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USE OF STEADY FLOW ONE-DIMENSIONAL MODEL IN UNSTEADY FLOW CONDITIONS

by

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BSc

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ABSTRACT

In this thesis, the use of a one-dimensional steady model in unsteady flow conditions in a river was studied.

To examine the applicability of a one-dimensional steady model in unsteady flow conditions (flood flow) in a river, besides the one-dimensional steady model (HEC-RAS), the one-dimensional unsteady model (ISIS) was employed.

The middle of the River Tame in Birmingham in the UK was selected as a study reach. The reach, about 29 km long, consists of 64 bridges and 275 cross-sections with an average cross-section spacing of 103 m. However, the reach was modified by omitting the bridges and increasing the bed roughness. These modifications produced 4 different cases that were analysed to find out the most suitable condition for the use of the steady model.

With regard to the following criteria; the transient effects of the bridges, the attenuation rate parameter and the extent of the unsteadiness of the flow, the selection of the steady model in the unsteady flow conditions was examined. In addition, for each case, a comparison between the water surface profiles obtained from the steady model and the unsteady model was made and the following conclusions were drawn. Firstly, in the absence of the bridges the use of the steady model in the unsteady flow conditions was found to be more suitable than when there were bridges. Secondly, the attenuation rate parameter was found to be a useful criterion on which to select the use of the steady or the unsteady model in the unsteady flow conditions. Finally, when the extent of the unsteadiness of the flow increased, the dissimilarities between the results obtained from the steady and the unsteady models also amplified. Therefore, it was discovered that the use of steady model depended on the degree of the unsteadiness of the flow.

NOMENCLATURE

Symbol	Description	Unit
A	The wetted-cross section area (flow area)	(m^2)
B	The water surface width	(m)
C	Chezy's coefficient	($m^{1/2}s^{-1}$)
c_d	Coefficient of discharge	-
c	The mean propagation speed of the flood peak	(ms^{-1})
c_c	Contraction or expansion loss coefficients	-
C_D	Drag coefficient	-
F	Froude number	-
F_f	Force due to external friction losses	N
g	Gravitational acceleration	(m^2s)
H	Head	(m)
h_e	Energy head loss	(m)
K	Conveyance	(m^3s^{-1})
K_y	Yarnell's pier shape coefficient	-
L	Cross-section reach length	(m)
n	Manning's roughness coefficient	-
Q	Discharge	(m^3s^{-1})
Q_P	The peak discharge of the flood hydrograph	(m^3s^{-1})
Q^-	The discharge before the peak discharge	(m^3s^{-1})
Q^+	The discharge after the peak discharge	(m^3s^{-1})
q	Lateral inflow	($m^3s^{-1}m^{-1}$)
P	Wetted perimeter	(m)
P_h	Hydrostatic pressure force	(kNm^{-2})
R	Hydraulic radius	(m)
S	The mean bed slope	-
S_f	Friction Slope	-

t	Time	(sec., hrs.)
V	Velocity	(ms^{-1})
V_e	Vedernikow number	-
W	Force due to the weight of water	(N)
x	Longitudinal channel distance	(m)
y	Water surface elevation above datum	(m)
Y	Hydraulic depth	(m)
$\overline{Y}$	Depth measured from the water surface to the centroid of the cross-section area	(m)
χ	The curvature of the peak of the flood hydrograph	(m^3s^{-3})
γ	Attenuation rate parameter	-
γ_w	Unit weight of water	(Nm^{-3})
θ	Weighted coefficient	-
α	Velocity weighting coefficient	-
α_o	Obstructed area of the piers divided by the total unobstructed area	
ρ	Density of water	kgm^{-3}
τ	Shear stress	Nm^{-2}
β	Momentum coefficient	-
ω	Ratio of velocity head to depth	-

Subscripts:

BD	Bridge downstream
BU	Bridge upstream
lob	Left overbank
ch	Channel
p	pier
rob	Right overbank
t	Total

x	X direction

Superscripts:

-	Average

JEREMY BENN ASSOCIATES

Jeremy Benn Associates, JBA, is a specialist engineering consultancy dealing with the feasibility, design and construction aspects of water resources, river engineering, scour/siltation and environmental engineering

This study was carried out in cooperation with JBA. The role of JBA in this study is so important that without their help, this study could never have been achieved.

The idea of the use of a steady model in unsteady flow conditions was given by JBA.

Overall data, cross-section elevations and station points, bridge deck, bridge piers, abutments, flow data (flood hydrograph, observed in 1987), boundary condition data (rating curve), roughness values, were all given by JBA.

The unsteady model (ISIS) was used by Dr. Charles Mbigha and the overall results of unsteady flow computations were provided by him.

I would like to thank Jeremy Benn, the managing director, and Dr. Charles Mbigha and all the others working for JBA.

CHAPTER 1

INTRODUCTION

1.1 GENERAL

With the development of powerful computers, many mathematical models have been developed to describe water and sediment movement in rivers. One of the main aims of producing a mathematical model is to avoid tedious hand calculations. In addition to this, the same model can be applied to different rivers and the users can test many options in a comparatively short time. Mathematical models are also developed for commercial purposes.

To set up a mathematical model, modellers must tackle two important problems. Firstly, the physical processes involved in the problem should be mathematically described. The mathematical description of the water and sediment motion very often consists of ordinary or partial differential equations with some assumptions being made. Moreover, they can have empirical parts. These equations cannot generally be solved by the use of analytical methods due to their complexity. That is why, in most cases numerical solution techniques have to be chosen. Nowadays, the use of digital computers seems to be not only the best way, but often the only way for this purpose. Secondly, modellers need to have some data such as hydrometric and topographic data. Unfortunately, in practice most modellers have to work with inadequate data because of the difficulty involved in obtaining them. Besides these two problems, calibration and verification of the model are also necessary in the development of a mathematical model.

As mentioned above, making some assumptions is inevitable. In this age, the most common assumption is that although the physical processes of water and sediment movement are three-dimensional and time dependent, one-dimensional models are widely used. The reason for this is that this approach not only simplifies the problem but also decreases computational load. In addition, the correct application and interpretation of two and three-dimensional models require expertise which is not generally available. Therefore, the user should be aware of the assumptions and make sure that the model is suitable for the purpose in hand and that the results are realistic. Throughout this thesis the flow is assumed to be one-dimensional even though truly one-dimensional flow does not exist in nature and the term 'one-dimensional model' refers to a model that is used to compute water surface elevations.

Applications of one-dimensional models in practice cover a wide area. According to the research done by the Institution of Water Engineers and Scientists (IWES, 1987), one-dimensional models can be applied to the following problems;

One-dimensional steady models: Backwater computation, determination of the effects of hydraulic structures such as bridges, weirs, sluices, etc. on flow, computation of flow in a network of channels.

Besides, Cunge *et al.* (1980) mentioned that steady models may also be used for the calibration of unsteady models.

One-dimensional unsteady models: the attenuation of the peak discharge along a wide river valley, the influence of tides, the transient effects of the operation of sluices, pumps, pumped drainage systems, the calculation of surge heights in power canals and of flood heights following the collapse of a dam, simulation of sediment movement in mobile alluvial rivers etc.

In one-dimensional steady models, variations of flow for each cross-section are generally considered along a river (not across the width and through the depth). When looking at one-dimensional unsteady models, as well as the consideration of flow variations along a river, the flow is considered as a function of time. Consequently, the equation of fluid flow becomes more complicated than that of a steady flow.

With respect to their solution techniques, while the equations of one-dimensional unsteady flow are too complex to be solved by analytical methods (Cunge *et al.*, 1980) and require the use of numerical solution techniques, one-dimensional steady flow equations may be solved analytically. However, with the powerful digital computer it may be more desirable to use numerical methods rather than analytical methods to find the solution to the one-dimensional steady flow equations.

While numerical solutions to the one-dimensional steady flow equations are generally straightforward and the modellers are rarely faced with problems in developing steady flow models, there are some problems that often occur in developing the one-dimensional unsteady flow models. These can be given as follows: accuracy and stability[*]

Besides the above problems, due to the complexity of the unsteady flow equations the use of unsteady models brings about a substantial increase in computational load and time, in particular in the simulation of a long river reach with some hydraulic structures. Above all, these problems prevent one-dimensional steady models being used for such a river. What is more, they lead us to think about the applicability of unsteady flow models on a river having an unsteady flow.

As a result, the application of a one-dimensional steady model has been considered[†] even for unsteady flow conditions. As it is expected, this consideration is not valid for all unsteady flow conditions and there are some limitations.

From a practical point of view, it could be very beneficial. It may be agreed that if the results obtained from a steady model indicate that they are realistic or acceptable for

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[*] See Chapter 2 background section 2.1

[†] See Chapter 2 background section 2.2

practical purposes even though the flow is unsteady, then there will be no need to use such a complicated model. It should also be considered that engineers in practice tend to use a model that is straightforward.

To be able to apply the one-dimensional steady model accurately on the unsteady flow conditions in a river, the properties of steady and unsteady flow should be well defined. In other words, the cases in which the unsteady flow can be suitable for a steady model should be examined. This is because the extent to which the flow is unsteady will govern how applicable the steady model is to the unsteady flow conditions. It is obvious that the less the unsteadiness of flow, the more the applicability of a steady model on unsteady flow conditions. Therefore, this approach can only be acceptable unless the unsteadiness of flow is significant. Otherwise, these two flow conditions can represent completely different flow characteristics and require different solution methods and models as well.

1.2 OBJECTIVES AND SCOPE OF THE WORK

The major objective of this study is to examine the applicability of steady models in a river that has an unsteady flow.

This thesis consists of 7 chapters and appendices.

Chapter 2 covers some background information about the applicability of a one-dimensional steady model in unsteady flow conditions and some difficulties with which modellers are often faced in the development of a one-dimensional steady and a one-dimensional unsteady model in a river.

In Chapter 3, a one-dimensional steady model, HEC-RAS, used for performing steady flow computations is introduced.

Chapter 4 has two parts, firstly a brief introduction to a one-dimensional unsteady model, ISIS, used for performing unsteady flow computations and secondly the determination of the attenuation rate parameters.

In order to find the most suitable condition for the use of the steady model, 4 different cases, which were produced by modifying the reach and explained in Chapter 4, have been analysed and overall results are given in Chapter 5.

In addition to the 4 different cases mentioned above, another modification was also made by decreasing the bed roughness of the reach. However, this modification caused some accuracy problems in the use of the unsteady model. Therefore, the discussion in Chapter 6, has been divided into 2 sections, namely a discussion of the possible sources of the occurrence of these errors and the selection of the steady model in the unsteady flow conditions.

The conclusions, which were drawn according to the results and discussions, are given in Chapter 7. This chapter also covers some recommendations and further studies.

In the presentation of the results graphical views instead of numerical values were preferred due to the large sizes of numerical values. However, the values which were used for providing the graphical views are given in the Appendix, which is divided into three parts.

In the first part, the bridges and their bounding cross-sections are presented graphically. The second part covers the numerical results obtained from the steady flow computations. Finally, the results obtained from the unsteady flow computations are given.

CHAPTER 2

BACKGROUND

2.1 APPLICABILITY OF ONE-DIMENSIONAL STEADY MODEL IN A RIVER WITH UNSTEADY FLOW

When examining the applicability of steady models in a river that has an unsteady flow, the characteristic differences between steady and unsteady flow should be clearly known.

With respect to stage-discharge relationships (rating curves), Cunge *et al.* (1980) stressed the differences between the steady and unsteady flow. These are briefly as follows:

While the rating curves obtained from a steady model are generally defined as single-valued relationships between discharge and water stage, the unsteady character of flood flow is in principle incompatible with the hypothesis of a single-valued rating curve. In other words, in unsteady flow conditions, e.g. during the passage of a flood wave when the Q(y) relationship is plotted at a given station, a multi-valued curve is observed. In fact, for a single-peak flood wave the curve takes the shape of a loop as shown in **Figure 2.1.** Its form indicates that there is not one discharge value Q for a given depth, but two or more; indeed, every recorded flood will produce a particular loop. They noticed that for slow natural floods the rising and falling branches of the loop are more or less symmetric with respect to the steady flow rating curve; deviations from it may be large but are nearly equal in absolute value during rising and falling levels.

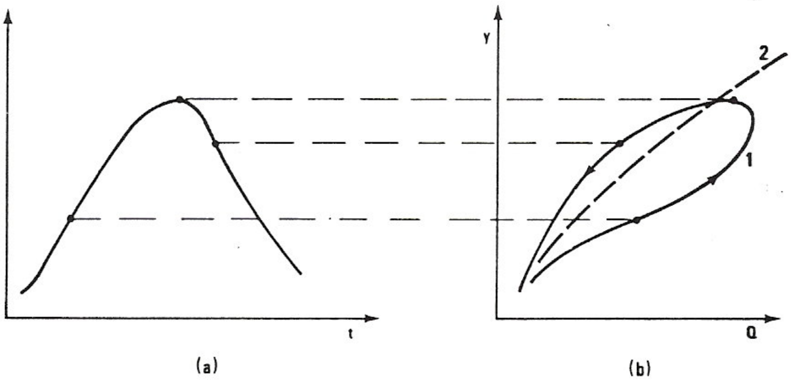

Figure 2.1: Unsteady flow Q(y) relationship: (a) schematic representation of flood hydrograph; (b) associated rating curve Q(y).

(After Chunge *et al.*, 1980)

Conversely, when the flood wave shows a rapid change, this symmetry may disappear. **Figure 2.2** shows Q (y) curves measured in two fixed-bed natural rivers for rapid variations of water stages during single and double-peak floods with the corresponding steady state rating curve.

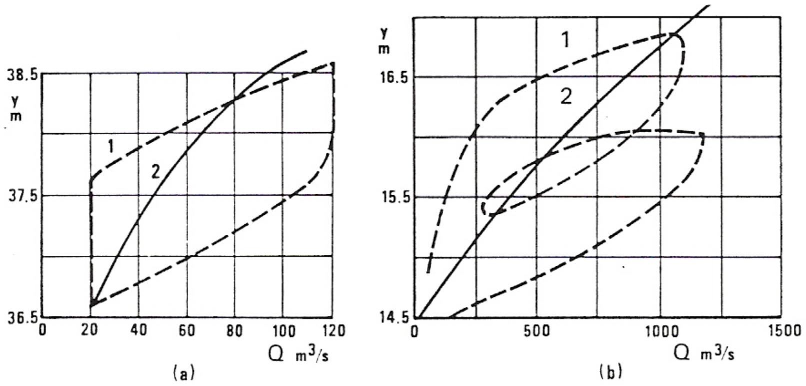

Figure 2.2: Observed Q(y) curves in natural rivers subject to rapid changes. (a) Single peak power station release in the river Tvertsa(USSR). (b) Two-peak flood in the river Svir (USSR): (1) Unsteady flow Q(y) curve; (2) steady flow rating curve.

(After Cunge *et al.*, 1980)

As in **Figure 2.1** in unsteady flow the free surface elevations are lower during the rising flood and higher during the falling flood compared with steady flow stages corresponding to the same discharges, but there is now a strong asymmetry in the unsteady curves.

They have found that there are four factors that affect the form of multi-valued rating curves. These factors are: acceleration of the flow in time and space, longitudinal bed slope, roughness (or conveyance) and evolution of downstream water stages (for example, dynamic reservoir operations or tidal conditions producing dynamic backwater effects).

They concluded that depending on these factors, the loop may be more or less spread out 'open' as compared with the steady flow rating curve.

They also mentioned that according to Russian experiments there are three factors which influence the shape of Q(y) curves: intensity of the discharge variation ΔQ/Δt, longitudinal bed slope S, and the roughness coefficient. These three factors are given below.

1- Intensity of Discharge Variation:

Based on the numerical experiments, the discharge variation intensity tends to dampen the flood peak and also to increase the unsteadiness of the flow. **Figure 2.3** shows the effect of the intensity of the discharge variation on the rating curves.

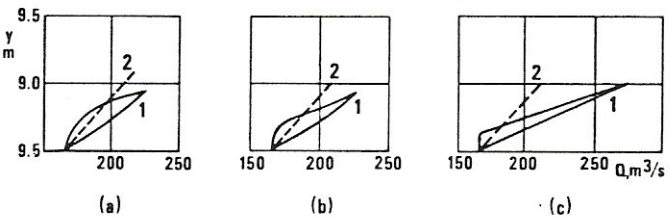

Figure 2.3: Influence of flood rise intensity on the shape of the Q(y) curve. (a) ΔQ/Δt =0.015m^3s^{-2}: (b) ΔQ/Δt=0.030m^3s^{-2}: (c) ΔQ/Δt=0.600m^3s^{-2}: 2, steady flow rating curve; 1, unsteady flow Q(y) relationship.

(After Cunge *et al.*, 1980)

2- Bed Slope S:

Bed slope is an important factor as far as unsteady behaviour of the flow is concerned. The greater the slope the smaller the deviation of the unsteady Q(y) relationship from the single-valued steady rating curve. If there is no backwater effect due to tributaries, dams, etc., the loop may in fact never exist in natural conditions, and could be relatively unimportant even in artificial release conditions. With respect to the numerical results, they found that in usual flow conditions, Q(y) loops always exist during floods when $S < 0.0001$ and if the longitudinal slope is large (i.e. $S > 0.001$, loops are practically never observed. However, these conclusions are not valid in back water conditions, for which the role of the bottom slope decreases. In these conditions, it affects the results mainly through the increase of the wetted area in the downstream direction, with a corresponding decrease in water velocity and thus in the energy loss.

3-The Roughness:

An increase in the roughness tends to increase the unsteadiness of the flow. In the absence of the backwater influence, the differences in discharge hydrographs and Q(y) relationships computed with two different values of the Manning coefficients $n_1 < n_2$ are shown in **Figure 2.4.** This figure shows that the flood peak decreases (the damping increases) with higher values of n, but the Q(y) loop opens up somewhat.

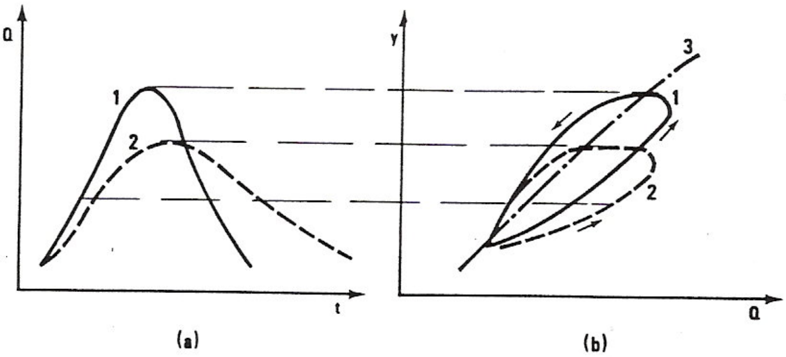

Figure 2.4: Influence of roughness on the shape of the hydrograph and Q(y) curve at a station (same upstream hydrograph). (a) Hydrographs. (b) Q(y) relationships: 1, roughness n_1; 2, roughness $n_2 > n_1$; 3, steady flow rating curve.

(After Cunge *et al.*, 1980)

In brief, from the explanations above it may be said that if the shape of an unsteady flow rating curve is close to that of a steady flow rating curve, the unsteadiness of the flow is not predominant. In other words, either an unsteady or a steady flow computation approach may be acceptable for practical purposes.

The following references indicate that a steady flow computation approach for the unsteady flow conditions can be reasonable for some cases.

When there is a gradual change in discharge with time, unsteady flow is approximated by steady flow. The discharge hydrographs in natural water courses consist of flow increases followed by recession curves. Only those flows occurring during a prolonged drought and those occurring for short time intervals at the highest and the lowest points of the hydrographs can be treated as steady flows (Yevjevich, 1975).

When the river is non-tidal and the transient effects of the operation of control structures such as sluices are not required, a steady flow may be considered. In addition to this, flow conditions will be suitable if the attenuation rate parameter, γ, introduced by Samuels and Gray is less than $2\text{x}10^{-6}$ (IWES, 1987). The equation used for determination of the attenuation rate is given as follows:

$$\gamma = (2BSc^3)^{-1}\chi \text{ ....} [2.1]$$

Where: B = The mean surface width

S = The mean bed slope

c = The mean propagation speed of the flood peak (ms^{-1})

χ = The curvature of the peak of the flood hydrograph (m^3s^{-3})

$$\chi = (2Q_P - Q^- - Q^+)/(3600T)^2 \text{ ....} [2.2]$$

Where: Q_p = The peak discharge of the flood hydrograph

Q^-, Q^+ = The discharges T hours before and after the peak respectively.

They mentioned the following ways to evaluate the propagation speed

1- From the time of travel between two water level recorder sites

2- From the local mean velocity V setting:

$$c \cong 1.7V \qquad [2.3]$$

3- From a slope of a rating curve $\frac{dQ}{dh}$ at the flood peak:

$$c = B^{-1}\frac{dQ}{dh} \qquad [2.4]$$

4- From the following approximate formula with an estimate of Manning's roughness coefficient n:

$$c = 1.7Q^{0.4}S^{0.3}n^{-0.6}B^{-0.4} \qquad [2.5]$$

2.2 DIFFICULTIES IN THE DEVELOPMENT OF ONE-DIMENSIONAL STEADY AND UNSTEADY MODELS

2.2.1 DATA NEEDS

Data for developing both steady and unsteady models can be briefly given as: boundary conditions data such as known water depth, discharge and rating curves, cross-section data (ground surface elevations, cross-section spacing), Manning's n or Chezy 's C, hydraulic structures data such as culvert, bridge and weir. For unsteady models the timestep and overall computation time also need to be known.

In addition to the above data, the modellers need to have a detailed set of field data for calibration and verification of models (Przedwojski *et al.*, 1995).

As mentioned earlier the modellers and the users always suffer from inadequate data. However, Przedwojski *et al.* (1995) stated that the model can be efficient only if it relies on field data and if its predictions can be verified by measurable data.

In short, even though the modellers and the users have very powerful computers, without field data mathematical modelling will be nothing more than solving a set of equations by using digital computers.

2.2.2 ACCURACY AND CALIBRATION

The reasons for the occurrence of errors in the model could be the following: processes not described by the model equations, errors in topographic data, errors in hydrometric data, numerical representation of various quantities, model calculation parameters, computer precision (IWES, 1987).

1- **Processes not described by the model equations**: such as the effects of changes in the river bed level due to sediment movement in a fixed bed model and the effects of variations in roughness due to seasonal vegetation or change in bed form in a fixed roughness model.

2- Error in topographic data: e.g. changes in the level of bench marks, reading errors on instruments and the precision limitations of aerial survey.

3- Errors in hydrometric data: e.g. movement of gauge boards, reading errors, effects of loop rating at a gauging station with a fixed rating curve.

4- Numerical representation of various quantities: the influences of space and time steps selected for the numerical simulation, the discrete equations chosen to represent the flow.

In steady models, since the flow is independent of time and is fixed along the river, only the selection of space (between two cross-sections) could affect the computations. Cross-section spacing is a function of stream size, slope and the uniformity of cross section shape. In general, large uniform rivers of flat slope normally require the fewest number of cross sections per mile (US Corps of Engineers, 1995).

The selection of large cross-section spacing can cause errors in the computation of steady flow. For example, when the standard step method, which is an iterative process, is used to compute the water surface elevations, the iteration will be terminated when a converge parameter has been satisfied. If the converge parameter is not satisfied within a number of iterations, the errors will arise.

When modelling an unsteady flow, both space and time have a very important role in deciding the accuracy of the model. To explain the reason why the selection of space and time are so important in the development of unsteady models, it may worth starting with a description of the solution methods being applied on unsteady flow equations.

There are three well-known numerical solution methods used for solving the unsteady flow equations namely the finite element method, the method of characteristics and the finite difference method (Cunge *et al.*, 1980). Since the finite difference method is the one currently used in the great majority of industrial models (Przedwojski *et al.*, 1995), a detailed description is given below.

The finite difference method described by Cunge *et al.* (1980) is as follows: functions of continuous arguments that describe the state of flow are replaced by functions defined on a finite number of grid points within the considered domain. The derivatives are then replaced by divided differences. Thus the differential equations, i.e. the laws describing the evolution of the continuum, are replaced by algebraic finite difference relationships. The different ways in which derivatives and integrals are expressed by discrete functions are called finite difference schemes. The finite difference schemes can be classified into two groups; explicit and implicit schemes.

