	0.0198	0.0186	0.0025	0.00029	0.0244
0.002	0.700	0.0187	0.0178	0.0025	0.00029	0.0252
0.002	0.840	0.0183	0.0176	0.0025	0.00029	0.0260
0.002	0.850	0.0181	0.0174	0.0025	0.00029	0.0261
0.002	0.930	0.0184	0.0177	0.0025	0.00029	0.0264
0.002	0.850	0.0189	0.0181	0.0025	0.00029	0.0259
0.002	0.800	0.0185	0.0177	0.0025	0.00029	0.0258
0.002	0.750	0.0185	0.0177	0.0025	0.00029	0.0255
0.002	0.700	0.0192	0.0182	0.0025	0.00029	0.0251
0.004	1.040	0.0254	0.0242	0.0025	0.00029	0.0256
0.004	1.100	0.0252	0.0241	0.0025	0.00029	0.0258
0.004	1.100	0.0252	0.0241	0.0025	0.00029	0.0258
0.004	1.070	0.0251	0.0240	0.0025	0.00029	0.0257

0.004	1.110	0.0252	0.0241	0.0025	0.00029	0.0258
0.004	1.000	0.0243	0.0232	0.0025	0.00029	0.0256
0.004	1.180	0.0251	0.0241	0.0025	0.00029	0.0261
0.003	0.750	0.0229	0.0216	0.0025	0.00029	0.0247
0.006	1.390	0.0284	0.0273	0.0025	0.00029	0.0262
0.006	1.390	0.0286	0.0274	0.0025	0.00029	0.0262
0.006	1.400	0.0281	0.0271	0.0025	0.00029	0.0263
0.006	1.220	0.0292	0.0278	0.0025	0.00029	0.0256
0.006	1.400	0.0291	0.0279	0.0025	0.00029	0.0262
0.006	1.300	0.0290	0.0278	0.0025	0.00029	0.0259
0.006	1.250	0.0293	0.0280	0.0025	0.00029	0.0257
0.005	1.330	0.0254	0.0245	0.0026	0.00029	0.0265
0.005	1.340	0.0249	0.0240	0.0026	0.00029	0.0266
0.005	1.310	0.0257	0.0248	0.0026	0.00029	0.0264
0.005	1.200	0.0252	0.0242	0.0026	0.00029	0.0261
0.005	1.300	0.0256	0.0246	0.0026	0.00029	0.0264
0.005	1.150	0.0254	0.0243	0.0026	0.00029	0.0259
0.005	1.200	0.0258	0.0247	0.0026	0.00029	0.0260
0.004	1.040	0.0249	0.0238	0.0027	0.00029	0.0256
0.004	1.100	0.0247	0.0237	0.0027	0.00029	0.0259
0.004	1.140	0.0253	0.0242	0.0027	0.00029	0.0259
0.004	1.000	0.0249	0.0237	0.0027	0.00029	0.0255
0.004	1.090	0.0247	0.0236	0.0027	0.00029	0.0258
0.004	1.000	0.0249	0.0237	0.0027	0.00029	0.0255
0.004	1.150	0.0250	0.0239	0.0027	0.00029	0.0260
0.002	0.780	0.0186	0.0177	0.0027	0.00029	0.0256
0.002	0.800	0.0189	0.0180	0.0027	0.00029	0.0257
0.002	0.860	0.0187	0.0179	0.0027	0.00029	0.0260
0.002	0.700	0.0196	0.0185	0.0027	0.00029	0.0250
0.002	0.760	0.0192	0.0183	0.0027	0.00029	0.0254
0.002	0.600	0.0198	0.0186	0.0027	0.00029	0.0244
0.002	0.700	0.0193	0.0183	0.0027	0.00029	0.0251
0.006	1.300	0.0299	0.0286	0.0027	0.00029	0.0258
0.006	1.300	0.0298	0.0285	0.0027	0.00029	0.0258
0.006	1.350	0.0296	0.0283	0.0027	0.00029	0.0260
0.006	1.150	0.0306	0.0291	0.0027	0.00029	0.0252
0.006	1.450	0.0292	0.0281	0.0027	0.00029	0.0263
0.006	1.350	0.0296	0.0283	0.0027	0.00029	0.0260
0.006	1.300	0.0299	0.0286	0.0027	0.00029	0.0258
0.005	1.110	0.0265	0.0253	0.0028	0.00029	0.0256
0.005	1.170	0.0263	0.0252	0.0028	0.00029	0.0259
0.005	1.200	0.0263	0.0252	0.0028	0.00029	0.0260
0.005	1.120	0.0270	0.0257	0.0028	0.00029	0.0256
0.005	1.250	0.0266	0.0256	0.0028	0.00029	0.0261
0.005	1.200	0.0266	0.0255	0.0028	0.00029	0.0259
0.005	1.200	0.0262	0.0251	0.0028	0.00029	0.0260
0.003	0.920	0.0223	0.0213	0.0029	0.00029	0.0256
0.003	0.930	0.0225	0.0214	0.0029	0.00029	0.0256
0.003	0.980	0.0227	0.0217	0.0029	0.00029	0.0258
0.003	0.900	0.0229	0.0218	0.0029	0.00029	0.0254
0.003	0.860	0.0226	0.0214	0.0029	0.00029	0.0253
0.003	0.750	0.0233	0.0220	0.0029	0.00029	0.0246
0.003	0.950	0.0225	0.0215	0.0029	0.00029	0.0257