Since the exact solution (analytical solution) of the unsteady flow equations is impossible, the comparison between the exact and the numerical solution is also not possible. Hence, the accuracy of the numerical solutions cannot be directly checked. The only way to tell the accuracy of the solution is to analyse the numerical method. The numerical solution can be analysed by decreasing the space (Δx) and time (Δt) intervals which represent computational grid in space (x) and in time(t) respectively. When these intervals reduce (Δx, $\Delta t \rightarrow 0$), it is expected that the numerical solution will approach the analytical solution. If this happens, the scheme is convergent. A converge scheme should give a sequence of results which approach the analytical solution at computational points. For linear equations which are derived from the non-linear expressions converge is confirmed if the conditions of Lax theorem are satisfied.

Lax theorem: ‘given a properly posed initial-value problem and a finite difference approximation to it that satisfies the consistency condition, stability is the necessary and sufficient condition for converge.’

Consistency means that finite difference operators approach the differential equation when Δt and Δx go to zero. Numerical stability means the solutions are bounded. In other words, a small error (e.g. round-off error in the sixth place after the decimal point) should stay small during the whole computations and never become significant (Cunge *et al.,* 1980).

Chow (1988) and Cunge *et al.* (1980) agreed that while all explicit schemes are conditionally stable, implicit schemes are generally unconditionally stable. Therefore, when using explicit schemes, computational time step and space cannot be chosen freely. With respect to stability of the implicit schemes, there is not generally any limitation on the selection of time steps. However, Cunge *et al.* (1980) mentioned that implicit schemes must not be applied blindly with any arbitrary values of computational time and space intervals being used.

Many works have been done to analyse the accuracy of the schemes. For instance, Kumar Jha *et al.* (1994) applied a mathematical model that is based on modified Beam and Warming implicit scheme on dam-break and propagation-of-surge problems and they found that the modified model significantly improved the accuracy of results at almost no additional complication or cost of computation. They mentioned that the use of this scheme resulted in more accurate results than that of the Euler implicit scheme. They also proposed that the modified Beam and Warming scheme could be applied in a natural stream or flow in a transition.

Since Preissmann's scheme is used to develop the ISIS, it may be worth mentioning the stability of Pressmann's scheme. This scheme is one of the best-known schemes. It has two main advantages: it is compact and implicit. Its compactness allows the modeller to space grid points, (or river cross sections), nonuniformly along the river system, Samuels & Skeels (1990). The detailed description of Pressmann's scheme is given in Chapter 4.

Samuels & Skeels (1990) found that there are two limits on the stability of the Preissmann scheme. The first one is that the scheme must be forward weighted θ[‡] $\geq 1/2$. The second is that the Vedernikow number satisfies $|V_e| \leq 1$. The equation that was used to evaluate the Vedernikow number is as follows:

[‡] See Chapter 4

$$V_e = \frac{mFAdR}{n_c RdA} \quad \text{[2.6]}$$

Where: F = Froude number of flow

n_c ,m = coefficients (n_c varies according to flow type, m is usually greater than unity)

dA = The differential of the wetted-cross section area

dR = The differential of the Hydraulic radius

While the first limit links the stability of the scheme being applied to simplifications of the St. Venant Equations, the second limit links the stability of the calculation to the hydrodynamic stability of the flow.

Meselhe and Holly (1997) pointed out that in the use of the Preissmann scheme, if local supercritical-flow zones form adjacent to the computational domain boundaries, the problem becomes ill-posed. However, with respect to linear stability analysis they found that the Preissmann scheme is marginally stable if a critical point is encountered in the domain; consequently, any error (e.g., arbitrary initial conditions) will not be dampened. They stated that adding artificial viscosity to overcome the difficulty associated with the existence of critical points within the computational domain will destroy either the unconditional stability or the bidiagonal structure of the Preissmann scheme.

Use of the Preissmann scheme can also result in a numerical instability for steady frictionless slow if coarse cross-section data are used. This instability can cause errors in the total energy level. The errors have been quantified and lead to a restriction on the ratio of flow area from one cross-section to another (Samuels, 1985).

From the above point, it may be concluded that the selection of both time step and grid space have an important role in deciding the stability of the scheme. The condition of the stability of the scheme depends on the type of the scheme, the type of problem and the equations.

5- Model calculation parameters : The flow equations are solved using an iterative process. Iterative computations are generally finished when converge parameters have been satisfied. Selection of the converge parameters affects the accuracy of the model.

6- Computer precision: This type of error can exist because of the number of decimal digits used to represent real numbers such as water level and discharge.

Calibration of the model against observations of various flows in the river is necessary in order to apply the model successfully. In this process, the values of roughness coefficients and discharge coefficients for structures are adjusted until the simulations match the observed conditions. During the calibration the aim should be to match all peak water levels within ± 0.1m with a near zero average error (IWES, 1987).

CHAPTER 3

HEC-RAS: ONE-DIMENSIONAL STEADY MODEL

3.1 INTRODUCTION TO HEC-RAS

The word ‘HEC-RAS’ stands for Hydrologic Engineering Center’s River Analysis System. The integrated system of software developed by the US Army Corps of Engineers is also called HEC-RAS. Although the last version performs one-dimensional steady flow, unsteady flow and sediment transport calculations, in this project Version 1.0, which can only perform one-dimensional steady model over a full network and constructed channel, has been used.

Version 1.0 is capable of modelling subcritical, supercritical and mixed flow regime water surface profiles. The water surface profile computation is based on the solution of a one-dimensional energy equation. Energy losses are determined by using Manning’s equation for friction and multiplying the coefficient by the change in velocity head for contraction/expansion. The momentum equation is used in cases where the water surface profile shows a rapid change. Mixed flow regime calculations (e.g. Hydraulic jumps), hydraulics of bridges and flow at stream junctions can be given as examples of these cases. Moreover, the program is also used for application in flood plain management and flood plain insurance studies to evaluate floodway encroachments. The effects of channel improvements, levees and ice cover in water surface profiles can also be analysed (HEC-RAS User’s Manual, 1995). In addition, the software has other facilities such as graphics and reporting facilities.

Although it is possible to evaluate the water surface profiles for all cases mentioned above, during this project only the cases related to the project have been explained.

For other cases the readers can consult HEC-RAS User's Manual and Hydraulic

Reference Manual, Version 1.0, 1995.

3.2 DATA FOR HEC- RAS

Data that should be entered into the program can be divided into two groups namely geometric data and flow data.

3.2.1 GEOMETRIC DATA:

Geometric data consists of cross-section data and hydraulic structure data (bridges, culverts, weirs, etc.). Cross-section data are necessary in order to represent a river throughout its length. It is obvious that the higher the number of cross-sections, the better the simulation. However, in practice it is often not possible to have enough cross-section data because measurement of ground surface elevations is labour-intensive and the higher the number of cross-sections along a river, the higher the cost. On the other hand, from a hydraulic point of view where there is a change in discharge, slope, shape or roughness or at locations where levees begin or end and at bridges or control structures such as weirs cross-section data at these points need to be known.

Cross-section spacing is also a function of stream size, slope and the uniformity of cross-section shape. In general, uniform rivers with flat slope require fewer cross-sections than rivers with steep slope.

When looking at the River Tame, 275 cross-sections most of which have an irregular shape were entered into the program. The length of the reach of the River to be analysed is about 29 km. The average cross-section spacing is about 103 m. Each cross-section consists of elevation and station points. The number of points depends on the shape of the cross-section and varies from 15 to 100. Hence, about 4,100 to 27,500 co-ordinates had to be measured. These numbers indicate not only the difficulty in obtaining cross-section data but also the need for the use of a powerful computer for water profile computations.

For each cross-section, the following data were also entered into the program; downstream reach lengths (distance between two cross-sections), roughness coefficients, contraction and expansion coefficients. Roughness (Manning's n) values can be found in several references. For instance, Chow (1959) gives not only the values but also factors affecting Manning's n coefficients. These factors are surface roughness, vegetation, channel irregularity, channel alignment, silting and scouring, obstruction, size and shape of channel, stage and discharge.

To reduce the size of the appendices, overall cross-sections data did not given but the cross-sections where there were bridges presented graphically in **Appendices, pp. 99.**

After entering the cross-section data, the program produces the shape of the cross-section. **Figure 3.1** shows an example of a typical cross-section. In this figure red points represent the locations where the Manning's n changes. It is also possible to see the whole reach of river and where the cross-sections were located graphically (**Figure 3.2**).

As well as cross-section data, hydraulic structure data are also required for simulation. The reach of the River Tame has 64 bridges. The required data for bridges are bridge deck, abutments and piers. These data were also entered into the program. The elevations of bridge deck data are used for both determination of when the weir flow starts and evaluating bridge opening through which the water passes. If abutments exist, the area covered by them should be known for computation of the flow area. If there is a pier, its length, width and location should be given to the program. The shape of pier is also very important in order to distinguish modelling approaches and calculation of energy losses.

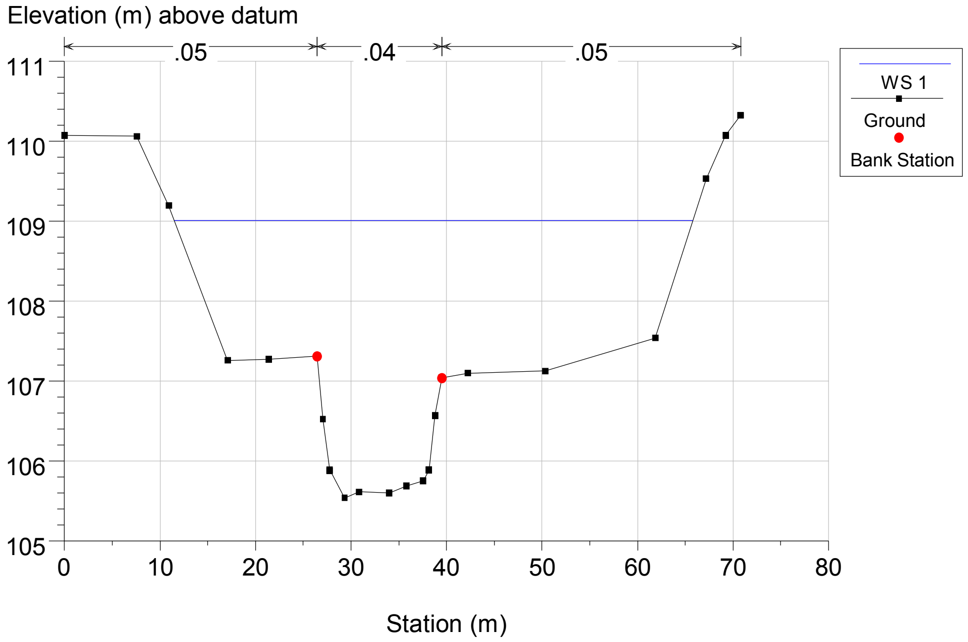

Figure 3.1: A typical Cross-Section of the River Tame

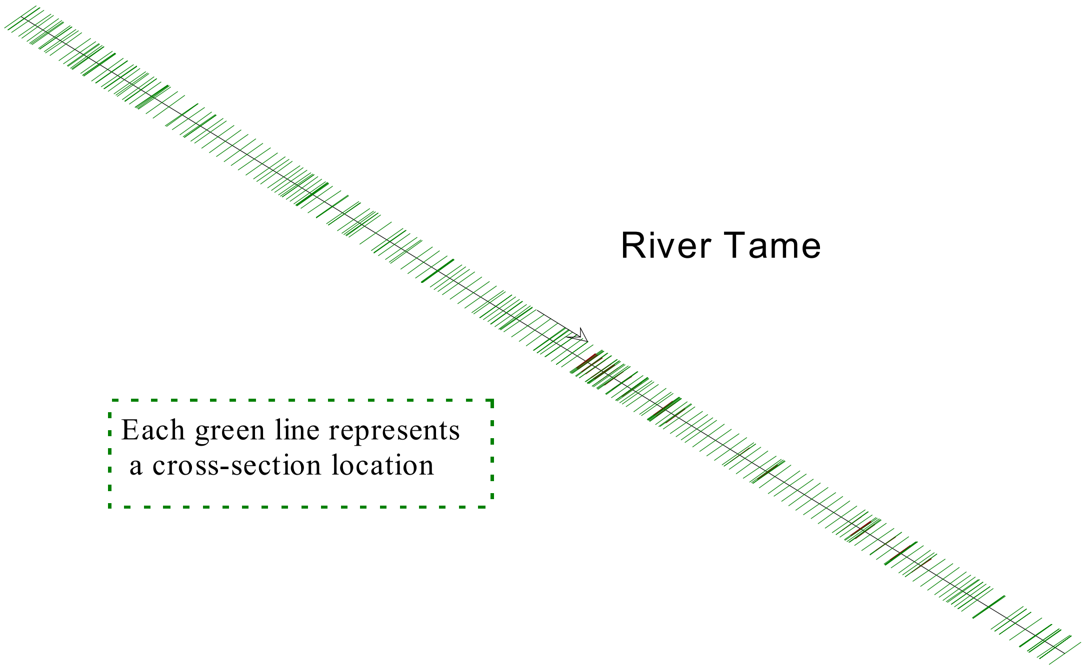

Figure 3.2: The reach of the River Tame with Cross-section Locations

If there is a multiple opening, the elevation and station co-ordinate should be entered to define the ineffective flow area (stagnation points). **Figure 3.3** shows an example of an upstream face of a bridge with piers.

It is also possible to see a three-dimensional graphical view. A graphical view of a cross-section and bridge shape helps the user to check the data used. **Figure 3.4** indicates a three-dimensional view of a bridge with its bounding cross-sections.

Contraction and expansion coefficients are used to evaluate the amount of energy loss that occurs because of a flow contraction and expansion. Chow (1959) gives the coefficients for different cases. The coefficients depend on the change in between two cross-sections. When the change is small, these values are typically on the order of 0.1 to 0.3. On the other hand, when there is an abrupt change in the effective area between upstream and downstream cross-sections, the coefficients are on the order of 0.3 to 0.8. In general, a sudden change can occur at a location where there is a bridge, culvert or any other obstruction. If there is no contraction and expansion, the coefficients are taken as 0.

3.2.2 FLOW DATA:

Steady flow data include boundary conditions, discharge information and flow regime. Boundary conditions are necessary to start computations. They should be specified and then entered into the program. They can be a known water surface elevation, critical depth, normal depth and rating curve. Boundary condition data should be located according to type of flow regime. If flow is subcritical, boundary conditions are only necessary at the downstream ends of the river system. If a supercritical flow regime is going to be calculated, they are only necessary at the upstream ends of the river. For mixed flow regime, boundary conditions at both the upstream and downstream ends of the river are necessary.

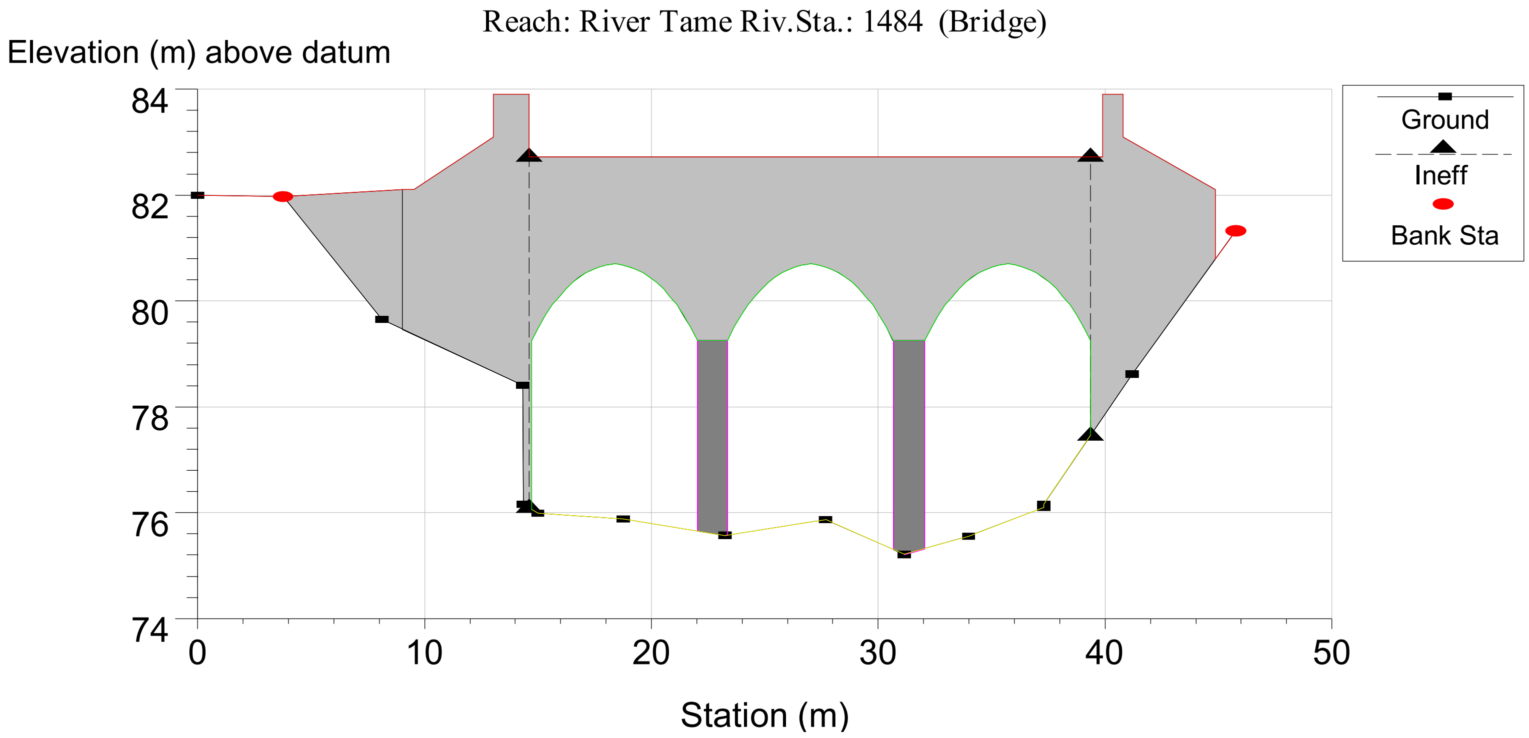

Figure 3.3: An example of the upstream face of a bridge with piers

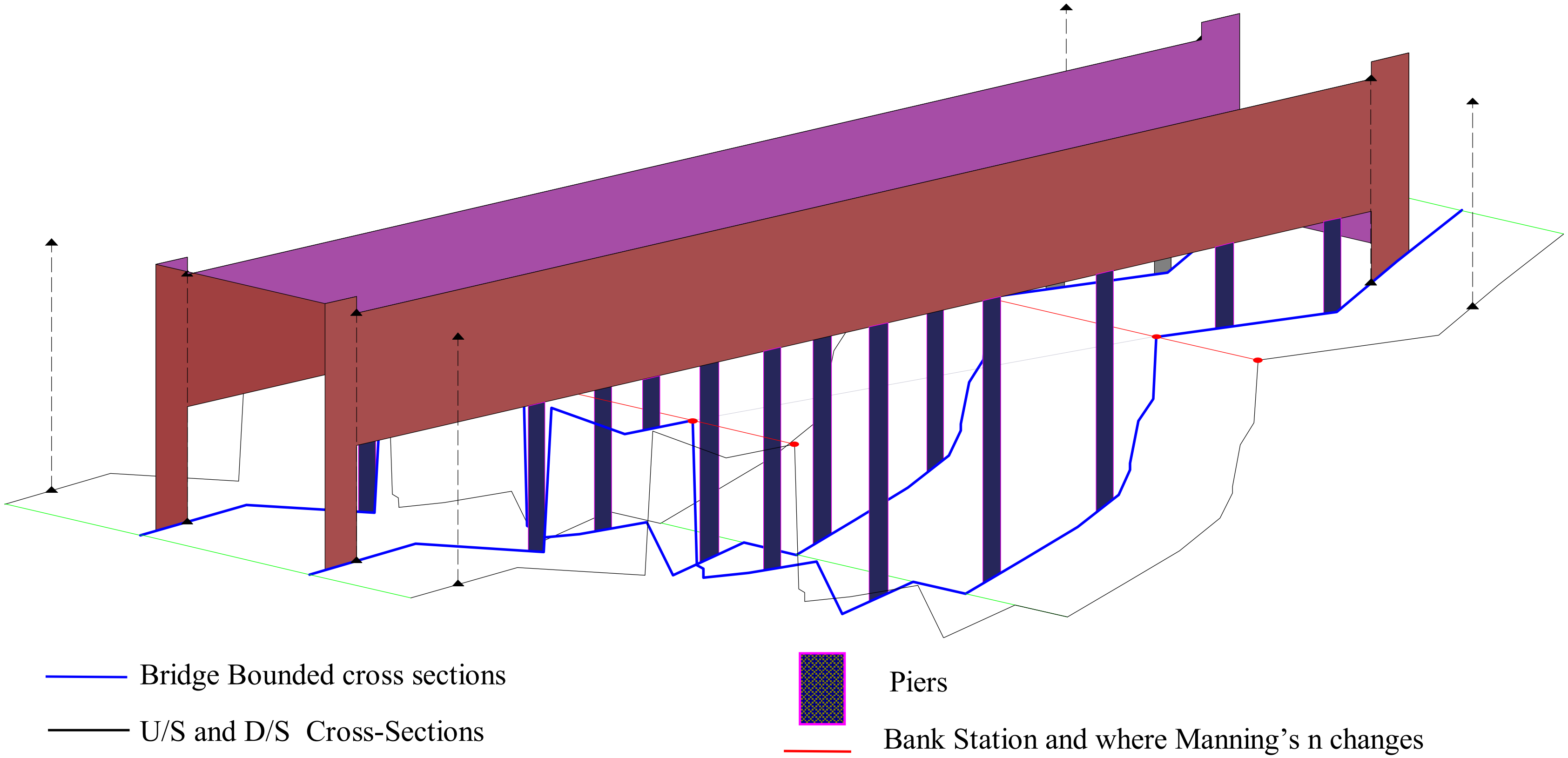

Figure 3.4: Three- dimensional view of a Railway Bridge with its bounding cross-sections (station 1606- 1582)

Discharge information is required to compute the water surface profile at each cross-section. The flow rate can be changed at any cross-section, except from in the middle of a bridge, culvert or stream junction. Furthermore, up to 15 different discharges can be entered. After entering the discharge, the program computes the water surface profile at each cross-section. If more than one flow rate is entered, the program calculates the water profile at each flow rate separately.

For this study, a constant peak discharge (105 m^3s^{-1}) observed during the flood in August 1987 was used. Boundary condition data given in **Appendices, Table A1** is a rating curve and entered in to the program for subcritical flow computations.

3.3 METHODOLOGY OF HYDRAULIC COMPUTATIONS IN HEC-RAS

In this section, the theory behind the computation of water surface profiles, conveyance calculations, evaluation of friction and expansion/contraction losses, brief computation procedure of gradually varied flow, application of momentum equations and bridge modelling approach is explained. All equations are taken from HEC-RAS Hydraulic Reference Manual's, Version 1.0, 1995. For more detail, the reader can consult this manual.

3.3.1 WATER SURFACE PROFILE COMPUTATION FOR STEADY GRADUALLY VARIED FLOW:

The water surface profile between two cross-sections is computed by using the Energy equation. The energy equation used in the program is as follows;

$$y_2 + \frac{\alpha_2 V_2^2}{2g} = y_1 + \frac{\alpha_1 V_1^2}{2g} + h_e \text{......................................} [3.1]$$

where: y_1, y_2 = Water surface elevations at cross-sections

V_1, V_2 = Average velocities (total discharge/total flow area)

α_1, α_2 = Velocity weighting coefficients g = Gravitational acceleration

h_e = Energy head loss

In equation [3.1], velocity weighting coefficient is calculated as:

$$\alpha = \frac{(A_t)^2 \left[\frac{(K_{lob})^3}{(A_{lob})^2} + \frac{(K_{ch})^3}{(A_{ch})^2} + \frac{(K_{rob})^3}{(A_{rob})^2} \right]}{(K_t)^3} \qquad \text{.............................[3..2]}$$

where: A_t = Total flow area of cross-section

A_{lob}, A_{ch}, A_{rob} = Flow areas of left overbank, main channel and right overbank, respectively

K_t = Total conveyance of cross-section

K_{lob}, K_{ch}, K_{rob} = Conveyance of left overbank, main channel and right overbank, respectively.

Energy head loss has two components; friction losses and contraction/expansion losses. It is determined by using the following equation.

$$h_e = L\bar{S}_f + c_c \left| \frac{\alpha_2 V_2^2}{2g} - \frac{\alpha_1 V_1^2}{2g} \right| \qquad \text{..[3.3]}$$

where: L = Discharge weighted reach length

$\bar{S}_f$ = Representative friction slope between two cross-sections

c_c = Contraction or expansion loss coefficient

The discharge weighted reach length is calculated as:

$$L = \frac{L_{lob}\,\overline{Q}_{lob} + L_{ch}\,\overline{Q}_{ch} + L_{rob}\,\overline{Q}_{rob}}{\overline{Q}_{lob} + \overline{Q}_{ch} + \overline{Q}_{rob}} \qquad [3.4]$$

where: L_{lob}, L_{ch}, L_{rob} = Cross-Section reach lengths specified for flow in the left overbank, main channel, and right overbank respectively.

$\overline{Q}_{lob}, \overline{Q}_{ch}, \overline{Q}_{rob}$ = Arithmetic average of the flows between sections for the left overbank, main channel, and right overbank respectively.

Representation of the terms in equation [3.1] is shown in **Figure 3.5**. There are various methods such as graphical and numerical integration, the direct step and the standard step to solve equation [3.1]. However, as Featherstone & Nalluri (1995) and Chow (1959) mentioned, the most suitable one for numerical solution in nonprismatic channels is the standard step method that is also used in HEC-RAS.

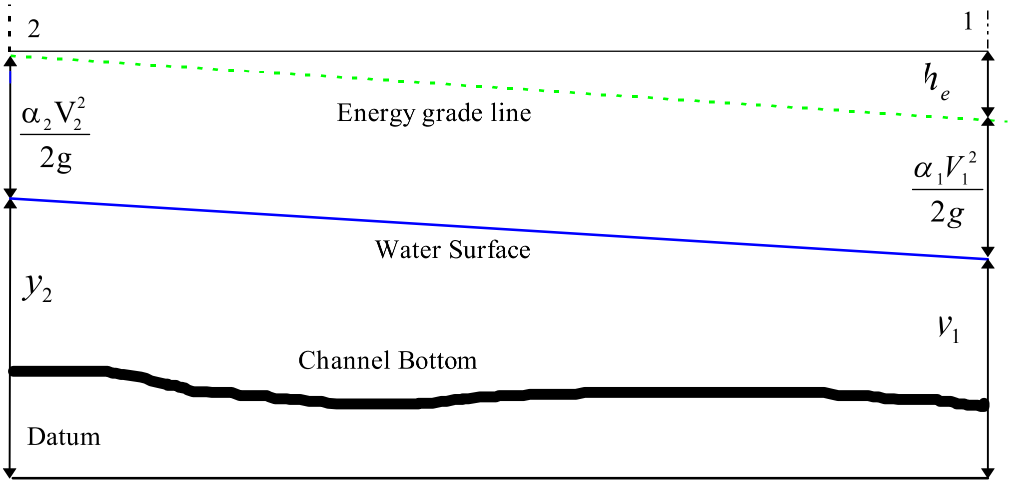

Figure 3.5: Description of the terms in the Energy Equation (After US Army Corps of Engineers, 1995)

3.3.2 CROSS-SECTION SUBDIVISION FOR CONVEYANCE CALCULATIONS:

Similar to determination of the velocity coefficients for a cross-section, determination of total conveyance requires that flow should be subdivided into units for which the velocity is uniformly distributed.

In HEC-RAS, the flow is subdivided in the overbank areas according to points where Manning's n changes. For each subdivision, conveyance is calculated as the following equation based on English Units[§].

$$\mathrm{K} = \frac{1.486}{\mathrm{n}}\mathrm{AR}^{\frac{2}{3}} \qquad [3.5]$$

where: K = Conveyance for subdivision

n = Manning's roughness coefficient for subdivision

A = Flow area for subdivision

R = Hydraulic Radius for subdivision (area/wetted perimeter, P).

The total conveyance for the cross-section is determined by summing the left and right overbank and channel conveyance. **Figure 3.6** illustrates the conveyance subdivision.

There is also an alternative method available to calculate conveyance in HEC-RAS. This method was first used for the Corps HEC-2 program. In this method, conveyance is calculated between every co-ordinate point in the overbank and then the conveyance is summed to get the total left overbank and right overbank values. In this project, the first method was applied.

[§] The program allows the user to change the units; e.g. K = $\frac{1}{n}AR^{\frac{2}{3}}$ in SI units

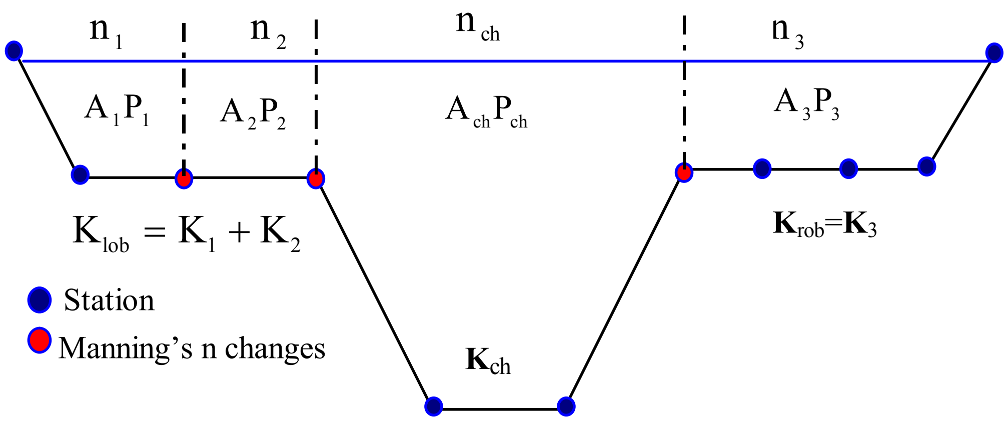

Figure 3.6: Conveyance Subdivision

(After US Army Corps of Engineers, 1995)

3.3.3 EVALUATION OF FRICTION AND CONTRACTION/EXPANSION LOSSES:

As given in equation [3.3], friction loss is determined by $\overline{S}_f$ x L. There are four alternative equations used for the calculation of $\overline{S}_f$ in the program. These are given below.

- Average Conveyance Equation

$$\overline{S}_f = \left(\frac{Q_1 + Q_2}{K_1 + K_2}\right)^2 \quad \text{..........}[3.6]$$

- Average Friction Slope Equation

$$\overline{S}_f = \frac{S_{f1} + S_{f2}}{2} \quad \text{..........}[3.7]$$

- Geometric Mean Friction Slope Equation

$$\overline{S}_f = \sqrt{S_{f1} x S_{f2}} \qquad [3.8]$$

- Harmonic Mean Friction Slope Equation

$$\overline{S}_f = \frac{2S_{f1} x S_{f2}}{S_{f1} + S_{f2}} \qquad [3.9]$$

According to the research done by the US Corps of Engineers (1995), for computation of M1 and M2 flow profile, the best method is the average conveyance equation. However, they also mentioned that Reed and Wolfkill (1976) recommended equation [3.6] for M1 profile and equation [3.9] for M2 profile. The program can select the most suitable equations according to the criteria given in **Table 3.1.**

Table 3.1: Criteria for selection of friction equation by the program (Hydraulic Reference Manual, 1995).

PROFILE TYPE	Is friction slope at current cross section greater than friction slope at preceding cross section?	Equation Used
Subcritical (M1,S1)	yes	[3.7]
Subcritical (M2)	no	3.9]
Supercritical (S2)	yes	[3.7]
Supercritical (M3,S3)	no	[3.8]

Contraction and expansion losses were explained in section 3.2.1, the energy losses caused by transition are evaluated by multiplying the absolute difference in velocity heads between two cross-sections by the coefficients. When the velocity head downstream is greater than the velocity head upstream, the program assumes that a contraction is occurring. Similarly, when the velocity head upstream is greater than the velocity head downstream, the program assumes a flow expansion is occurring. The second component of equation [3.3] gives the loss caused by contraction/expansion.

3.3.4 BRIEF COMPUTATION PROCEDURE FOR GRADUALLY VARIED FLOW IN HEC-RAS

As mentioned earlier, the solution method for gradually varied flow is the standard step method. This method requires an iterative solution. The brief computational procedure given in HEC-RAS Hydraulic Reference Manual (1995) is as follows:

1- Assume a water surface elevation at the upstream cross-section (or downstream cross-section if a supercritical profile is being calculated).

2- Based on the assumed water surface elevation, determine the corresponding total conveyance and velocity head.

3- With values from step 2, compute $\overline{S}_f$ and solve equation [3.3] for h_e

4- With values from steps 2 and 3, solve equation [3.1] for y_2

5- Compare the computed value of y_2 with the value assumed in step 1; repeat steps 1 through 5 until the values agree to within 0.003m.

3.3.5 APPLICATIONS OF THE MOMENTUM EQUATION

As stressed earlier the energy equation is only used for gradually varied flow conditions in the Hec-Ras program. The momentum equation is used for the following problems; the occurrence of hydraulic jump, low flow[**] hydraulics at bridges and stream junctions. The momentum equation is derived from Newton's second law of

---

[**] See section 3.3.6.1 bridge modelling

motion (Force = Mass x Acceleration) . Derivation of the momentum equation in HEC-RAS is as follows.

Applying Newton's second law of motion to a body of water enclosed by two cross-sections at locations 1 and 2 (**Figure 3.7**), the following expression for the change in momentum over a unit time can be given as;

$$P_{h1}-P_{h2}+W_X-F_f = Q\rho\Delta V_X \qquad [3.10]$$

where: P_h = Hydrostatic pressure force at locations 1 and 2.

W_X = Force due to the weight of water in the X direction.

F_f = Force due to external friction losses from 1 to 2.

Q = Discharge

ρ = Density of water

ΔV_x = Change in velocity from 1 to 2, in the X direction.

The terms in the equation [3.10] are given below

Hydrostatic Pressure Forces:

The force in the X direction due to hydrostatic pressure is:

$$P_{h1} = \gamma_w A_i \overline{Y}_i \cos\theta \qquad [3.11]$$

where: γ_w = Unit weight of water.

A_i = Wetted area of cross-section at locations 1 and 2.

$\overline{Y}_i$ = Depth measured from the water surface to the centroid of the cross-sectional area at locations 1 and 2.

$\cos\theta$ = The pressure-correction factor.

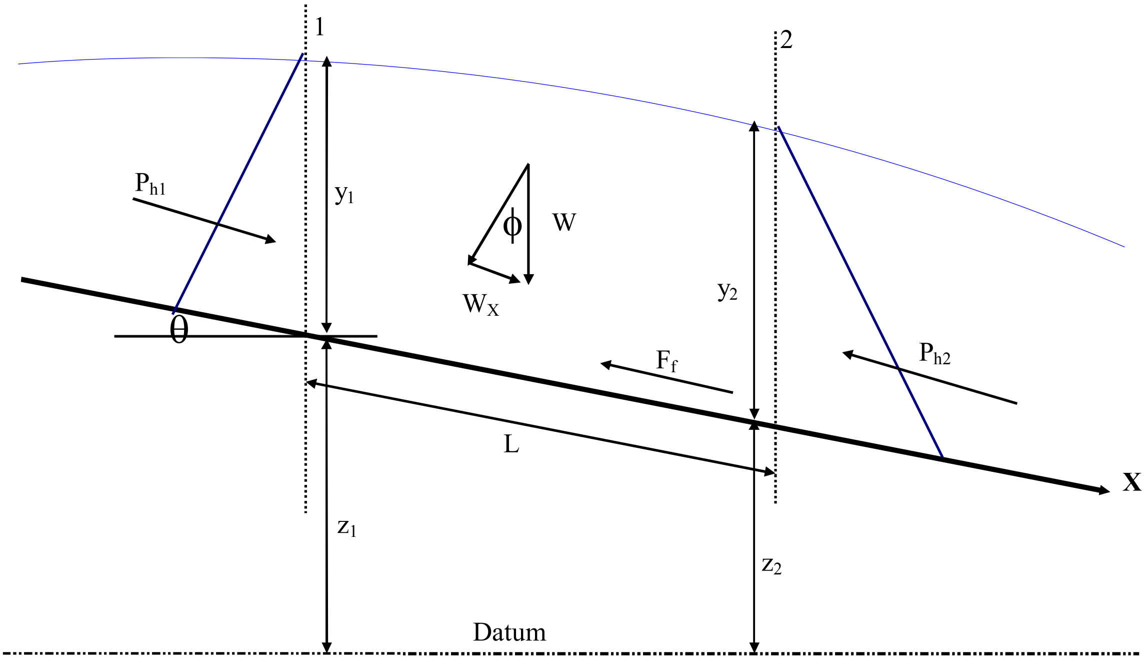

Figure 3.7: Application of the Momentum Principle (After US Army Corps of Engineers, 1995).

However, referring to Chow (1959), they assumed that $\cos\theta$ is equal to unity. This assumption brought a limitation that the hydrostatic distribution is only valid for a river having a slope of less than 1:10.

Weight of Water Force:

Weight of water = (Unit weight of water)x(volume of water).

$$W = \gamma_w \left(\frac{A_1 + A_2}{2} \right) L \qquad [3.12]$$

$$W_X = W\sin\phi \qquad [3.13]$$

$$\sin\phi = \frac{z_1 - z_2}{L} = S \quad [3.14]$$

Hence, the equation [3.13] can be rewritten as follows

$$W_X = \gamma_w \left(\frac{A_1 + A_2}{2} \right) LS \quad [3.15]$$

where: L = Distance between sections 1 and 2 along the X axis.

z_i = Mean bed elevation at locations 1 and 2.

Force of External Friction:

$$F_f = \tau \overline{P} L \quad [3.16]$$

where: τ = Shear Stress.

$\overline{P}$ = Average wetted perimeter between sections 1 and 2.

$$\tau = \gamma_w \overline{R} \overline{S}_f \quad [3.17]$$

where : $\overline{R}$ = Average hydraulic radius.

Rewriting the equation [3.16] given:

$$F_f = \gamma_w \left(\frac{A_1 + A_2}{2} \right) \overline{S}_f L \quad [3.18]$$

Mass times acceleration:

$$ma = Q \rho \Delta V_X \quad [3.19]$$

$\rho = \frac{\gamma_w}{g}$ and $\Delta V_X = (\beta_2 V_2 - \beta_1 V_1)$

$$ma = \frac{Q\gamma_w}{g}(\beta_2 V_2 - \beta_1 V_1) \ldots\ldots [3.20]$$

where: β = momentum coefficient that accounts for a varying velocity distribution in irregular channels.

Substituting back into equation [3.10], and assuming Q can vary from 1 to 2:

$$\gamma_w A_1 \overline{Y}_1 - \gamma_w A_2 \overline{Y}_2 + \gamma_w \left(\frac{A_1 + A_2}{2}\right) LS - \gamma_w \left(\frac{A_1 + A_2}{2}\right) L\overline{S}_f$$

$$= \frac{Q_2 \gamma_w}{g} \beta_2 V_2 - \frac{Q_1 \gamma_w}{g} \beta_1 V_1 \ldots\ldots [3.21]$$

$$\frac{Q_1 \beta_1 V_1}{g} + A_1 \overline{Y}_1 + \left(\frac{A_1 + A_2}{2}\right) LS - \left(\frac{A_1 + A_2}{2}\right) L\overline{S}_f$$

$$= \frac{Q_2 \beta_2 V_2}{g} + A_2 \overline{Y}_2 \ldots\ldots [3.22]$$

$$\frac{Q_1^2 \beta_1}{g A_1} + A_1 \overline{Y}_1 + \left(\frac{A_1 + A_2}{2}\right) LS - \left(\frac{A_1 + A_2}{2}\right) L\overline{S}_f.$$

$$= \frac{Q_2^2 \beta_2}{g A_2} + A_2 \overline{Y}_2 \ldots\ldots [3.23]$$

All applications of the momentum equation within HEC-RAS are derived from equation [3.23].

3.3.6 BRIDGE MODELLING

Hydraulic computations through the bridge can be divided into two sections namely low flow and high flow computations.

3.3.6.1 Low Flow Computations:

When the water surface is below the highest point on the low chord of the bridge opening (open channel flow), it is classified as low flow. The low flow can also be subdivided; class A flow, class B flow, class C flow.

To start low flow computations, the momentum equation is used to identify the class of flow. This is accomplished by first calculating the critical depth inside the bridge at the upstream and downstream ends. The end with the higher momentum (most constricted section) will be the controlling section in the bridge. If the two sections have the same momentum, the upstream bridge section is selected as the controlling section. The momentum at critical depth in the controlling section is then compared to the momentum of the flow downstream of the bridge when performing a subcritical profile (upstream of the bridge for a supercritical profile). If the critical depth momentum inside the bridge is less than the momentum downstream, the flow is classified as completely subcritical flow (class A flow). If the critical depth momentum in the controlling bridge section is greater than the momentum downstream, then it is considered that the constriction will cause the flow to pass through critical depth and a hydraulic jump will occur at some distance downstream (class B flow). If the flow is completely supercritical, then it is called class C flow.

Class A Low Flow:

If the flow through the bridge is above the critical depth, class A flow exists. Energy losses through the expansion (section 2 to 1, see **Figure 3.8**) are computed as friction losses and expansion losses.

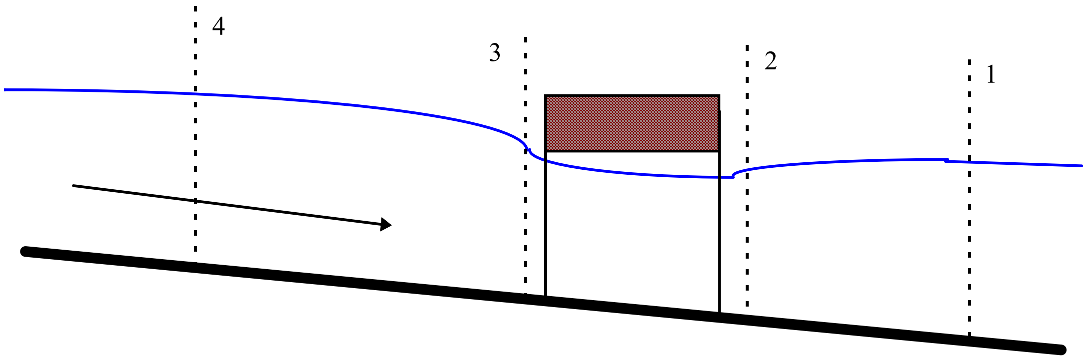

Figure 3.8: Cross-section locations near a bridge
(After US Army Corps of Engineers, 1995)

There are three different methods available for calculating losses through the bridge (section 2 to 1). These are:

- Energy Equation (standard step method)
- Momentum Balance
- Yarnell Equation

Energy Equation (Standard Step Method):

Similar to the application of the standard step method to solve the energy equation on a natural river cross-section, a bridge is treated in the same way. However, the area of the bridge below the water surface is subtracted from the total area and the wetted perimeter is increased where the water is in contact with the bridge structure. The program produces two cross-sections inside the bridge by combining the ground information of sections 2 and 3 with the bridge geometry (see **Figure 3.9**). These cross -sections are named as BD (bridge downstream) and BU (bridge upstream).

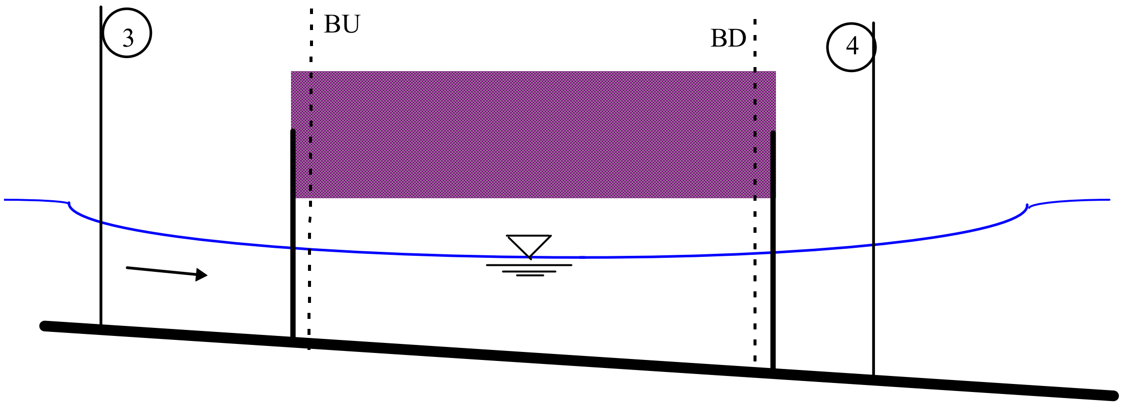

Figure 3.9: Cross sections near and inside the bridges.
(After US Army Corps of Engineers, 1995)

The computation starts with a standard step calculation from just downstream of the bridge (section 2) to just inside of the bridge (section BD) at the downstream end. Then, the program performs a standard step through the bridge (from section BU to section 3). Lastly, the water surface profile from section BU to section 3 is computed.

Momentum Balance Method:

There are three steps in which the momentum balance is performed. These steps are in the same manner as in the energy method. The first step is to achieve a momentum balance from cross-section 2 to cross section BD inside the bridge. The following equation is used for this momentum balance.

$$A_{BD}\overline{Y}_{BD} + \frac{\beta_{BD} Q_{BD}^2}{gA_{BD}} = A_2\overline{Y}_2 - A_{P2}\overline{Y}_{P2} + \frac{\beta_2 Q_2^2}{gA_2} + F_f - W_x \text{........[3.24]}$$

where: A_2, A_{BD} = Active flow area[††] at section 2 and BD, respectively

A_{P2} = Obstructed area of the pier on the downstream side

$\overline{Y}_2, \overline{Y}_{BD}$ = Vertical distance from water surface to centre of gravity of flow area A_2 and A_{BD}, respectively.

$\overline{Y}_{P2}$ = Vertical distance from water surface to centre of gravity of wetted pier area on the downstream side.

In the second step, a momentum balance from section BD to BU is performed. The equation for this step is given as follows:

$$A_{BU}\overline{Y}_{BU} + \frac{\beta_{BU}Q_{BU}^2}{gA_{BU}} = A_{BD}\overline{Y}_{BD} + \frac{\beta_{BD}Q_{BD}^2}{gA_{BD}} + F_f - W_X \text{..........[3.25]}$$

The third step is a momentum balance from section BU to section 3. For this step, the following momentum equation is used.

$$A_3\overline{Y}_3 + \frac{\beta_3 Q_3^2}{gA_3} = A_{BU}\overline{Y}_{BU} + \frac{\beta_{BU}Q_{BU}^2}{gA_{BU}} + A_{P3}\overline{Y}_{P3}$$

$$+\frac{1}{2}C_D\frac{A_{P3}Q_3^3}{gA_3^2} + F_f - W_x \text{..[3.26]}$$

where: C_D = Drag coefficient for flow going around piers. **Table 3.2** shows some typical drag coefficients used for piers.

[††] See section 3.4 program limitations and assumptions

Table 3.2: Typical Drag Coefficients

(HEC-RAS Hydraulic Reference Manual, 1995)

PIER SHAPE	DRAG COEFFICIENT, C_D
Circular Pier	1.2
Elongated Piers with semi-circular ends	1.33
Elliptical Piers with 2:1 length to with	0.60
Elliptical Piers with 4:1 length to with	0.32
Elliptical Piers with 8:1 length to with	0.29
Square Nose Piers[‡‡]	2.00
Triangular Nose with 30 degree angle	1.00
Triangular Nose with 60 degree angle	1.39
Triangular Nose with 90 degree angle	1.6
Triangular Nose with 120 degree angle	1.72

Drag coefficients are used to evaluate the force due to the water moving around the piers, the separation of the flow, and the resulting wake that occurs downstream.

Yarnell Method:

The Yarnell method is based on an empirical equation that is used to determine the change in water surface from just downstream of the bridge (section 2) to just upstream of the bridge (section 3). This equation is derived from experimental results (US Army Corps of Engineers, 1995). The equation is as follows:

$$H_{3-2} = 2K_y(K_y + 10\omega - 0.6)(\alpha_o + 15\alpha_o{}^4)\frac{V_2^2}{2g} \text{ ....[3.27]}$$

where:H_{3-2} = The drop in water surface from section 3 to 2.

[‡‡] Due to inadequate data, it was assumed that all piers had a square nose shape

K_y = Yarnell's pier shape coefficient.

ω = Ratio of velocity head to depth at section 2.

α_o = Obstructed area of the piers divided by the total unobstructed area.

While the Yarnell equation is sensitive to the pier shape, the pier obstructed area and the velocity of the water, it is not sensitive to the shape of the bridge opening, and the shape of the abutments. Therefore, it is recommended that it should only be used at bridges where the majority of the energy losses are associated with the piers. Some examples of Yarnell's pier coefficient, K, are given in **Table 3.3.**

Table 3.3: Yarnell's Pier Coefficient for different pier shapes
(HEC-RAS Hydraulic Reference Manual, 1995)

PIER SHAPE	YARNELL K COEFFICIENT
Semi-circular nose and tail	0.90
Twin-cylinder piers without diaphragm.	1.05
90 degree triangular nose and tail	1.05
Square nose and tail	1.25
Ten pile trestle bent	2.5

Class B Low Flow:

Class B flow can occur for either subcritical or supercritical profiles that pass through critical depth in the bridge constriction. An upstream water surface profile (section 3) above critical depth and a downstream water surface (section 2) below critical depth can be calculated using either the momentum or energy method for a subcritical flow condition. For a supercritical flow condition the bridge acts as a control and causes the upstream water surface elevation to be above critical depth. In this case, again either the momentum or energy method can be used to compute an upstream water surface above critical depth and a downstream water surface below critical depth.

Class C Low Flow:

Class C low flow exists when the water surface through the bridge is completely supercritical. Either the momentum or the energy method can be chosen for the computation of water surface profile through the bridge.

3.3.6.2 High Flow Computations:

When the flow comes into contact with the maximum low chord of the bridge deck, the flow is called high flow. The computation of the high flow can be achieved by using either energy (standard step method) or hydraulic equations for pressure and / or weir flow

Since the energy based method is applied to high flows in the same manner as it is applied to low flows, only the pressure and weir flow method are explained in this section.

Pressure and Weir Flow:

Apart from the energy method, there are two methods available in the program for the computation of high flows; pressure and weir flow.

Pressure Flow Computations:

Pressure flow occurs when the flow comes into contact with the low chord of the bridge. Once the flow comes into contact with the upstream side of the bridge, a backwater occurs and orifice flow is established. Orifice flow computation is performed in two different cases. The first is when only the upstream side of the bridge is in contact with the water and the second is when the bridge constriction is flowing completely full. For the former case (see **Figure 3.10**) the sluice gate type of equation given below is used.

$$Q = c_d A_{BU}\left[2g\left(Y_3 - \frac{Z}{2} + \frac{\alpha_3 V_3^2}{2g}\right)\right]^{\frac{1}{2}} \quad \text{[3.28]}$$

where: Q = Total discharge through the bridge opening.

c_d = Coefficient of discharge for pressure flow.

A_{BU} = Net area of the bridge opening at section BU.

Y_3 = Hydraulic depth at section 3.

Z = Vertical distance from maximum bridge low chord to the mean river bed elevation at section BU.

The discharge coefficient, c_d, depends on the depth of the water upstream. It changes from 0.35 to 0.5. The user can either input this coefficient or leave the program to determine a suitable value based on the amount that the inlet is submerged.

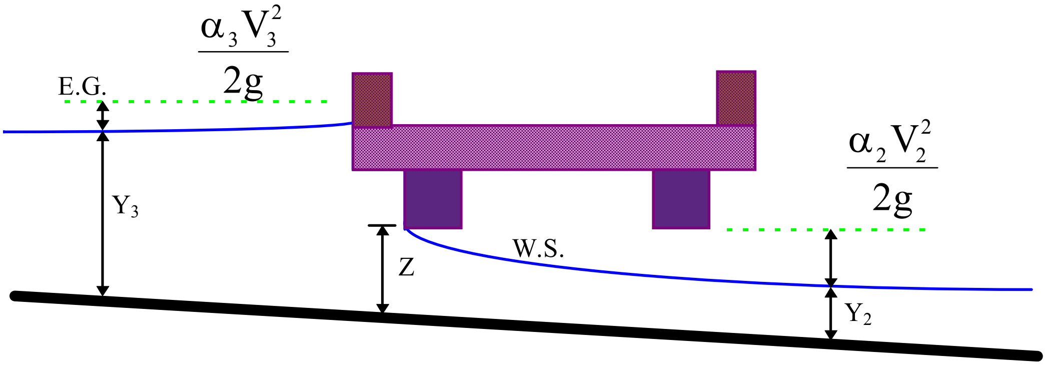

Figure 3.10: A bridge under sluice gate type of pressure flow (After US Army Corps of Engineers, 1995)

In the latter case, since both the upstream and downstream sides of the bridge are submerged (see **Figure 3.11**), the standard full flowing equation is used This equation is given as follows.

$$Q = c_d A\sqrt{2gH} \quad \text{[3.29]}$$

where: c_d = Coefficient of discharge for fully submerged pressure flow.

H = The difference between the energy gradient elevation upstream and the water surface elevation downstream.

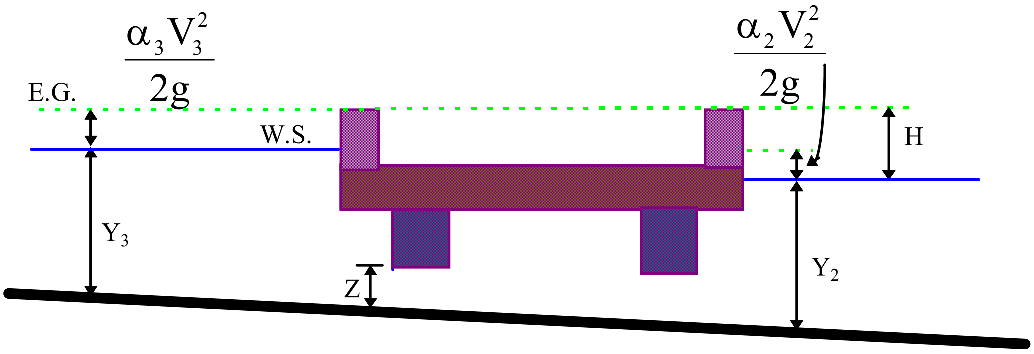

Figure 3.11: A bridge under fully submerged pressure flow
(After US Army Corps Of Engineers, 1995)

Weir Flow Computations:

Flow over the bridge and the roadway approaching the bridge (see **Figure 3.12**) is evaluated by using the following standard weir equation.

$$Q = c_d L H^{\frac{3}{2}} \quad \text{[3.30]}$$

where: Q = Total flow over the weir

c_d = Coefficient of discharge for weir flow.

L = Effective length of the weir

H = Difference between energy upstream and road crest

Under free flow conditions (discharge independent of tailwater) the coefficient of discharge c_d, ranges from 1.38 to 1.71.

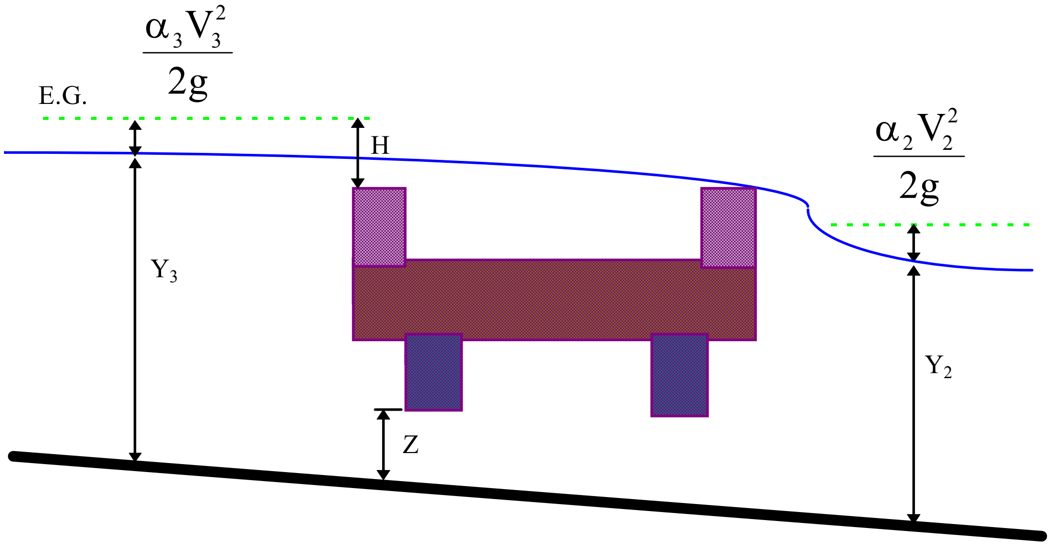

Figure 3.12: A bridge with weir flow

(After US Army Corps of Engineers, 1995)

3.4 PROGRAM LIMITATIONS AND ASSUMPTIONS

The modellers (US Army Corps of Engineers) made the following assumptions to set up the HEC-RAS.

1- Flow is steady

2- Flow is gradually varied (except at hydraulic structures such as bridges, culverts and weirs. At these locations where the flow can be rapidly changed, the momentum equation is used).

3- Flow is one-dimensional (i.e., velocity components in directions other than the direction of flow are not accounted for).

4- River channels have ‘small slopes’, i.e. less than 1:10.

In addition to assumptions made by them, the following assumptions were also made.

1- All piers had a square nose shape

2- The program allows the user to define ineffective areas in which the water is not actively being conveyed. These areas are used to describe portions of a cross-section in which water will pond. While this water is included in the storage calculations and other wetted cross-section parameters, it is not included as part of the active flow area. When using ineffective flow areas, no additional wetted perimeter is added to the effective flow area. Ineffective areas become effective when weir flow exits.

In this project, for cross-section 2 and 3, it was assumed that ineffective flow areas occurred to either side of the bridge opening for low flow and pressure flow (see **Figure 3.13**).

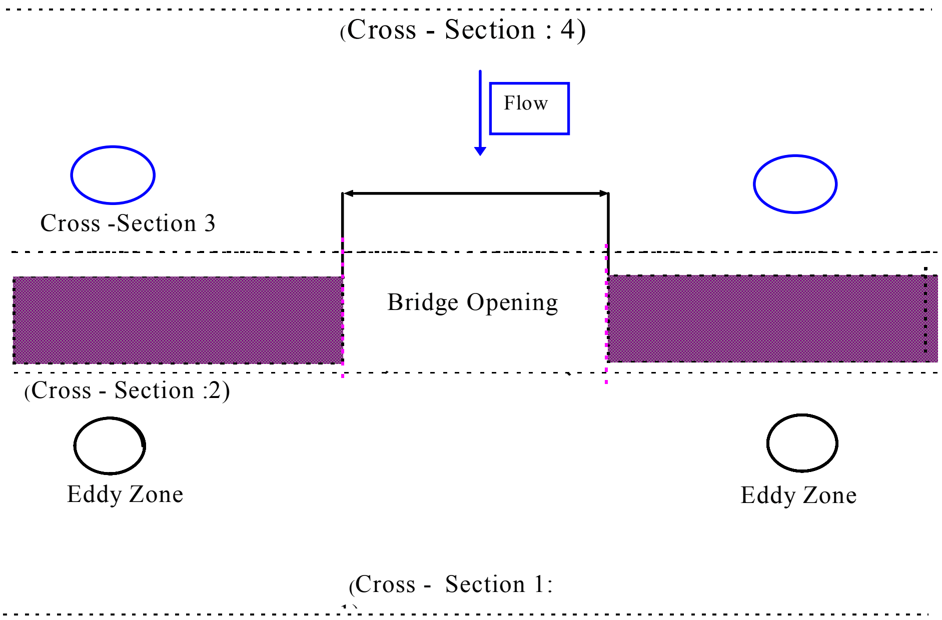

Figure 3.13: Determination of ineffective flow areas

CHAPTER 4

ISIS: ONE-DIMENSIONAL UNSTEADY MODEL

4.1 BRIEF INTRODUCTION TO ISIS

In this section, only brief information about ISIS is given because it was used by JBA. The reader can consult 'ISIS Flow User Manual' (1995) for more information.

ISIS is a one-dimensional model used for computations of both steady and unsteady flow in a river. The equations used to describe the motion of a body of water flowing in open channel are continuity and momentum conservation (dynamic). These equations are also called St Venant equations. These equations are given in ISIS Flow User Manual as follows:

Continuity Equation:

$$\frac{dQ}{dx}+\frac{dA}{dt}=q \qquad [4.1]$$

where: q = Lateral inflow ($m^3s^{-1}m^{-1}$)

x = Longitudinal channel distance (m)

t = times

Momentum (dynamic) Equation:

$$\frac{dQ}{dt}+\frac{d}{dx}\left(\frac{\beta Q^2}{A}\right)+gA\frac{dy}{dx}-g\frac{AQ|Q|}{K^2}=0 \qquad [4.2]$$

These equations are solved by using the finite difference approximations of the Preissmann scheme (the 4-point box scheme). The scheme is shown in **Figure 4.1**.

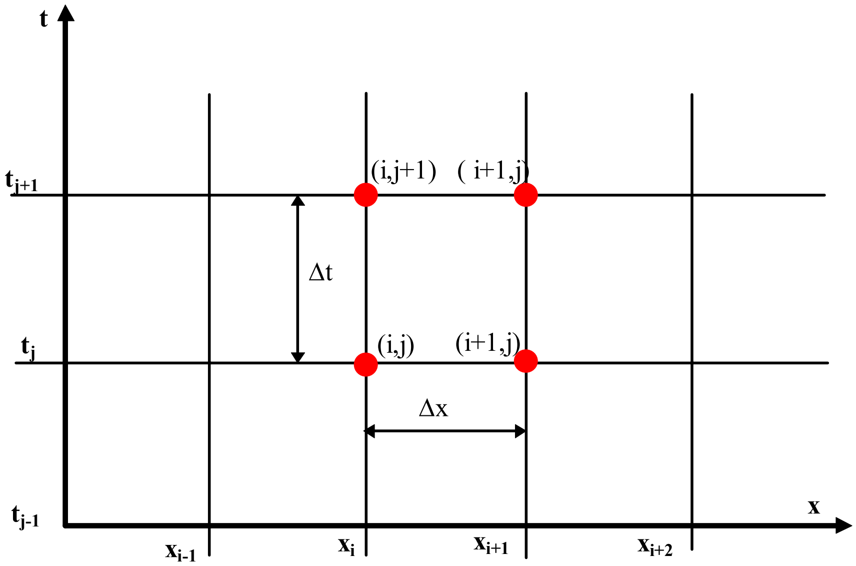

Figure 4.1: The Preissmann Scheme (4-point box scheme)

Let f be the value of depth or discharge or a function of depth or discharge at point $(i+\frac{1}{2}, j+\theta)$.

The value of f or its continues derivatives with respect to time or space can be discretised as:

$$f(x,t) = \frac{1}{2}\left[\theta\left(f_{i+1}^{j+1} + f_i^{j+1}\right) + (1-\theta)(f_{i+1}^{j} + f_i^{j}\right] \text{.........................[4.3]}$$

$$\frac{df}{dx} = \frac{1}{2\Delta x}\left[\theta\left(f_{i+1}^{j+1} - f_i^{j+1}\right) + (1-\theta)\left(f_{i+1}^{j} - f_i^{j}\right)\right] \text{.......................[4.4]}$$

$$\frac{df}{dt} = \frac{1}{2\Delta t}\left[\left(f_{i+1}^{j+1} - f_{i+1}^{j}\right) + \left(f_{i}^{j+1} - f_{i}^{j}\right)\right] \qquad [4.5]$$

where : θ = Weighting factor lying between 0.5 and 1

f_i^j = The value of f evaluated at the point (x_i, t_i)

Using the above finite difference approximations, de Saint-Venant equations can be transformed into the linear form:

$$aQ_I^{J+1} + by_I^{J+1} + cQ_{I+1}^{J+1} + dy_{I+1}^{J+1} = e \qquad [4.6]$$

The values of a, b, c, d and e are calculated for each iteration and each node in the open channel and depend on variables calculated at the previous iteration or timestep.

The coefficient matrix that consists largely of the a, b, c, d and e values described above is solved to evaluate Q and y at the following iteration or timestep.

The energy losses such as those caused by a sudden contraction or expansion are determined by a Bernoulli loss that relates the head loss to the square of the upstream velocity head.

The program is capable of bridge modelling, various types of weir (sharp crested weir, round nosed weir etc.).

The assumptions made in order to derive the de Seint-Venant equations are as follows:

1- The flow is one-dimensional; i.e. a single velocity and elevation can be used to describe the state of the water body in a cross-section.

2- The streamline curvature is small and vertical accelerations negligible; hence the pressure is hydrostatic.

3- The effects of boundary friction and turbulence can be accounted for by representations of channel conveyance derived from steady state flow.

4- The average channel bed slope is small enough that the small angle approximation can be used.

5- All the functions and variables are continuous and differentiable.

4.2 ATTENUATION

When the storm water flows downstream, the shape of the flood hydrograph is changed in two ways. Firstly, the time of the peak rate of flow occurs later at downstream points. This is known as translation. Secondly, the magnitude of the peak rate of flow is diminished at downstream points, the shape of the hydrograph flattens out, and the volume of flood water takes longer to pass a lower section. This modification to the hydrograph is called attenuation (Shaw, 1994). **Figure 4.1** shows these modifications to the hydrograph. In this figure A represents upstream hydrograph and B represents downstream hydrographs.

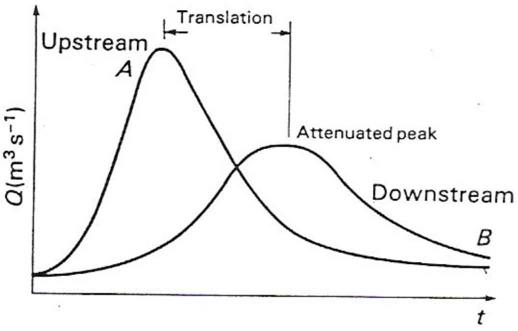

Figure 4.2: The modifications in the flood hydrograph
(After Shaw, 1994)

4.2.1 DETERMINATION OF ATTENUATION RATE PARAMETER

The attenuation rate parameter was computed by using equation [2.1] given in Chapter 2. Since it was assumed that an unsteady model was not available, the local mean velocity and the mean surface width in this equation were taken from the results of the steady model in which the peak discharge was used. To determine the terms in this equation the following steps were taken.

1- Determination of bed slope:

The reach was divided into 9 regions with respect to the variations in its bed level (**Figure 4.2).** For each region an average linear line was drawn between the min. channel elevation points and the slope of each line was computed. The mean slope was assumed the arithmetic mean of these slopes and given in **Table 4.1.**

The readers can see the minimum channel elevations for each coss-section and the cross-section spacing in **Appendices, Table A2.**

Table 4.1 The bed slope of each region

Region	Slope
1	0.0013
2	0.0023
3	0.0008
4	0.0015
5	0.001
6	0.0023
7	0.0013
8	0.0015
9	0.0016
Average	0.00151

2- Determination of the curvature of the peak of the flood hydrograph, χ :

The values of flood discharge-time relationships (flood hydrograph) observed in 1987 are given in **Table 4.2.** As can be seen from the table, the peak discharge and the discharges before and after the peak are 105, 104.5, 104.5 m^3s^{-1} respectively. The time between the occurrence of discharges before and after the peak is 1 hour. Therefore, using equation [2.2] given below, χ can be determined as follows.

$\chi = (2Q_P - Q^- - Q^+)/(3600T)^2$

$\chi = (2*105-104.5-104.5)/\ (3600*1)^2 = 1.6203*10^{-5}\ m^3s^{-3}$

Table 4.2: The values of flood hydrograph

Time (sec.)	Q (m^3s^{-1})	Time (sec.)	Q (m^3s^{-1})
0.0000	3.000	27000	105.0
1800.0	5.000	28800	104.5
3600.0	9.000	30600	103.5
5400.0	14.00	32400	101.0
7200.0	20.50	34200	95.00
9000.0	30.00	36000	85.00
10800	40.00	37800	63.00
12600	51.00	39600	44.00
14400	63.00	41400	31.00
16200	75.00	43200	22.50
18000	88.00	45000	16.00
19800	97.50	46800	11.50
21600	101.0	48600	7.500
23400	103.5	50400	4.000
25200	104.5		

3- Determination of the mean surface width: B

To determine the mean surface width, the values of the surface width for each cross-section inside the reach were summed up and then the total number was divided into the number of cross-sections. These procedures were repeated for the different cases explained below and determined mean surface width for all the cases are given in **Table 4.3.**

Case 1: It was assumed that there was no bridge along the reach and that Manning's roughness values were 0.05, 0.04, 0.05 for left overbank, channel and right overbank respectively. These values are actually given as real roughness values of the bed of the reach.

Case 2: All bridges were taken into account along the reach and Manning's values were taken to be the same as in Case 1.

Case 3: Similarly to Case 1 no bridge was considered but the roughness values were changed and considered as 0.06, 0.05, 0.06.

Case 4: Again it was assumed that there were bridges and the roughness values were taken to be the same as in Case 3.

These cases were analysed by both using the steady and the unsteady models and referred throughout the thesis.

Table 4.3: The values of the mean surface width,
(obtained from the Steady Model' Results)

Case 1	Case 2	Case 3	Case 4
The mean surface width (m)			
45.19	47.8	48.48	50.16

4- Determination of the mean propagation speed: c

To be able to estimate the mean propagation speed for the reach, equation [2.3] was used. Similar to the determination of the mean surface width, the mean local velocity for each case was computed in order to use equation [2.3]. The values of the local mean velocity and the propagation speed are given in **Table 4.4.**

Table 4.4 : The local mean velocity and corresponding propagation speed,
(obtained from the Steady Model' Results)

Case 1	Case 2	Case 3	Case 4
The mean local velocity (m/s)			
1.45	1.28	1.24	1.13
The mean propagation speed (m/s)			
2.47	2.18	2.11	1.92

5- Determination of attenuation rate parameter

Using equation [2.1] the attenuation rate parameter for each case was evaluated and given in **Table 4.5**

Table 4.5: Attenuation Rate Parameter

Case No	x	B (m)	S	c (m/s)	γ
1	$1.6203*10^{-5}$	45.19	0.00151	2.47	$7.87*10^{-6}$
2	$1.6203*10^{-5}$	47.8	0.00151	2.18	$1.08*10^{-5}$
3	$1.6203*10^{-5}$	48.48	0.00151	2.11	$1.18*10^{-5}$
4	$1.6203*10^{-5}$	50.16	0.00151	1.92	$1.51*10^{-5}$

The reader can see the computed surface width and velocity in each cross-section for these 4 different cases in **Appendices, Table A2, A3, A5, A6.**

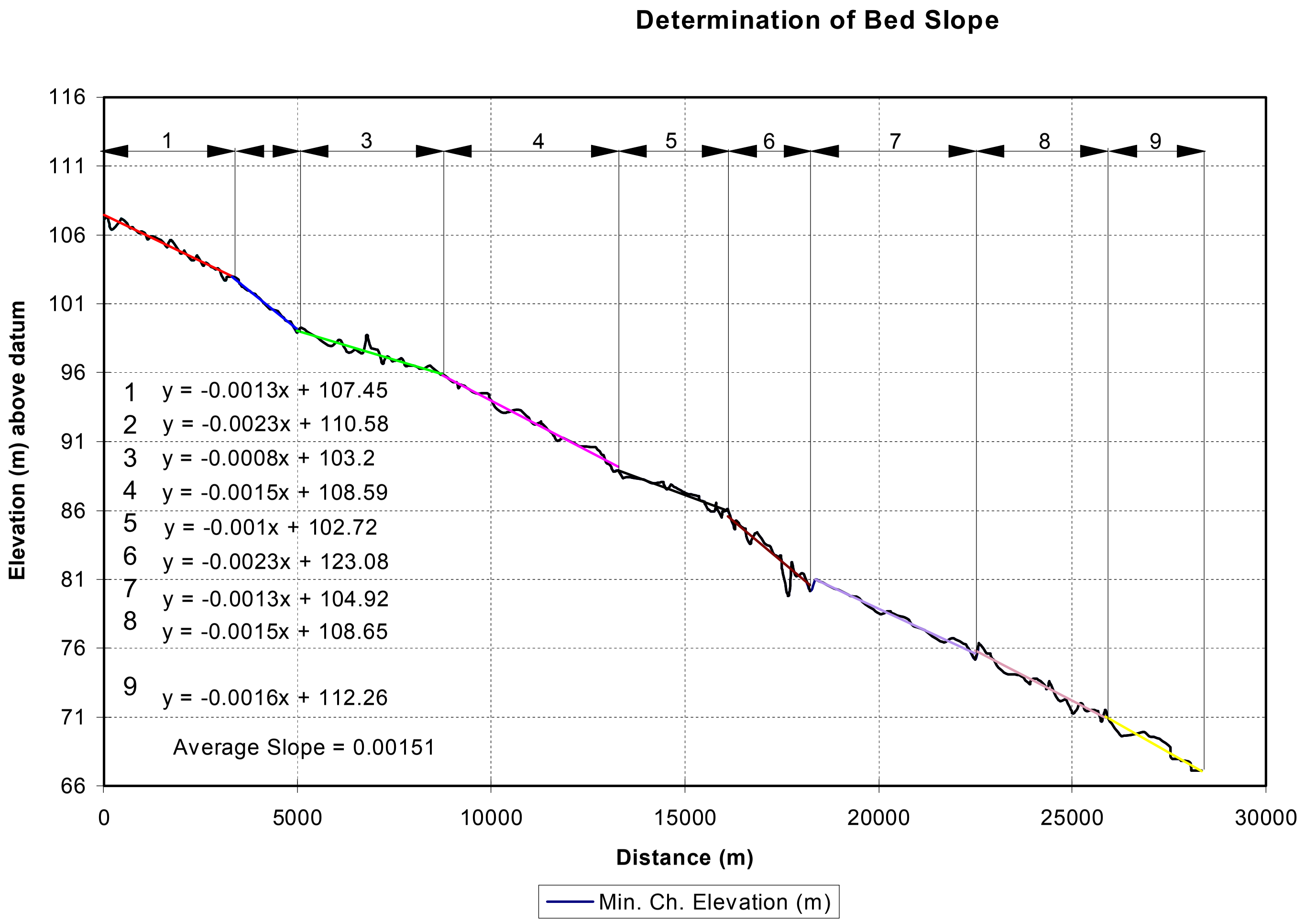

Figure 4.3: Determination of the bed slope of the reach of the River Tame

CHAPTER 5

RESULTS

5.1 INTRODUCTION

This chapter deals with the overall results. It consists of comparisons between the water surface profiles obtained from the steady and the unsteady flow computations, and shows the role of the attenuation rate parameter in a decision about how steady model can be used in unsteady flow conditions. During the computations the peak flow rate was used in the steady model (except for drawing the rating curves and examining the effects of bridges on the water surface profiles) and the acceptability of the use of the steady model was examined according to this flow rate. The use of peak discharge is actually inevitable unless the attenuated peak discharge for each cross-section is known. To be able to know the attenuated flow rate the unsteady flow computations should be made. However, the main idea behind this study is to find suitable conditions for the use of a steady model in unsteady flow conditions without doing the unsteady flow computations.

As mentioned before bridges affect the water surface profiles. Their effects were firstly analysed by using the steady model and then the comparison was made between the steady and unsteady flow computation results with respect to the water surface profiles.

Attenuation rate parameters were calculated in Chapter 4 for Case 1,2,3 and 4. In this section, the role of attenuation rate parameter in the selection of a mathematical model was investigated.

Roughness values for the left overbank, channel and right overbank were increased to raise the unsteadiness of the flow. Although they were also decreased to reduce the unsteadiness of the flow, the result could not be presented in this chapter due to a problem which will be explained in the next chapter. To modify the unsteadiness of the flow the bed slope or other geometric data such as cross-section elevation and station points could have been changed. However, because one of the goals of this study is also to have an idea about the acceptability of the use of the steady model for the reach of the River Tame, those changes have not been made. Therefore, the roughness values that were also easily changed were preferred to modify the unsteadiness of the flow. To illustrate the increase in the unsteadiness of the flow, for both Case 1 and Case 3 unsteady flow rating curves at the first 5 cross-sections were drawn.

In the presentation of the results graphical views instead of numerical values were preferred due to the large sizes of numerical values. Nevertheless, the values which were used to provide the graphical views are given in the appendices**.**

5.2 EFFECTS OF BRIDGES ON THE USE OF STEADY MODEL

5.2.1 STEADY ANALYSIS

As mentioned in Chapter 2, some researchers proposed that selection of a steady model cannot be suitable if the transient effects of hydraulic structures are considered. In this section the effects of bridges on the water surface profiles were briefly investigated by running the steady model at two different flow rates with both the existence and the absence of bridges in the river.

From the unsteady model results, it has been seen that the peak discharge attenuated downstream points and varied from 105 to 88.199 m^3s^{-1} (Case 2, **see appendices, Table A9**). To see the effects of bridges the use of only the peak discharge in the steady model may not be valid because when the discharge diminishes downstream points, the water surface elevations also decrease at the downstream cross-sections.

Moreover, the transient effects of bridge can be reduced at these locations and the type of the flow (open channel, pressure, weir flow) may also be changed. Therefore, the peak discharge 105 m^3s^{-1} and the attenuated peak discharge 88.2 m^3s^{-1} were used in the steady model. This analysis showed that at downstream bridge locations the transient effects of bridges reduced when using the attenuated peak discharge. In addition, at cross-section no: 920, while at the peak flow rate a weir flow occurred, at the attenuated peak discharge a pressure flow occurred (**see appendices, Table A4)**.

The steady model results also indicated that the transient effects of bridges were very significant at a location where the slope was not steep compared with other regions, where the number of bridges was higher or where pressure flow or weir flow occurred (**Figure 5.1**[*]**).** For instance, at both the peak and the attenuated peak flow rate the maximum differences between the water surface elevations obtained from the cases with bridges and without any bridge in the river were found between cross-section No: 17900 and 15780 where pressure and weir flow occurred and the bed slope was 0.0008 (**Figure 5.2).** As can be seen from **Figure 5.3** there are also considerable differences on the water surface profiles between cross-section No:9461 and 8944. The reason could be the density of the bridges in this region. In these figures the abbreviation 'br.' refers to the case with bridges. Some numerical values of the water surface elevations at the locations mentioned above are given in **Table 5.1**.

Table 5.1: Effects of bridges on the water surface profiles (Discharge: 105, 88.2m^3s^{-1})

Cross-Section No	Bridges (Water S. Elev., m)	No Bridge (Water S. Elev., m)	Difference (m)
17200	102.49, 101.98	100.95, 100.65	1.54, 1.33
15780	101.13, 100.5	99.27, 98.98	1.86, 1.52
9461	92.32, 91.71	91.31, 91.04	1.01, 0.67
9068	92.06, 91.41	90.49, 90.16	1.57, 1.25

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[*] See the numerical values Steady Analysis Case 1 and Case 2, Appendices, Tables A2, A3

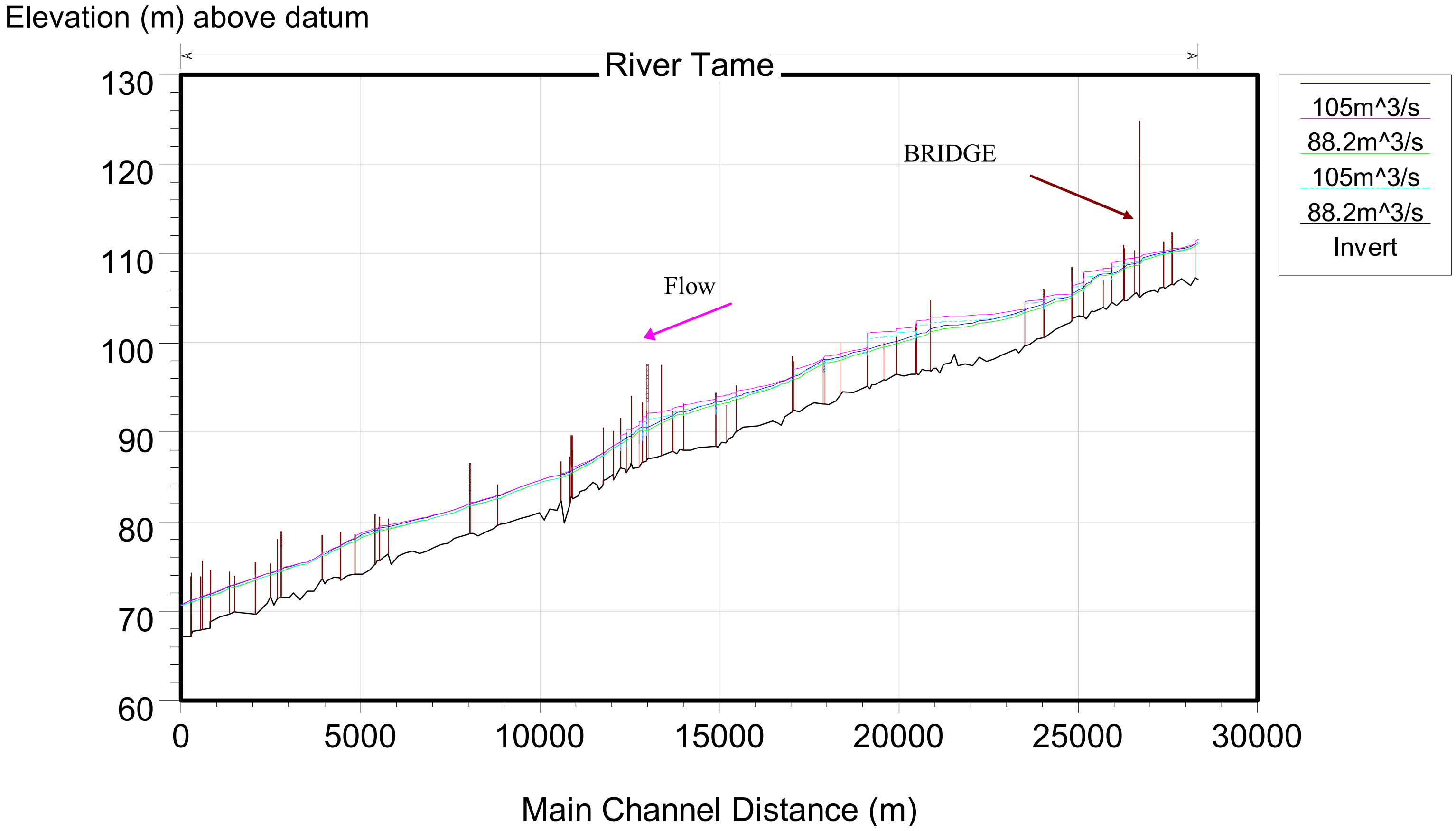


Figure 5.1: The effects of the bridges on the water surface profiles, steady flow analysis

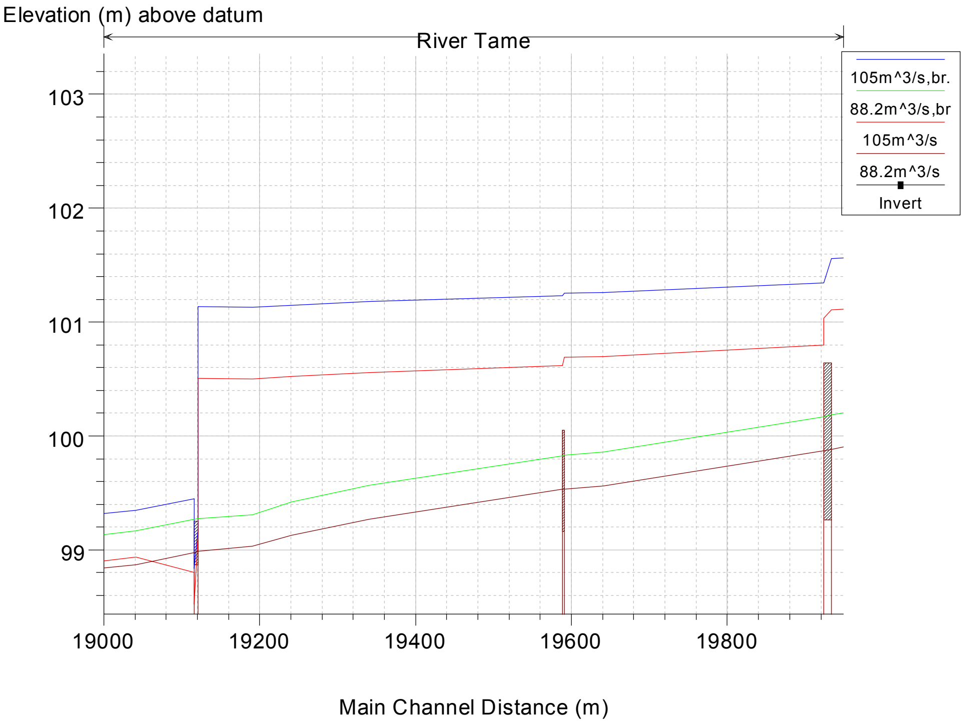


Figure 5.2: Pressure and Weir Flow and their effects on the water surface profiles at the location where the maximum differences on the water surface profiles were detected.

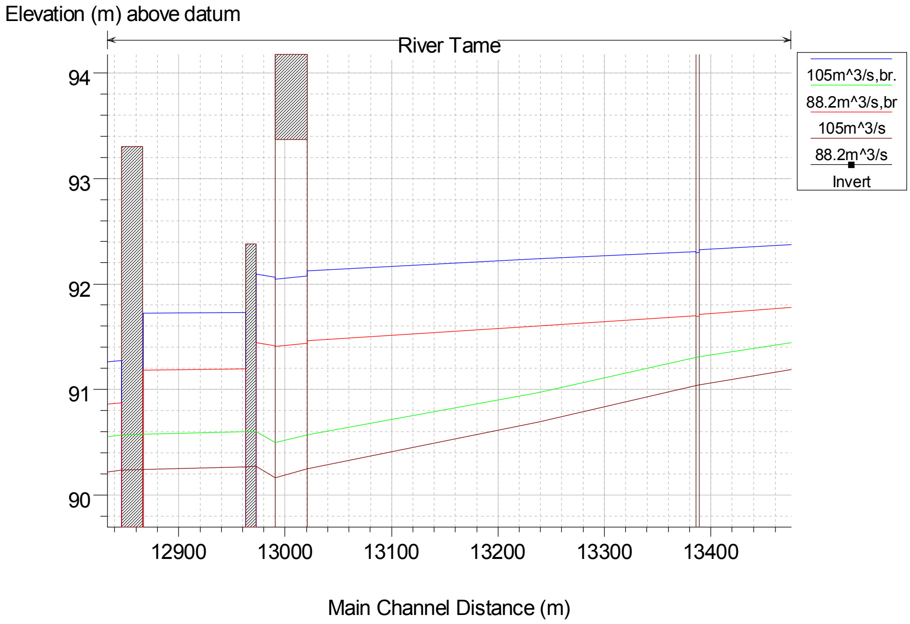


Figure 5.3: The location where the considerable changes in the water surface profiles were found and density of the bridges were higher than other locations

5.2.2 COMPARISON OF THE WATER SURFACE PROFILES

In order to see the effects of bridges on the use of a steady model in the unsteady flow conditions, not only the steady model but also the unsteady model were used. While for the steady model again the peak discharge was employed for the cases with and without bridges, the unsteady model was run by selecting time step 60 seconds until the flow became steady along the reach for the same cases. In addition, the maximum water surface elevations obtained from the unsteady model and occurred in a certain time for each cross-section, were compared with that of the steady model.

The results showed that a good agreement between the water surface profiles was achieved for the cases with no bridges. For instance, while the maximum difference between the water surface profiles obtained from the steady and the unsteady flow was found 0.219 m at a cross-section no: 511 (**Figure 5.4, see also appendices; Table A2, Table A8**), the minimum difference was found 0.006 m. On the other hand, when there were bridges in the reach the results showed quite big differences between the water surface profiles. For example, the maximum difference was seen 1.6 m at a cross-section no: 15780 (**Figure 5.5, see also appendices; Table A3, Table A9**). This result agrees well with the steady analysis given in section 5.2.1. For instance, the steady flow analysis indicated that at the peak flow rate the maximum backwater effect of bridge was 1.86 m at this bridge location. In fact, the bed slope in this region was estimated as 0.0008 that was not as steep as in the other regions. Moreover, the pressure flow occurred. It should also be mentioned that there were energy dissipating baffle blocks under the bridge (**Figure 5.6**). Hence the backwater effect in this cross-section was more effective than the other bridge locations due to the slope that could increase the backwater effect of the bridge. The minimum difference was observed 0.062 m for this case.

As for the average total differences between the water surface profiles obtained from the steady and the unsteady models, while Case 2 with bridges indicated 0.37 m difference, Case 1 without bridges showed 0.11 m.

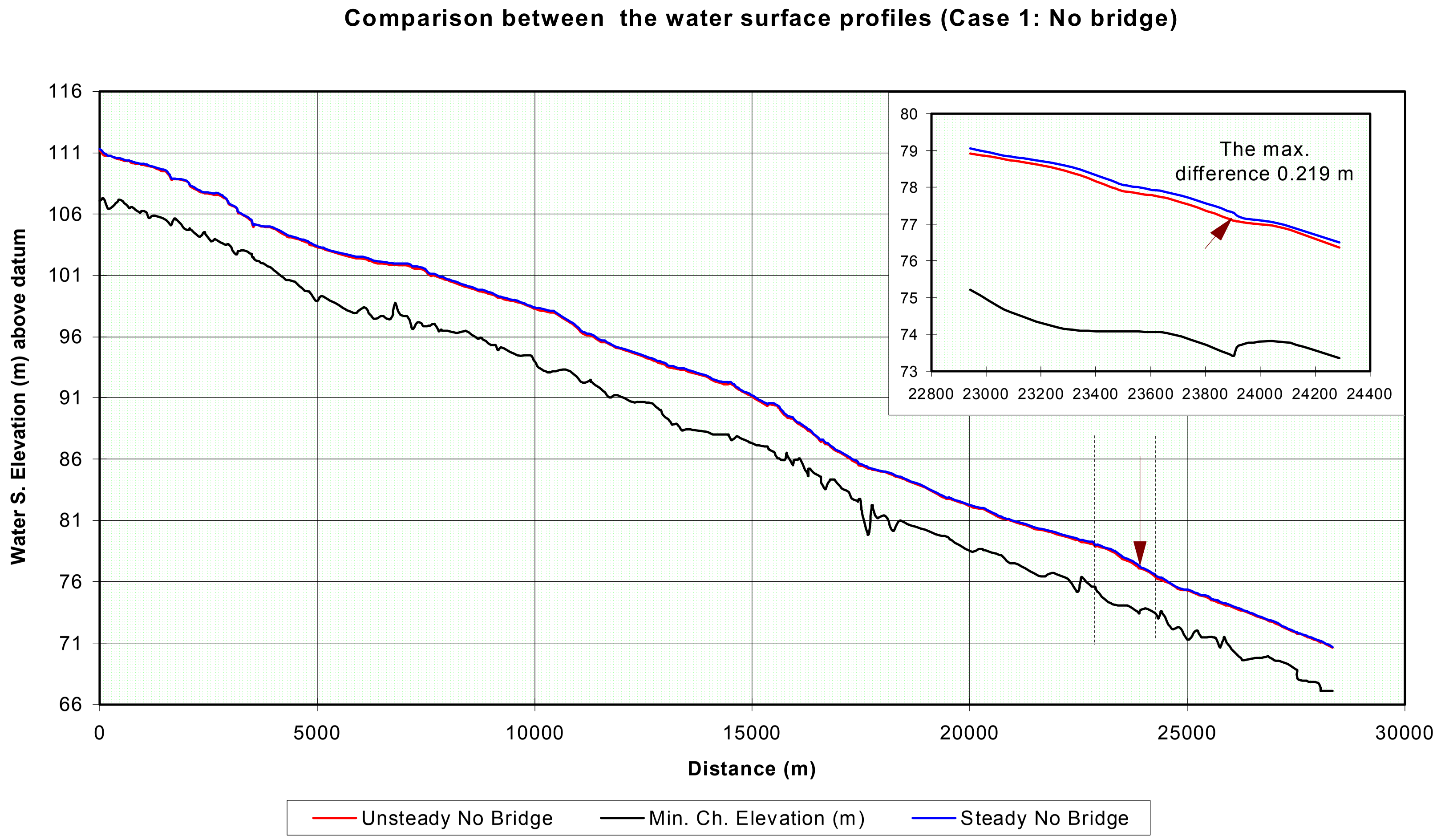


Figure 5.4: The water surface profiles obtained from the steady model (Case 1) and the unsteady model (Case 1)

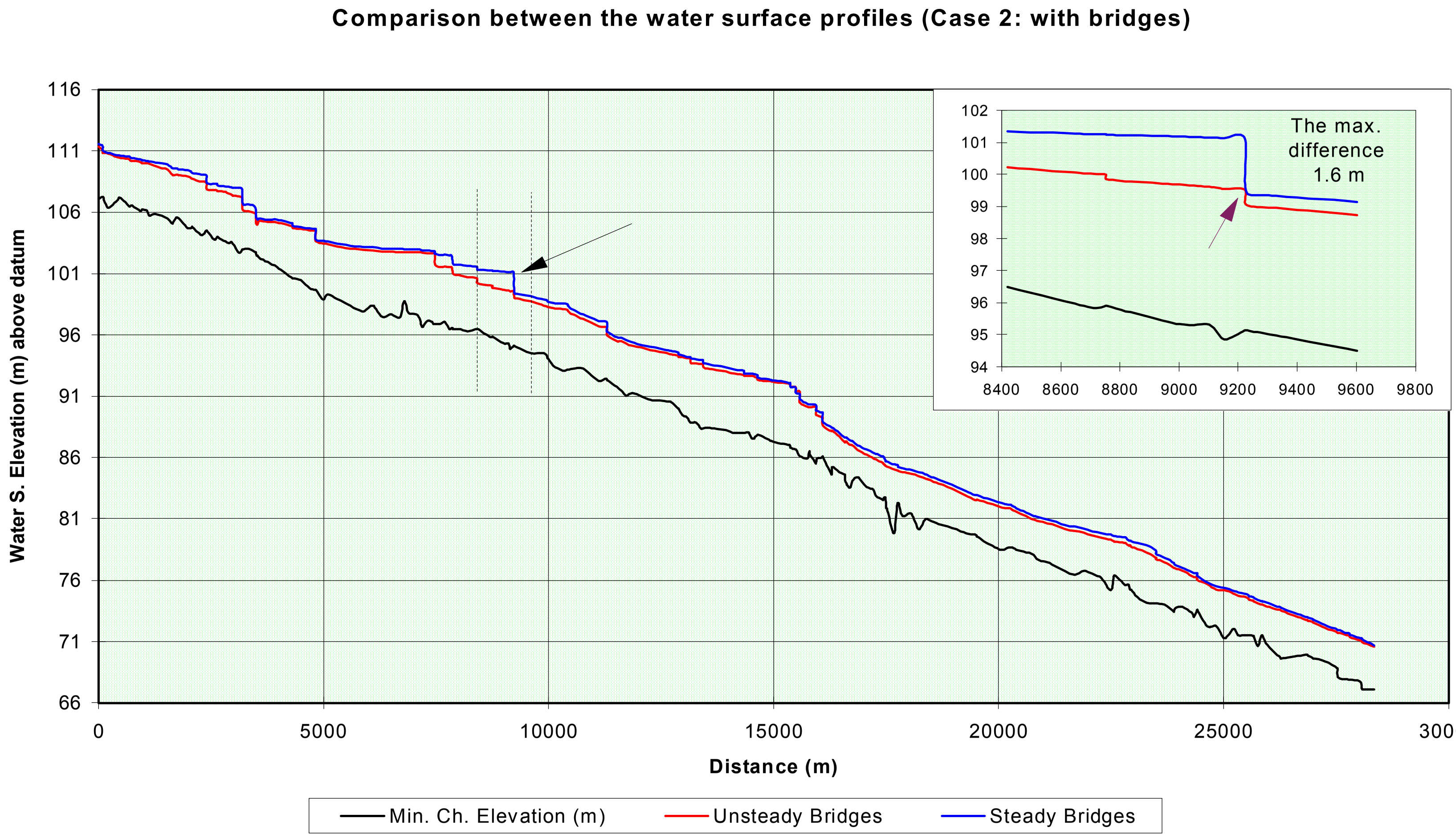


Figure 5.5: The water surface profiles obtained from the steady model (Case 2) and unsteady model (Case 2)

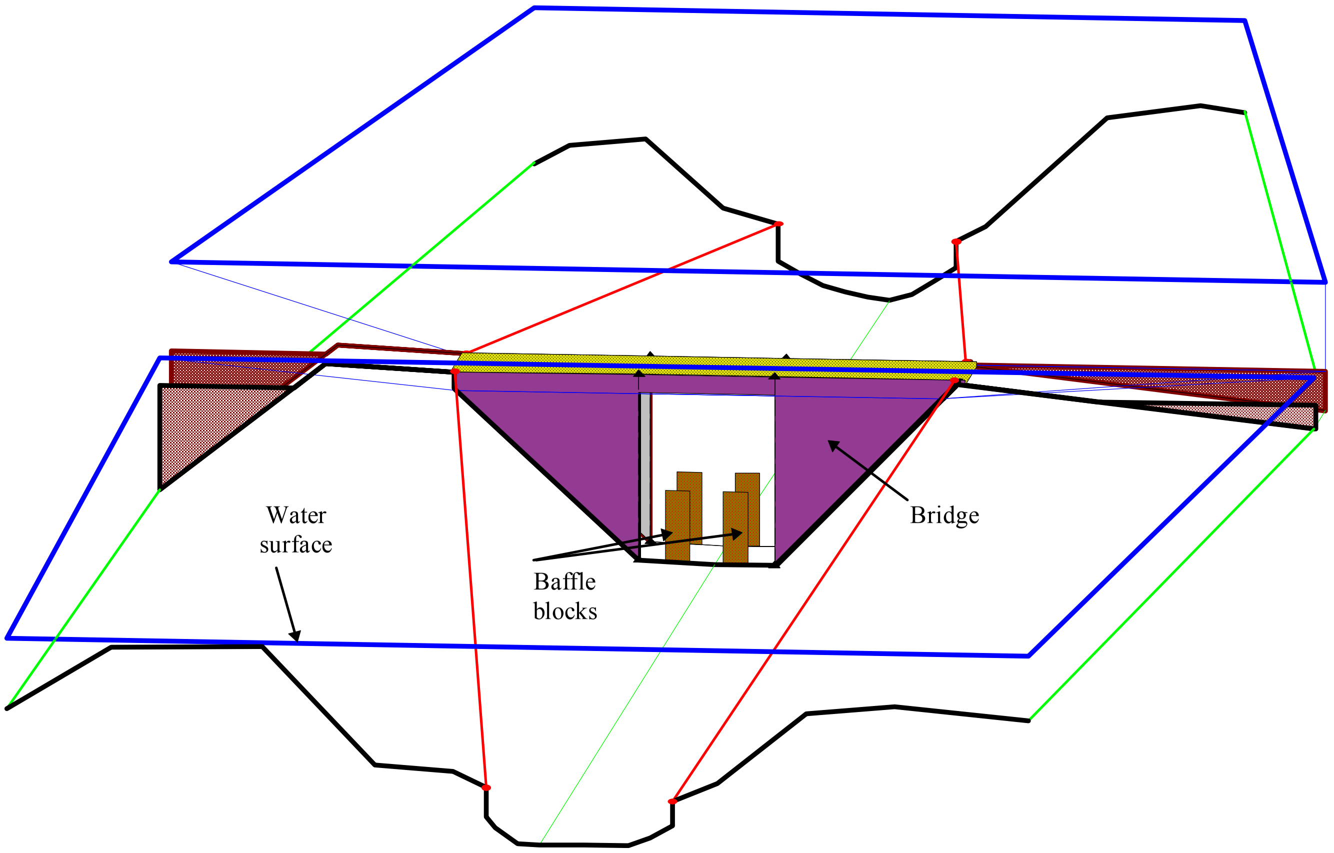


Figure 5.6: The occurrence of pressure flow at cross-section no: 15780

5.3 THE ROLE OF THE ATTENUATION RATE PARAMETER IN SELECTING A MODEL IN UNSTEADY FLOW CONDITIONS

One of the main criteria having an important role in the decision on whether the steady model can be suitable in unsteady flow conditions was chosen as the attenuation rate parameter. It was considered as the main criteria because according to previous research done by IWES (1987) the River Rhymney, which has an attenuation rate/m of $1.2*10^{-8}$, had been accepted for the use of a steady model whereas the River Severn, which has an attenuation rate/m of $1.5*10^{-5}$, had been found unsuitable for the use of a steady model.

The attenuation rate parameter was computed for each case and given in Chapter 4. The attenuation rate parameter depends on the mean water surface width, the bed slope, the mean propagation speed of the flood peak and the curvature of the flood hydrograph. To assess the validity of the attenuation rate parameter on the decision mentioned above, it was necessary to do some trials. The trials were produced by changing the roughness of the bed and omitting the bridges. An increase in the roughness resulted in a reduction in the velocity and an increase in the water surface elevations. As a result, the mean propagation speed of the wave also decreased. When the mean propagation speed of the wave decreased the attenuation rate parameter increased. Although the attenuation rate parameter was reduced by decreasing the roughness values and a quite good rate was achieved ($2.85*10^{-6}$), the comparison could not be made due to a problem. This problem is explained in **Chapter 6.** However, introducing the bridges resulted in a larger mean water surface width than found when there were no bridges. Consequently, another different attenuation rate parameter was able to be determined to make a comparison. In short, four different attenuation rate parameters were determined (Case 1, Case 2, Case 3, Case 4, see Chapter 4).

The results indicated that an increase in the attenuation rate parameter brought about comparatively big differences in the water surface profiles. In other words, when the attenuation rate parameter increased, the extent to which the steady model was valid for use in unsteady flow conditions declined. The attenuation rate parameter and the average total difference in the water surface profiles for each case are given in **Table 5.2.**

Table 5.2: The attenuation rate parameter and the average total difference in the water surface profiles

Case No	Attenuation Rate Parameter	The average total difference in the water surface profiles
1	$7.81*10^{-6}$	0.11
2	$1.08*10^{-5}$	0.37
3	$1.18*10^{-5}$	0.14
4	$1.51*10^{-5}$	0.32

It should be noted that although the attenuation rate parameter in Case 4 is bigger than in Case 2, the average total difference in the water surface profiles was found to be less than in Case 2. This problem is also explained in **Chapter 6**. Except for Case 2, when the attenuation rate parameters were plotted against the average total differences in the water surface profiles **Figure 5.7,** it can be clearly seen that when the attenuation rate parameter decreases, the average total difference also decreases. As a result, selection of a steady model instead of an unsteady model in an unsteady flow condition may be valid if there is a slight difference that is considered negligible for practical purposes.

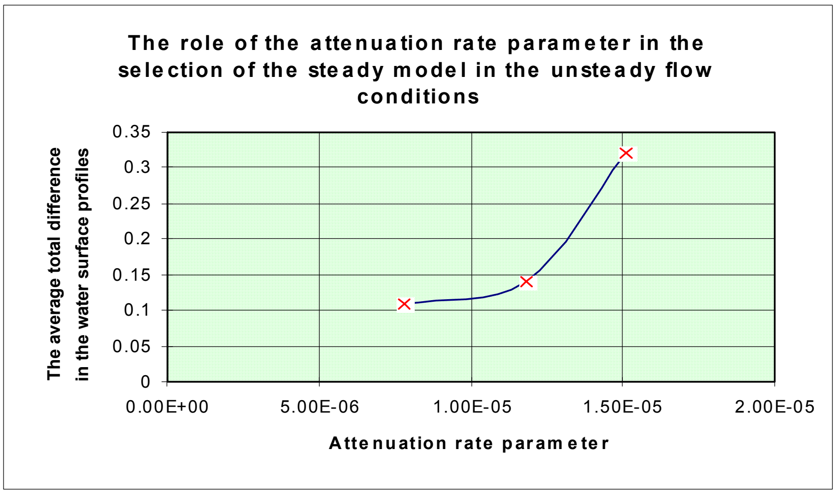


Figure 5.7: The role of the attenuation rate parameter in the selection of the steady model in the unsteady flow conditions

When looking at the unsteady model results, how much the peak discharge attenuated can be seen in **Table 5.3.** The relationship between the computed attenuation rate parameter and the difference between the peak and attenuated peak discharge for each case is given in **Figure 5.8.**

Table 5.3: Unsteady model results showing how much the peak discharge attenuated

Case No:	The peak and attenuated peak discharge (m^3s^{-1})	The difference between these two discharges
1	105-100.796	4.204
2	105-97.54	7.460
3	105-88.199	16.80
4	105-85.947	19.05

With respect to this table, it can be said that a good agreement was achieved between the calculated attenuation rate parameters and the differences between the peak and the attenuated peak discharge obtained from the unsteady model. This result also showed that there was something wrong with the water surface elevations obtained from the unsteady model for Case 2.

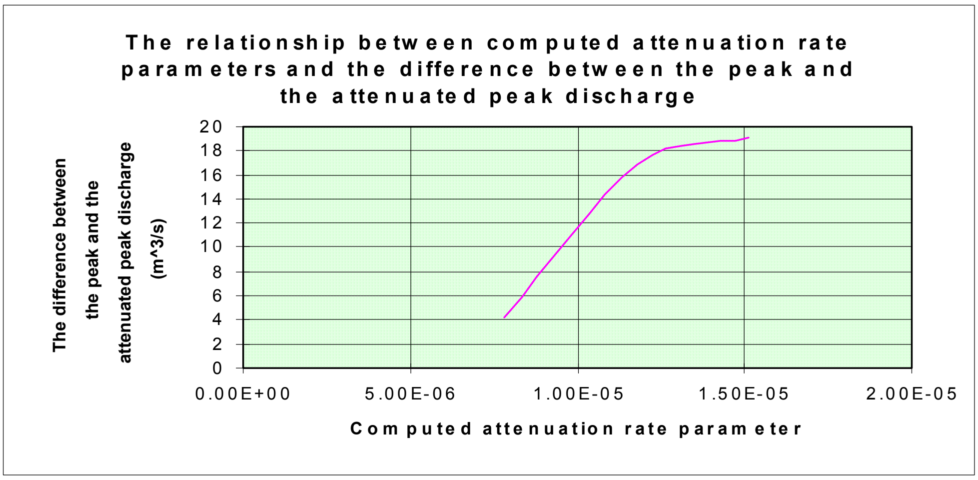


Figure 5.8: The relationship between the computed attenuation rate parameters and the difference between the peak and the attenuated peak discharge

5.4 THE EFFECT OF THE UNSTEADINESS OF THE FLOW ON THE USE OF THE STEADY MODEL

The extent of the unsteadiness of the flow was increased by increasing the roughness values only and this modification was analysed by drawing rating curves that were expected to show graphically the extent of the unsteadiness of the flow in the reach. To see the effects of this modification on the use of the steady model in the unsteady flow conditions, a comparison was made between the water surface profiles obtained from the steady and the unsteady model.

5.4.1 THE EXTENT OF THE UNSTEADINESS OF THE FLOW SHOWN BY DRAWING THE UNSTEADY FLOW RATING CURVES

As mentioned in Chapter 2 rating curves indicate the extent of unsteadiness of the flow. An unsteady flow rating curve is a loop whereas a steady flow rating curve is a single-valued. The aim in this section is to find out how much of the flow occurred in the reach is unsteady. The criterion for making a decision on this problem is that if the loop obtained from the unsteady flow is not so much open (if the rising and falling parts of the rating curve are close to each other) the flow can be treated as steady flow.

As explained in Chapter 2, the shape of the unsteady flow rating curve is affected by bed slope, intensity of discharge variation and roughness. Since the roughness was changed to increase the unsteadiness of the flow, it definitely affected the shape of the rating curves. Although the effect of bed slope was avoided by choosing the same cross-section in order to make a comparison between Case 1 and Case 3. It was impossible to avoid the intensity of discharge variation and it might have also affected the shape of the rating curves in **Figures 5.9**, **5.10**, **5.11, 5.12, 5.13**. To avoid the transient effects of bridges which may also change the shape of the rating curves, all rating curves were chosen from Case 1 and Case 3 (No bridge cases[†]). Even though the full analysis should have been made, it was not achieved due to time limitations. Hence only the unsteady rating curves of the first 5 cross-sections are given as examples.

As can clearly be seen from **Figures 5.9**, **5.10**, **5.11**, **5.12, 5.13** the rising and the falling parts of the rating curves in Case 3 are always much more open than that of the unsteady flow rating curves in Case 1. According to the average total differences given in Table 5.2, it has been seen that an increase in the roughness resulted in an increase in the difference between the water surface profiles obtained from the steady and the unsteady models. Now, it was found that an increase in the roughness (or maybe the change in the intensity of discharge variation) caused the space between the rising and falling part of the unsteady rating curve to be wider. It means that the unsteadiness of the flow increased.

[†] See numerical values (stage-discharge) , Appendices, Tables A13,14,15,16,17,18,19,20,21,22.

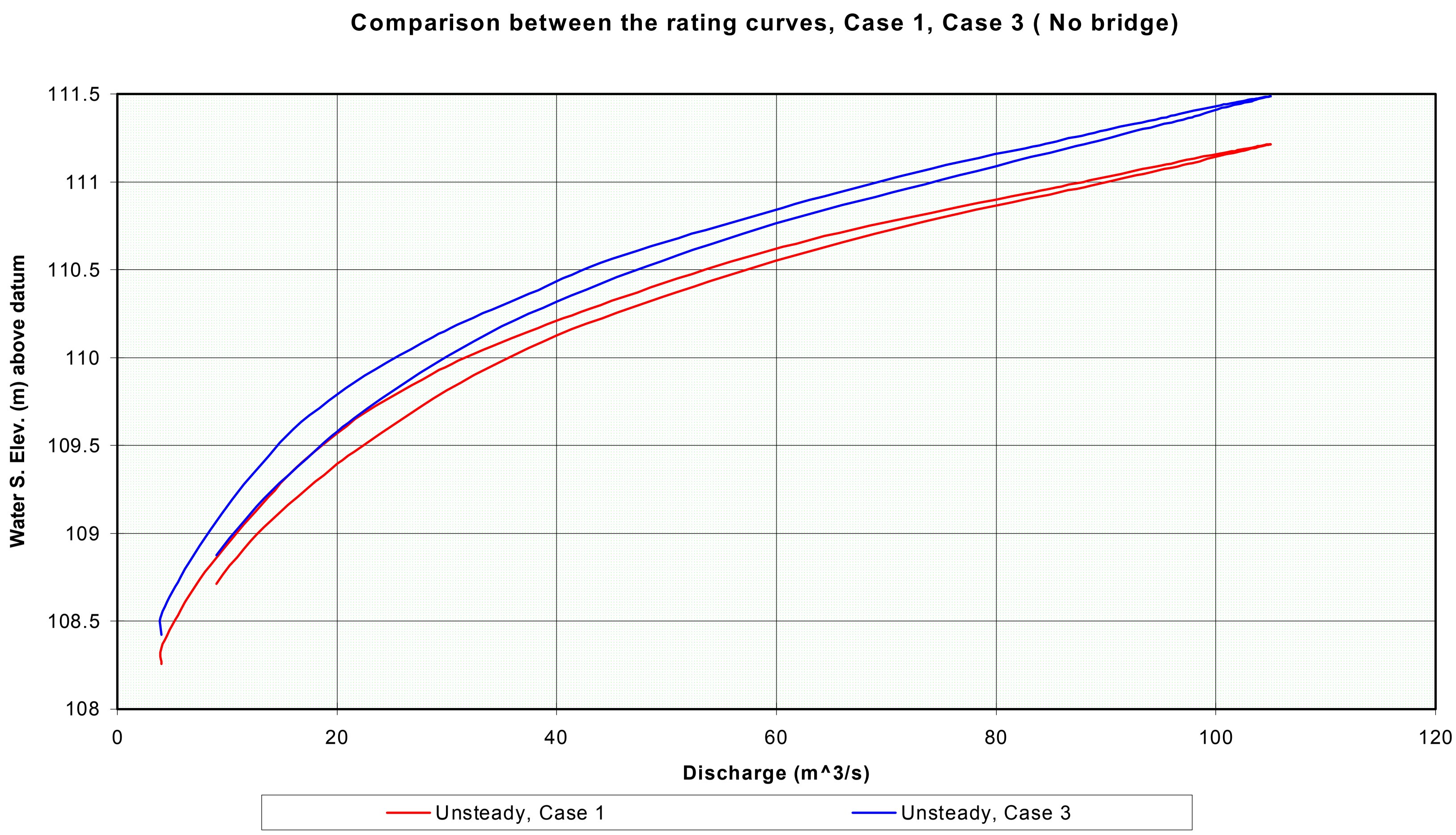


Figure 5.9: The change in the shape of the unsteady rating curve when the unsteadiness of the flow increased, Cross-Section 25144

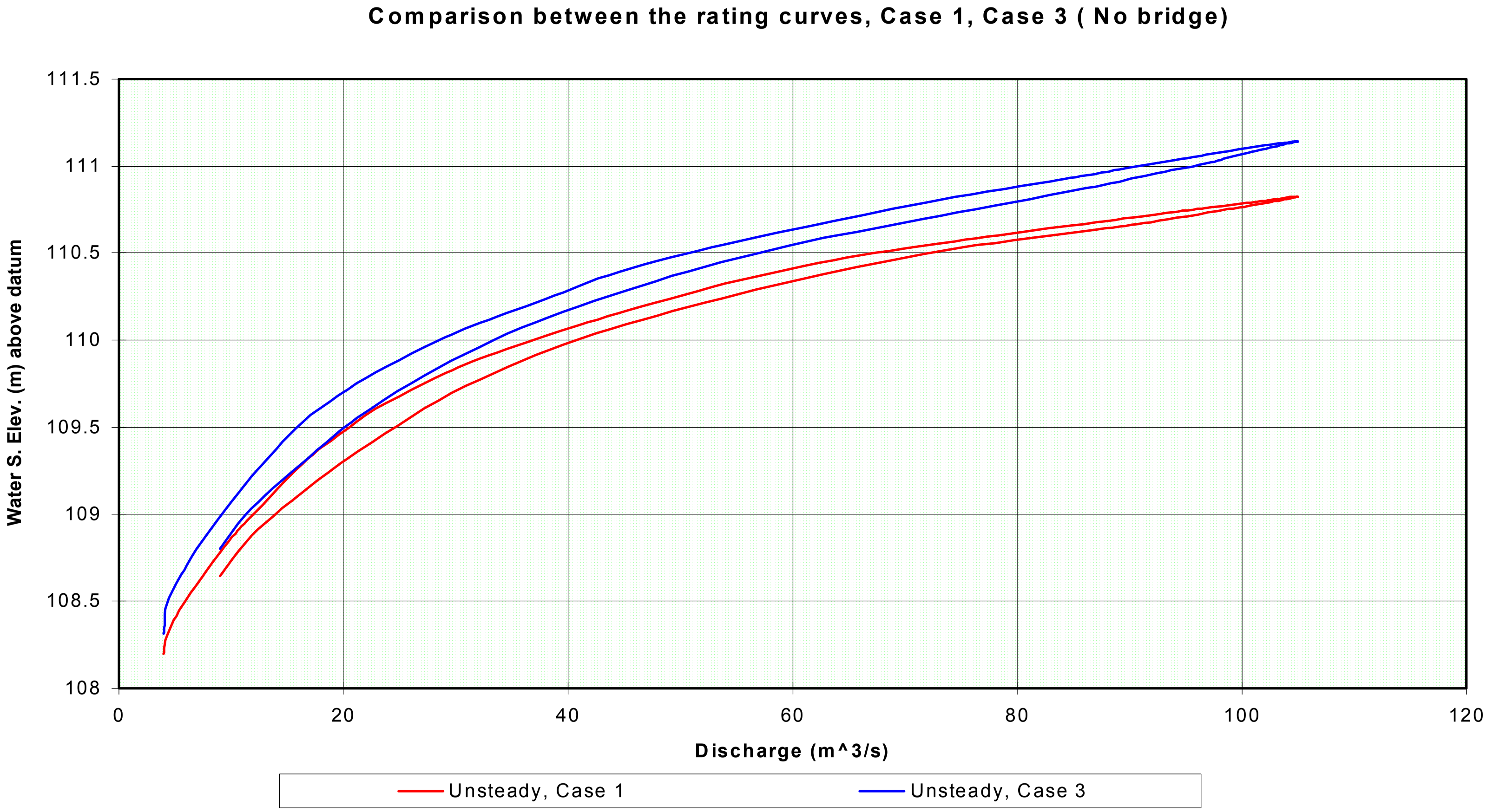


Figure 5.10: The change in the shape of the unsteady rating curve when the unsteadiness of the flow increased, Cross-Section No: 25045

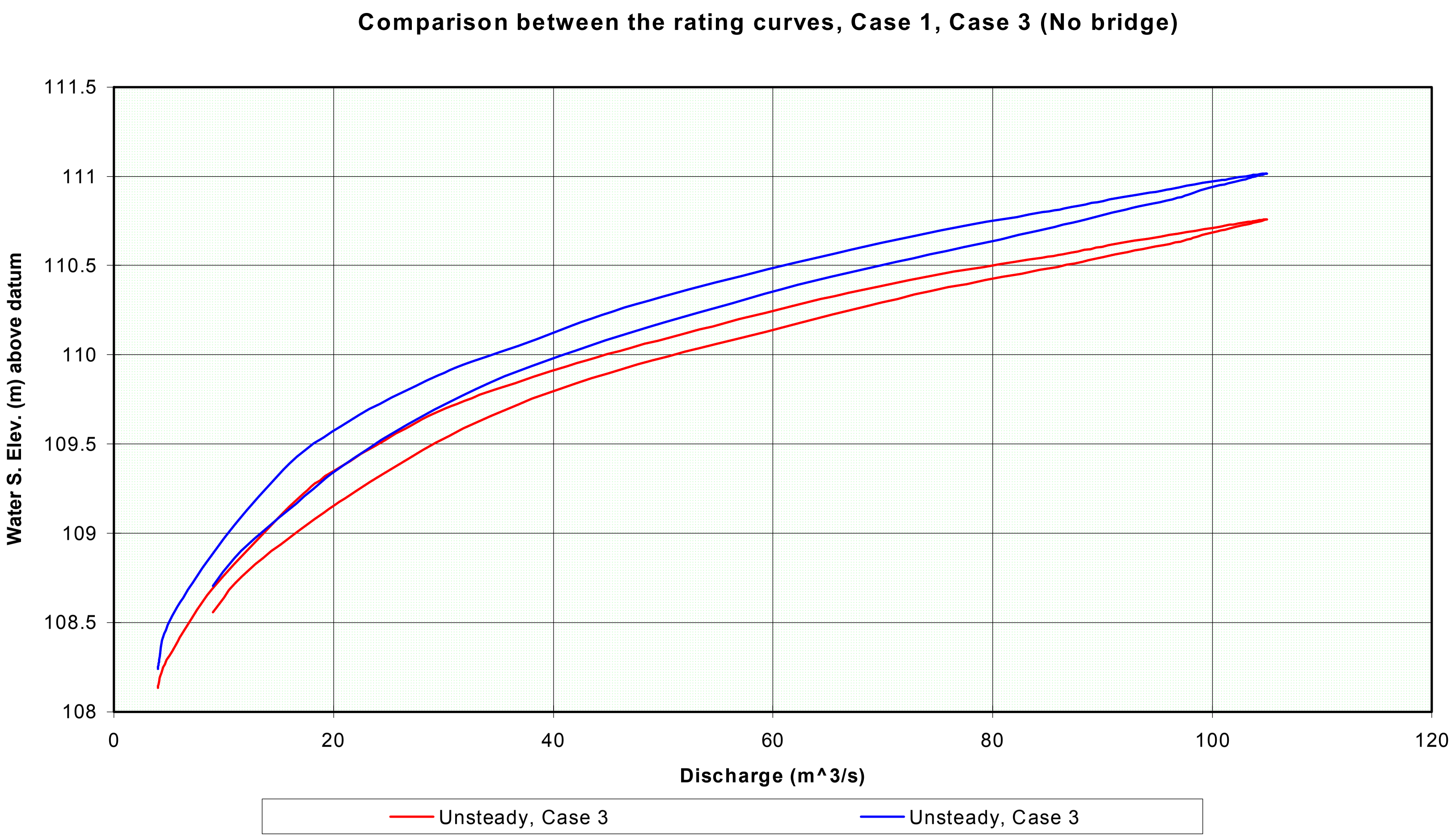


Figure 5.11: The change in the shape of the unsteady rating curve when the unsteadiness of the flow increased, Cross-Section 24940

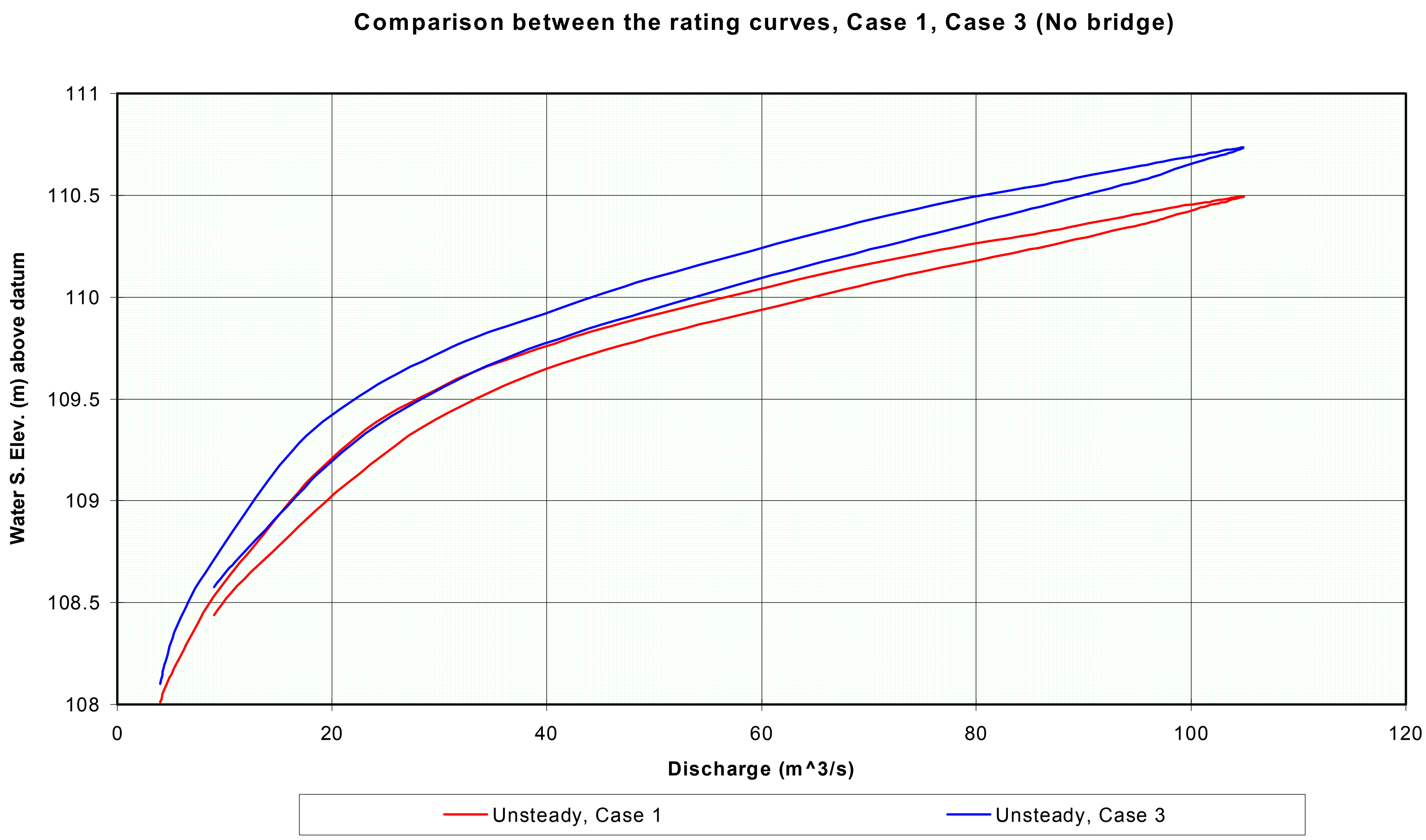


Figure 5.12: The change in the shape of the unsteady rating curve when the unsteadiness of the flow increased, Cross-Section 24745

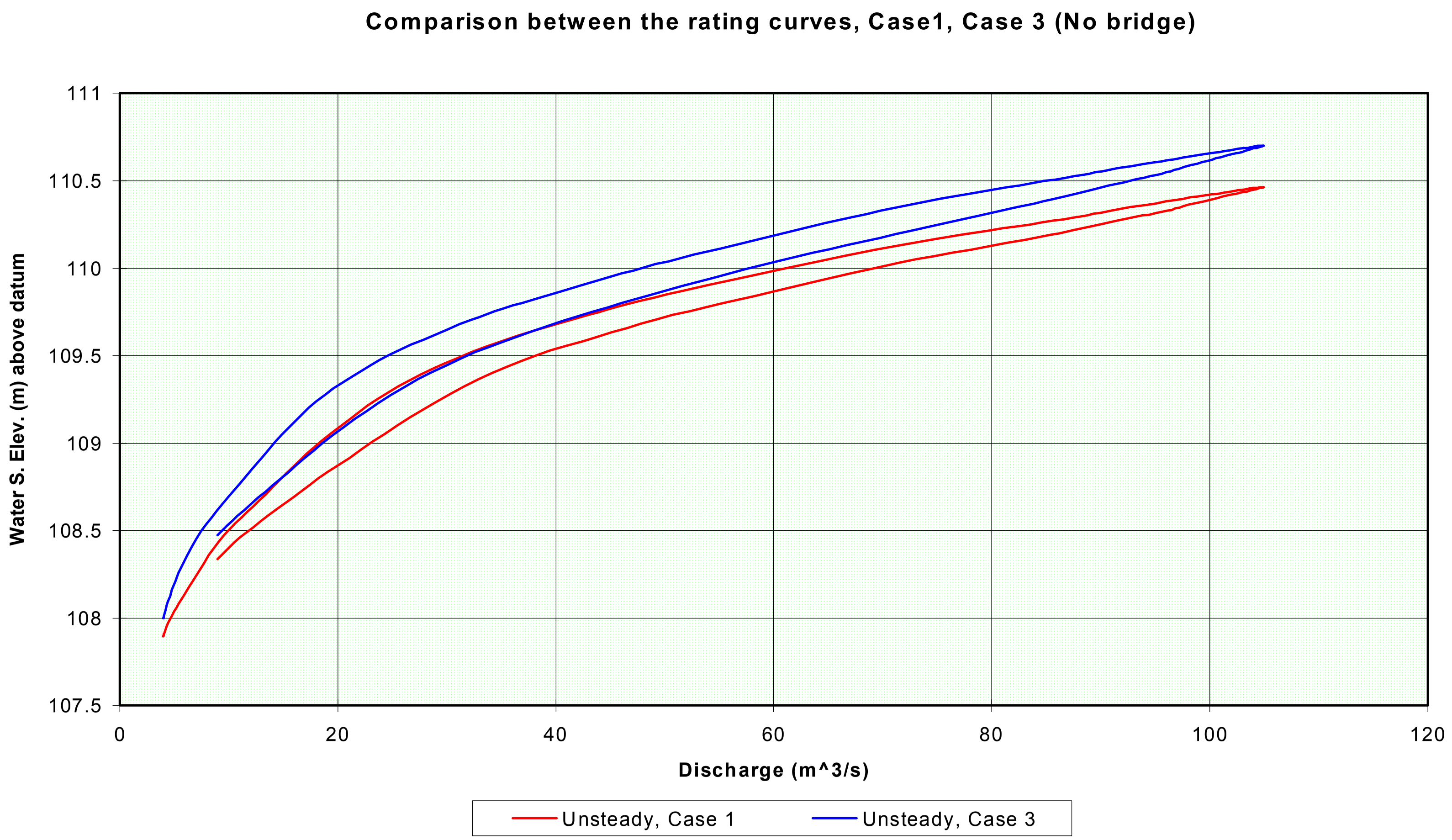


Figure 5.13: The change in the shape of the unsteady rating curve when the unsteadiness of the flow increased, Cross-Section 24680

5.4.2 THE EFFECT OF AN INCREASE IN THE UNSTEADINESS OF THE FLOW ON THE WATER SURFACE PROFILES

The unsteadiness of the flow was increased by increasing the bed roughness. In this section, the effect of this increase on the water surface profiles is analysed.

The water surface profile obtained from the rougher case (Case 3) was compared with Case 1 and presented graphically in **Figure 5.14** (**see also appendices, Table A8, Table A10**). The maximum difference between these two unsteady flow conditions was found to be 0.405 m at cross-section no: 11500. When there were bridges in the reach, the maximum difference again increased and was determined as 1.11 m at a cross-section no: 8834. This result also indicated that the transient effect of bridges considerably affected the water surface profiles (**Figure 5.15, see also appendices, Table A9, Table A11**).

Since the aim of this study is to investigate the use of the steady model instead of the unsteady model in the unsteady flow conditions, for this rougher case (without bridges) a comparison between the water surface profiles, which were determined by using the steady and the unsteady models, was made. (**Figure 5.16, see also appendices, Table A5, Table A10**). In section 5.1.2 the maximum difference between the water surface profiles calculated by using the steady and unsteady models was found to be 0.219 m , in this rougher case it was determined as 0.232 m . In other words, when the unsteadiness of the flow increased, the difference between the water surface profiles obtained from the steady and the unsteady models also increased. Hence, it was found that the use of the steady model depended on the extent of the unsteadiness of the flow. However, according to the average total differences given in section 5.3, the difference between Case 1 and Case 3 (0.14-0.11) was estimated as 0.04 m. This result indicated that for this reach such an increase in the unsteadiness of the flow did not make so much difference. The reason for this could be the bed slope (the mean bed slope 0.00151) which was quite steep. Therefore, it has been seen that the effect of bed slope on the unsteadiness of the flow should also be analysed.

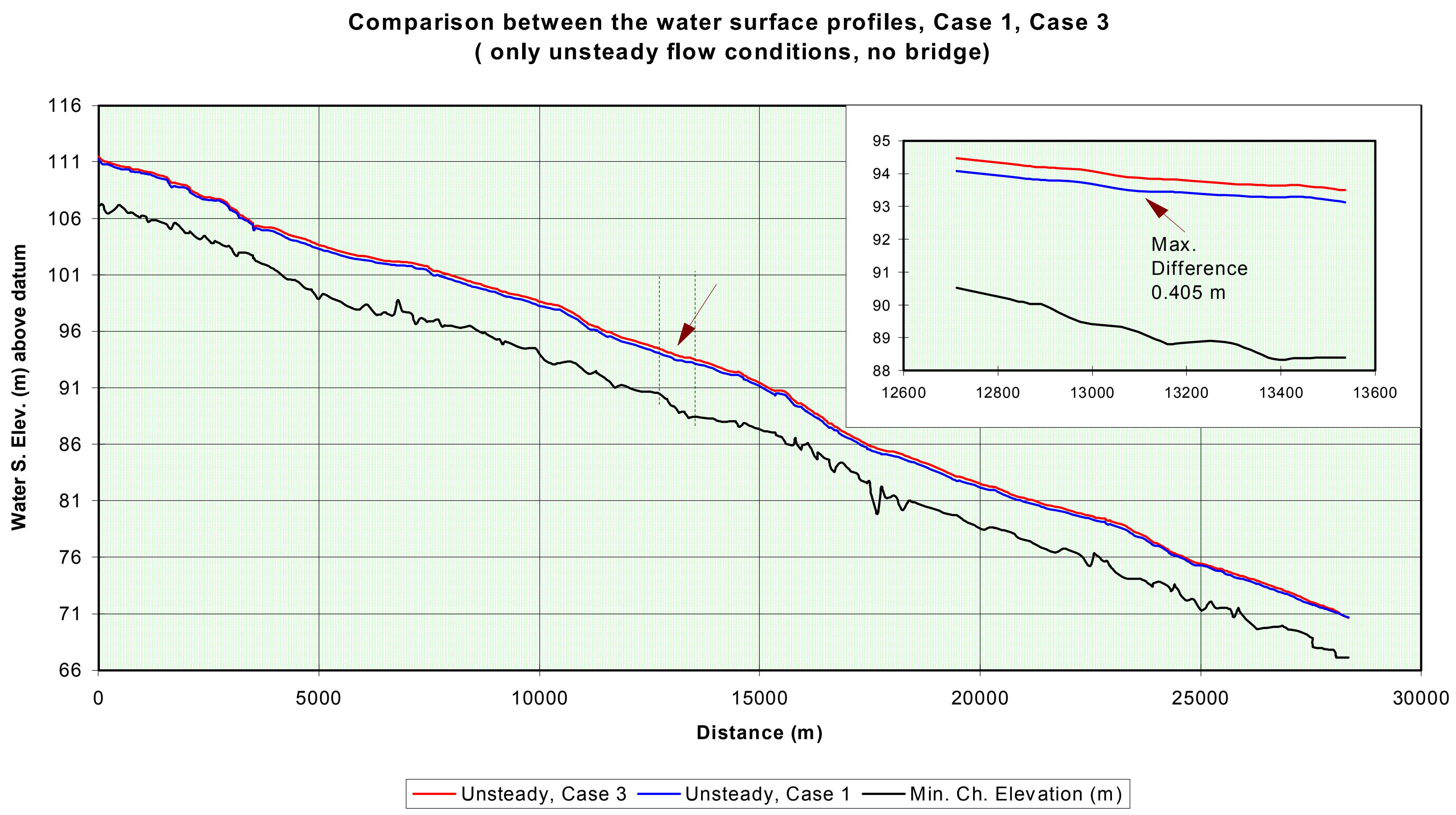


Figure 5.14: The effect of the roughness on the water surface profiles (Case 1, Case 3; no bridges and the unsteady model results)

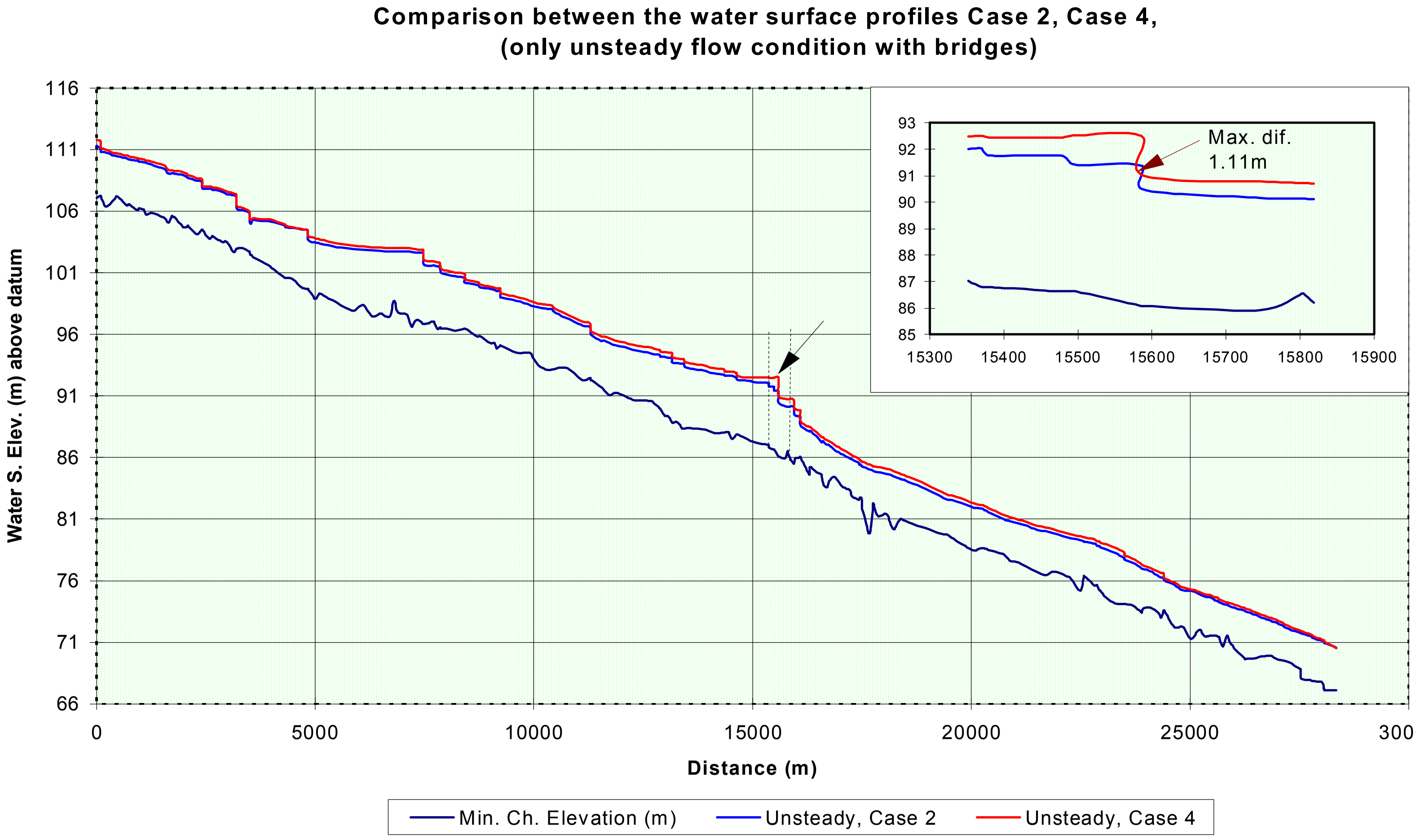


Figure 5.15: The effect of the roughness on the water surface profiles (Case 2, Case 4; with bridges and the unsteady model results)

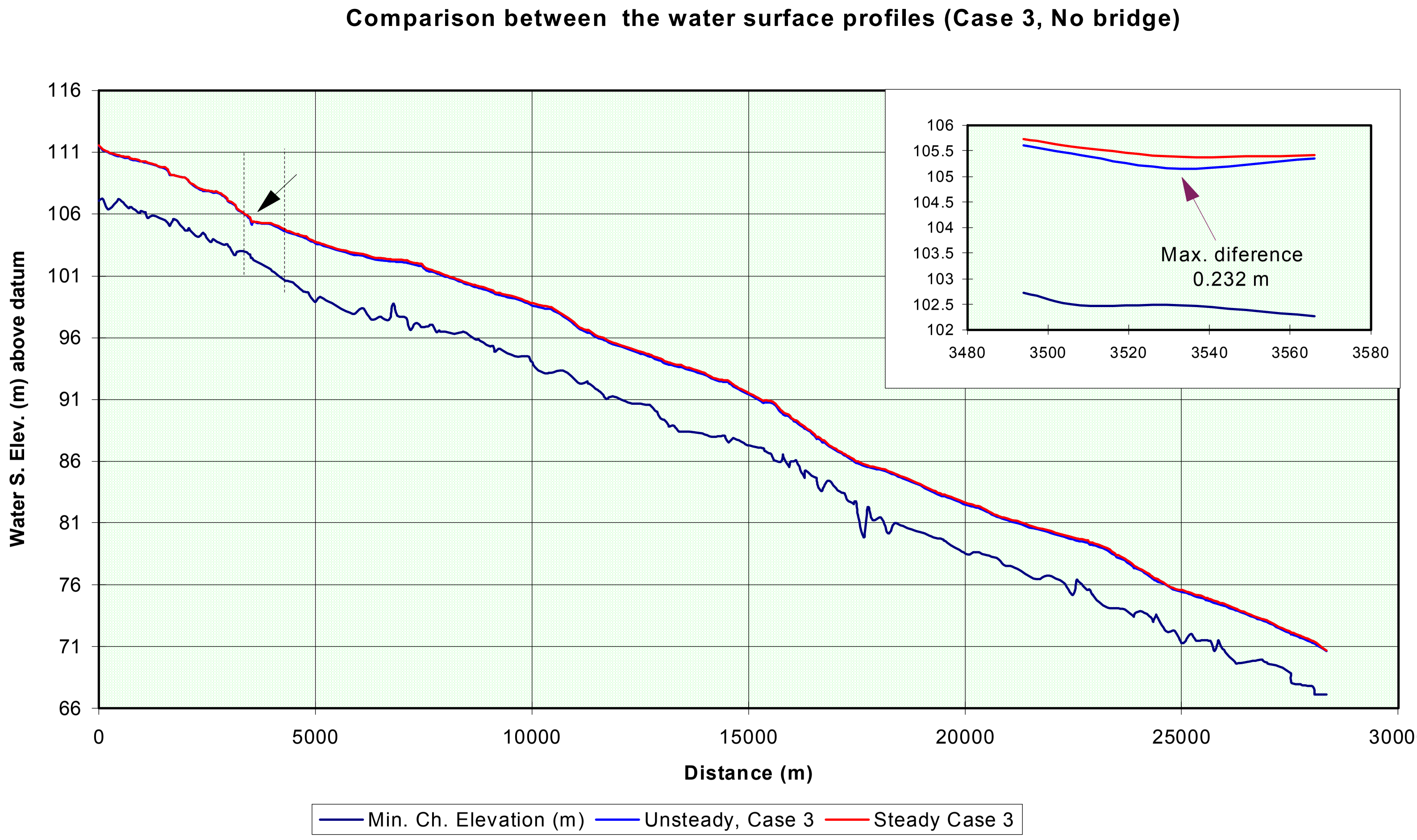


Figure 5.16: The effect of the roughness on the use of the steady model instead of the unsteady model (Case 3, rougher and no bridges)

CHAPTER 6

DISCUSSIONS

6.1 ACCURACY

Since some accuracy problems have been detected in the unsteady model results, the possible sources of these errors should be discussed before reaching a conclusion.

As stressed in Chapter 5, the best result might have been achieved when the roughness values were assumed as 0.03, 0.02, 0.03 left overbank, channel and right overbank respectively. This is because when the bed roughness decreased, the mean propagation speed of the wave increased and the attenuation rate parameter also reduced (**see appendices, Table A7**). In this case, using the steady model the mean surface width was determined as 36.37 m, the mean propagation speed of the wave was computed as 3.74 ms^{-1}. From these computations, the attenuation rate parameter was found to be $2.82*10^{-6}$, which is very close to the criterion given by (IWES). According to this result it was expected that the use of the steady model would have been more suitable here than for the other cases. Contrary to this expectation, the worst result was observed.

The result was considered unrealistic because even though the water surface elevations obtained from the steady model should always be higher or equal to that of the unsteady model (because in the steady model the peak discharge was used), in this case the water surface elevations obtained from the unsteady model were found to be higher in some locations than those of the steady model (**Figure 6.1**). Surprisingly, the peak discharge did not attenuate so much (**see appendices, Table A12**, 105 m^3s^{-1} -103.226 m^3s^{-1}). Furthermore, this attenuation is compatible with the computed attenuated rate parameter. When comparing this attenuation on the peak discharge with the others given in **Table 5.3**, it can be seen that the minimum attenuation occurred. This interesting result required further analysis. In this sense, the rating curves were drawn at the first 4 cross-sections (**Figure 6.2**).

As can be seen from **Figure 6.2**, the rising and falling branches of the loop in all rating curves are very close to each other compared to the others given in Chapter 5. However, each rating curve consists of more than one loop. This can be clearly seen in particular in **Figures 6.2c & 6.2d**. In these situations, although there is only one flood, it seems as though more than one flood occurred. Furthermore, when discharge decreased, the water surface elevation at the same cross-section should have been also decreased. However, as shown in **Table 6.1**, it was found that although the discharge decreased, the water surface elevation increased. In brief, the water surface elevations in some cross-sections were overestimated and there may have been some oscillations.

Table 6.1: An example of oscillation on the water surface profiles, obtained from the unsteady model (When the roughness values decreased)

Cross-Section No: ISIS	Discharge (m^3s^{-1})	Water Surface Elevations (m) above datum	Run Time (hours)
TM24940	63.995	109.705	10.50
TM24940	54.442	109.510	10.75
TM24940	44.928	109.139	11.00
TM24940	38.039	109.203	11.25
TM24940	31.632	109.062	11.50
TM24940	27.239	108.934	11.75

After proving that there were some errors, the possible source of these errors was needed to check the stability of the Preissmann Scheme.

Stability analyses can be made in terms of Δt, Δx (selection of time step and grid space), θ (weighting coefficient), and the occurrence of supercritical flow

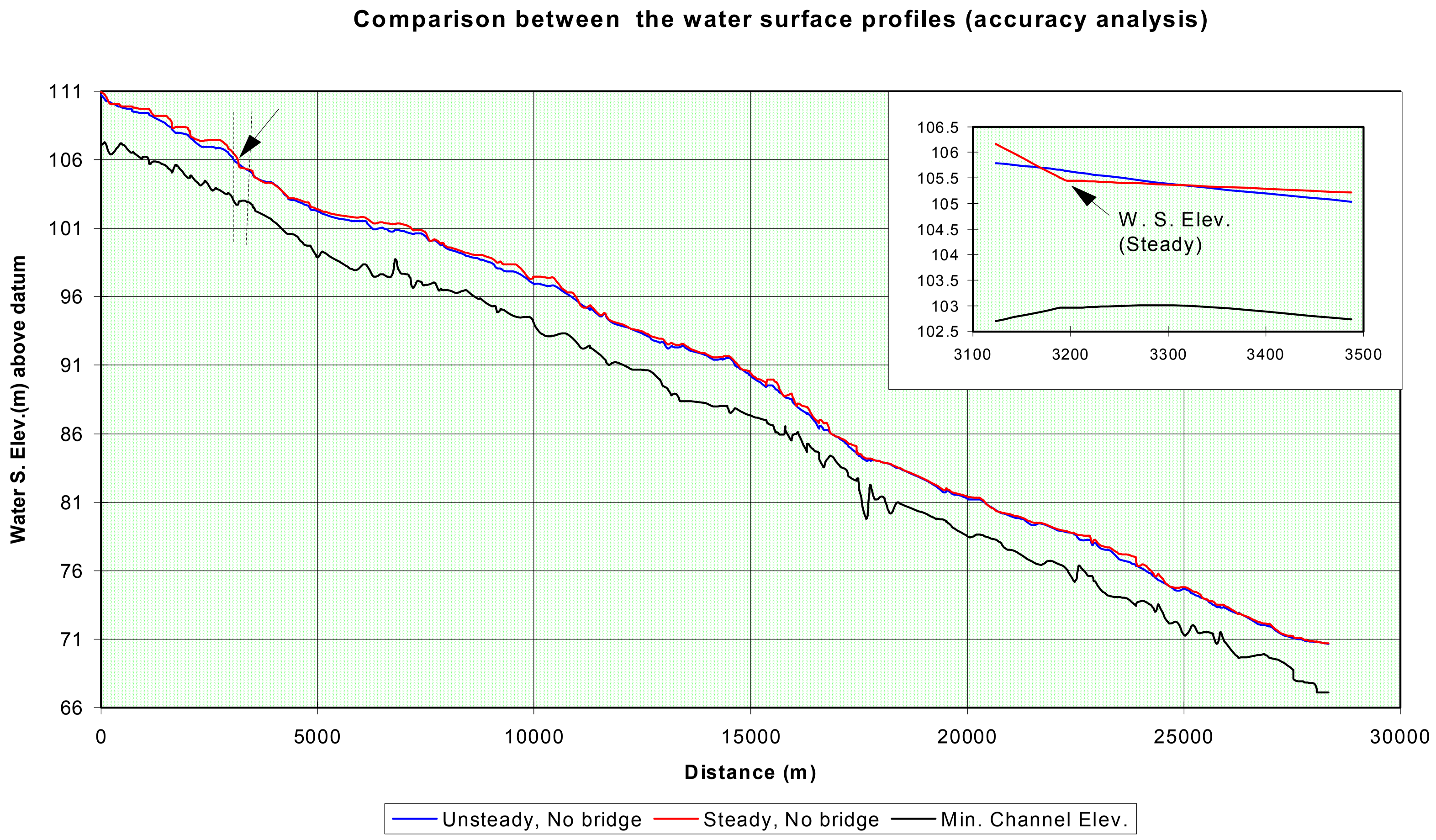
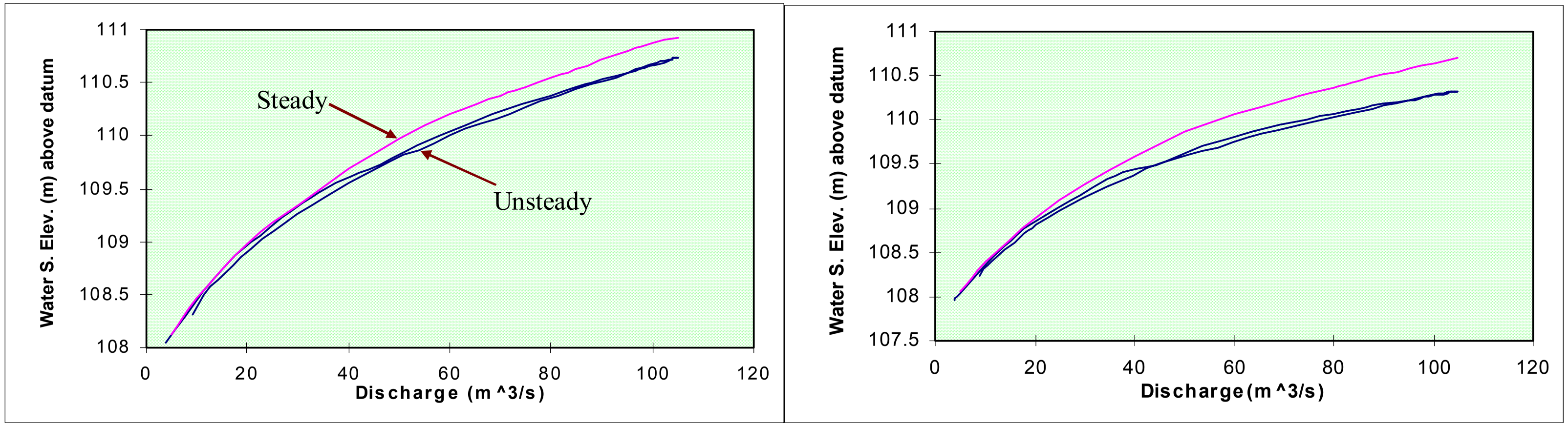
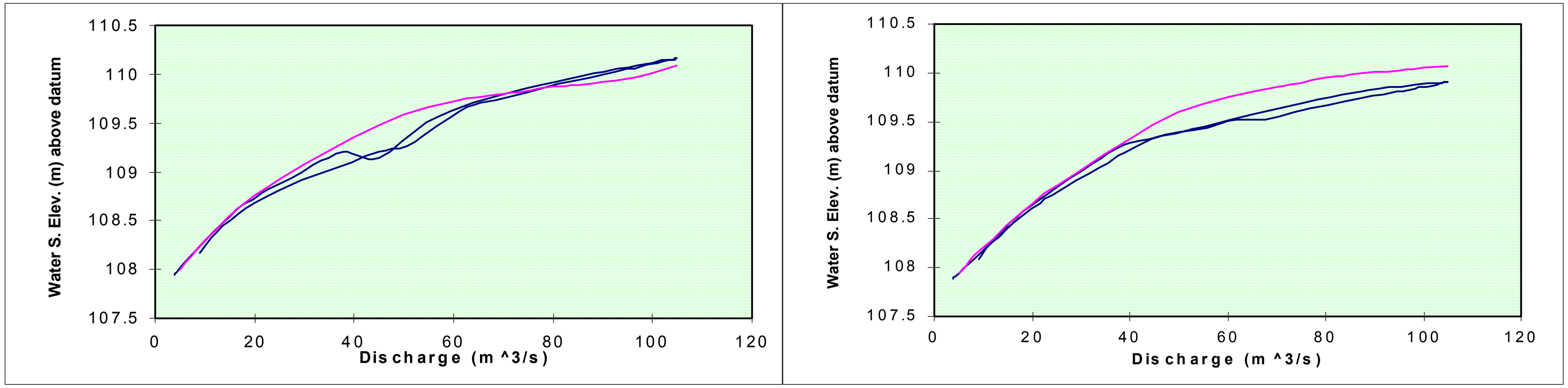


Figure 6.1: Accuracy analysis by drawing the water surface profiles (Case: decreasing roughness, no bridge)



(a, 25144) (b, 25045)



(c, 24940) (d, 24745)

Figure 6.2: Accuracy analysis by drawing rating curves (Cross-section No: 25144, 25045, 24940, 24745)

As Cunge *et al* (1980) mentioned that despite the fact that the selection of $\Delta t, \Delta x$ does not generally cause any errors in the use of the implicit scheme, they should not be chosen blindly. The criterion for the selection of these factors is a Courant number that is formulated as $\frac{c\Delta t}{\Delta x}$ where c is celerity of wave (m/s). However, the modellers (or modeller) of ISIS stated that the Courant number can be up to 5 or 10 in the implicit scheme. For an explicit scheme the maximum Courant number should be 1 for stability. In this case the Courant number calculated $\approx \frac{3.74*20}{100}$ = 0.748 (Δx being the average cross-section spacing) is even smaller than 1 and the scheme is the Preissmann **implicit** scheme. Consequently, the selection of the time step and the computational grid space were not seen as a reason for the occurrence of errors. On the other hand, it should be noted that there is a relationship between the weighting coefficient and the selected time step and computational grid space (Mahmood & Yevcevich, 1975).

With respect to the weighting coefficient, Mahmood and Yevcevich (1975) stated that selection of θ = 0.5 is theoretically the best value but they found that for the full flow equations and for a small resistance coefficient the oscillations will appear. They also recommended that it is better to take θ in the range of 0.6 and 1. In ISIS the weighting coefficient can be chosen between 0.5 to 1 and during the unsteady flow computations it was chosen as 0.7. Therefore, the selection of the weighting coefficient seems not to be a reason for the occurrence of the errors either.

According to the occurrence of the supercritical flow, Samuels & Skeels (1990) mentioned that there was a hypothesis that Preissmann's scheme cannot be applied to supercritical flow. Based on this hypothesis they defined a limit on the stability of the Preissmann scheme. This limit is given in Chapter 2 and they suggested that the Vedernikov number should not be higher than unity.

In addition, Holly & Meselhe (1997) stated that if local supercritical flow zones form adjacent to the computational domain boundaries, the problem becomes ill-posed. On the other hand, they stressed that the Preissmann scheme is marginally stable if a critical point is encountered in the domain.

When examining the occurrence of supercritical flow inside the computational reach, at upstream and downstream boundaries supercritical flow did not exist at any computational time. However, inside the reach most Froude numbers were found to be higher than unity (Table 6.2). The occurrence of the supercritical flow in this case could not be avoided because when the roughness decreased, the water depth also decreased and the critical depth existed in most of the cross-section locations.

Table 6.2: Some examples of the occurrence of the supercritical flow in the use of the unsteady model when the roughness values decreased after a run time 1 hour.

Cross-Section* ISIS	Cross Section HEC-RAS	Flow (m^3s^{-1})	Water S. Elev. (m) above datum	Froude Number	Velocity (ms^{-1})
TM21428	22066	9	104.332	1.069	2.62
TM20882	21493	9	103.099	1.262	2.781
TM18200	18200	9	99.193	1.288	2.413
TM15100	15100	9	95.174	1.037	2.194
TM13327	13327	9	93.097	1.264	2.28
TM13322	13322	9	93.051	1.584	2.651
TM9068	9068	9	87.782	1.334	2.518
TM9040	9040	9	87.617	1.069	1.857
TM8620	8620	9	86.924	1.220	2.21
TM8618	8618	9	86.905	1.331	2.345
TM8604	8604	9	86.824	1.011	2.094
TM8336	8336	9	86.488	1.015	1.893
TM8328	8328	9	86.445	1.227	2.148
TM7170	7170	9	83.796	1.253	2.012
TM6942	6942	9	83.31	1.121	1.906
TM6620	6620	9	82.67	1.253	1.963
TM4924	4924	9	80.143	1.083	2.064

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[*] The labels used to describe cross-sections in ISIS are different than HEC-RAS, to avoid confusion the cross-sections were also described as in HEC-RAS

It should also be mentioned that the computation of supercritical flow in ISIS is achieved by neglecting the part of the convective term ($\frac{dA}{dx}$) in the momentum equation when the Froude numbers exceed a specified upper value (during the use of ISIS the upper value was selected as 0.900). Kutija (1993) pointed out that the omission of part of the convective term in the Bernoulli equation has less influence on the accuracy of the solution. However, when the part of the convective term is neglected in the momentum equation, this influences the accuracy to a minimal degree

As stressed before the result of Case 2, which was obtained from the unsteady model, was also subject to some errors. This is because, in this case, for the following 4 cross-sections[*] (No: 9040, 8944, 8924, 8834) the water surface elevations determined by using the unsteady model were also found to be higher than the water surface elevations obtained from the steady model. However, the number of cross-sections where these problems were encountered was much less than as in the case (when roughness values decreased) discussed above.

A full analysis of the stability and the accuracy is beyond the scope of this study but from the above discussion it may be concluded that the errors most likely resulted from the occurrence of the supercritical flow. When detecting Case 2, it was seen that there were three cross-sections in which the flow was very close to supercritical flow and the Froude numbers were computed as 0.991, 0.983, 0.983 (Cross-section No: 13322, 7846, 7843 **see appendices, Table A9**). As can be seen, this number is bigger than the specified upper value. The reason for the occurrence of the small accuracy problems mentioned in Chapter 5 could be the occurrence of the supercritical flow. Moreover, in these cross-sections supercritical flow computations were achieved by neglecting the part of the convective term in the momentum equation and it might have caused these errors. When roughness values decreased, supercritical flow occurred in nearly all cross-sections and the supercritical flow computations were achieved by again neglecting the part of the convective term. However, the number of

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[*] See appendices, Tables A3, A9

the supercritical computations was much more than that of Case 2 so the reason for the occurrence of significant accuracy problems could be the increase in the number of the supercritical flow computations. In other words, the higher the supercritical flow computations, the more the omission of the part of the convective term which influences the accuracy of the solution.

In short, while the results of Case 1, Case 3 and Case 4 were considered reasonable, the run in which the roughness values were decreased and from which the most suitable result was expected, was considered not accurate due to the problems mentioned above.

6.2 OVERALL RESULTS

When examining the use of the steady model in the unsteady flow conditions in the river with bridges, the differences among the water surface elevations obtained from the steady and unsteady model were found to be considerably higher than with the absence of bridges. While the maximum difference in the water surface profiles in the former case was determined as 1.6 m, in the latter case this difference was found to be 0.219 m. Although these results clearly indicated the effects of the bridges on the use of the steady model in the unsteady flow conditions, they can be valid providing that the computational methods of bridge hydraulics in both programs were exactly the same.

When the mean surface width increased with the existence of bridges, the attenuation rate parameter was found to be higher than the absence of bridges owing to the decrease in the mean propagation speed of the wave. The mean surface width increased due to the backwater effects of the bridges but the velocity in the river decreased. Accordingly, the mean propagation speed of the wave decreased. In terms of the variables in equation [2.1] used for determination of the attenuation rate parameter, the propagation speed of the wave plays a much more important role than the mean surface width. That is why, the attenuation rate parameter was determined as $1.08*10^{-5}$ under the consideration of bridges in the reach whereas it was computed as $7.85*10^{-6}$ in the absence of bridges. It can be said that a good agreement was achieved between the computed attenuation rate parameters and the unsteady flow computation results. For instance, when the computed attenuation rate parameter was $7.85*10^{-6}$, the peak discharge of 105 m^3s^{-1} attenuated and resulted in 100.796 m^3s^{-1} at the downstream boundary cross-section (**see Table 5.3, Case 1**). When there were bridges, the peak discharge of 105 m^3s^{-1} reduced to 97.54 m^3s^{-1} (**see Table 5.3, Case 2**).

When the bed roughness values increased, the propagation speed of the wave decreased. This decrease resulted in higher differences among the water surface elevations obtained from the steady and the unsteady model. To see the effects of roughness on the extent of the unsteadiness of the flow, the unsteady rating curves were drawn. With respect to the rating curves, the space between the falling and the rising branches was found to be wider in the rougher case. In other words, the extent of the unsteadiness of the flow rose. As a result, in this case a comparatively large reduction in the peak discharge downstream was detected (from 105 to 88.199 m^3s^{-1}). Thus, the use of the steady model got worse and the average total difference between the water surface profiles obtained from the steady and the unsteady models was found to be 0.14 m that is higher than 0.11 m, which was estimated before increasing the roughness values. This result also agreed with the previous studies.

CHAPTER 7

CONCLUSIONS , RECOMMENDATIONS AND FURTHER STUDIES

7.1 CONCLUSION

According to the overall results the following conclusions were drawn:

1- The transient effects of bridges had an important effect on the water surface profiles particularly at locations where the bed slope was smaller than other regions and where weir flow or pressure flow occurred. When there were bridges in the reach the steady model application in the unsteady flow conditions was not found to be as suitable as in the absence of bridges.

2- The extent to which the flow is unsteady governed the use of the steady model in the unsteady flow conditions.

The degree of the unsteadiness of the flow increased by an increase in the roughness values. This was illustrated by drawing the rating curves which indicated that the space between the falling and rising branches of the loop was wider in the rougher case. Moreover, a comparison was made between the water surface profiles obtained from the steady and the unsteady models, where the average total difference was found to be higher in the rougher case. Consequently, it has been seen that the use of the steady model depended on the extent of the unsteadiness of the flow. Furthermore, when the unsteadiness of the flow increased, the attenuation rate of the peak discharge also rose. Accordingly, the differences between the water surface elevations attained from these two models increased as well.

3- The attenuation rate parameter was found to be the most important criterion on which to base a decision on whether the use of steady model was valid for unsteady flow conditions. When the attenuation rate parameter decreased, the results of the steady flow computations were found to be similar to those of the unsteady flow computations.

4- It was seen that the occurrence of errors was more likely in the use of the unsteady model. For instance, contrary to our expectations the worst result was observed by decreasing the roughness values. The most likely explanation of this problem was considered to be the occurrence of supercritical flow.

Apart from the cases in which errors were detected and could not be avoided due to limitations on the use of ISIS, it may be said that a good agreement was achieved between the overall results and the previous studies given in the literature review in Chapter 2.

7.2 RECOMMENDATIONS

1- The use of a steady model rather than an unsteady model in unsteady flow conditions could be more convenient if the extent of the unsteadiness of the flow is not significant. In this sense, the attenuation rate parameter may be used as a criterion

2- In the absence of bridges, the steady model can be applied to the unsteady flow in the reach of the River Tame because the average total difference between the water surface profiles obtained from the steady model and the unsteady model was determined as 0.11 m which can be considered as negligible for practical purposes.

However, considering the bridges in the reach, the average total difference between the water surface profiles was found to be 0.37 m. Although the use of the steady model could be considered conservative and always resulted in higher water surface elevations, in a bridge design this can bring about considerably higher cost particularly if a bridge is designed downstream of the reach where the maximum attenuation occurs.

It should be mentioned that while the maximum attenuation occurred at the end of the reach (downstream boundary cross-section), the maximum difference (1.6 m) between the water surface elevations computed by using the steady and the unsteady model was found at cross-section no: 15780 in region 3 (**see Figure 4.2**) where the bed slope was not as steep as in the other regions. Hence the bed slope rather than the change in discharge had important effect on the water surface profiles. On the other hand, it has been seen that while weir flow occurred in the use of steady model, pressure flow existed in the use of the unsteady model due to the attenuation at cross-section no: 920. After these explanations, it may be concluded that the selection of a steady model in unsteady flow conditions in a river with bridges may be acceptable providing that ...

a- the bed slope is steep enough that a small change in the discharge should not cause much difference in the water surface elevations and

b- the attenuation of the peak discharge is so small that both at the peak flow rate and the attenuated peak flow rate, the type of flow that will occur should be the same at each bridge location. Otherwise, depending on the attenuation rate, the type of flow determined by using the steady model can be totally different from the type of the flow determined by using the unsteady model. Similarly, the water surface elevation at this location can be found to be considerably higher in the use of steady model.

3- A mathematical model and in particular a hydrodynamic model should not be used if overall features of the model, such as the assumptions made to develop it, equations used to describe the physical process of fluid flow in a river and limitations on their usage are understood. Even if this is achieved, a calibration of the model is necessary.

To sum up, for practical purposes the results obtained from the steady model approach in unsteady flow conditions can be acceptable if the effects of bridges and the unsteadiness of the flow are not significant. The use of the steady model in these cases can ease the overall computations, particularly in the simulation of a long reach. On the other hand, the use of the unsteady model in unsteady flow conditions can be inevitable in cases at which the unsteadiness of the flow is predominant. Hence, there is a need to develop an unsteady model. Furthermore, depending on the problem there can be a need to develop a mathematical model that is two or even three-dimensional because the physical process of water and sediment movements are known to be three-dimensional and time dependent. For instance, Przedwojski *et al.*(1995) stated that while three dimensional models are generally used for the turbulent heat, mass flux simulations and sediment transport modelling, two dimensional models are used to predict sedimentation and erosion in rivers, estuaries and coastal waters. Many works have been done on this subject. For instance, a two-dimensional numerical simulation for the analysis of river and flood plain flooding was studied by Lesleighter (1983), Samuels (1983) studied the use of two dimensional models of flow over a flood plain by using the finite element method etc.

7.3 FURTHER STUDIES

The effects of slope on the use of a steady model in unsteady flow conditions need to be known. In fact, it can be the most important factor that determines the applicability of a steady model on such a flow. It should be pointed out that the backwater effects of bridges also decrease when the bottom slope is steeper. Therefore, it may be expected that in a very steep channel (say, $S>0.015$) with bridges the steady model approach may be acceptable.

Other research that may be helpful for practical engineers can be the use of a steady model in unsteady flow conditions in alluvial rivers and computation of sedimentation in these rivers. This study also showed that the unsteady model produced a substantial increase in the computational load compared to the steady model. If sediment transport computations are added to the unsteady flow computations, the computational load will be larger. On the other hand, if the steady model approach can be found suitable in this case, overall computations will be straightforward. As a result, it could be worth examining.

As it is known, some rivers end at a reservoir or joint the sea. In these situations, water surface profiles may be considerably changed. In the former case while the shape of the water profiles can depend on the water level in the reservoir, the tidal effects can be the most important parameter showing that the use of steady model is suitable in unsteady flow condition in the latter case.

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APPENDICES

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1- BOUNDARY CONDITION DATA

2-BRIDGES (upstream and downstream faces) AND THEIR BOUNDING CROSS-SECTIONS (GRAPHICAL VIEWS ONLY)

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STEADY FLOW COMPUTATION RESULTS OBTAINED FROM HEC-RAS

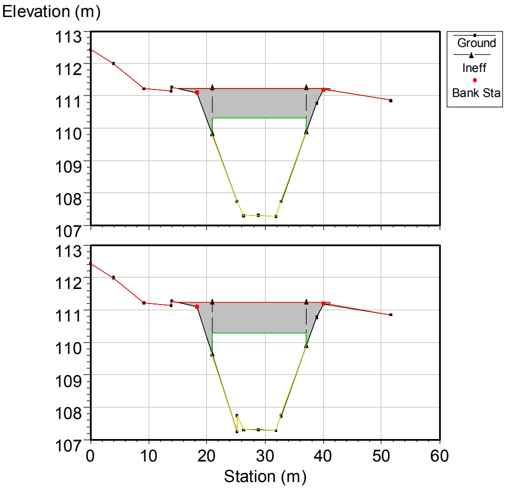
PART 3:

UNSTEADY FLOW COMPUTATION RESULTS OBTAINED FROM ISIS

PART 1

TABLE A1: BOUNDARY CONDITION DATA

Rating Curves (Stage(H) and Discharge(Q) realationship)	
Q(m^3s^{-1})	H(m)
0.00	67.05
2.50	67.69
5.00	67.88
10.0	68.16
20.0	68.60
30.0	68.78
40.0	68.90
50.0	69.17
60.0	69.59
70.0	70.01
80.0	70.45
90.0	70.59
100	70.66
105	70.69
110	70.73
120	70.8
130	70.89
140	70.97



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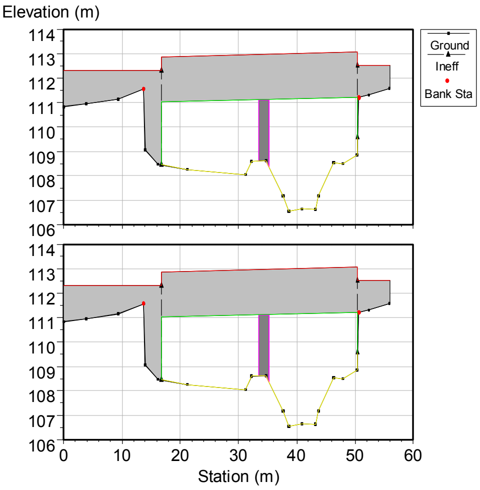

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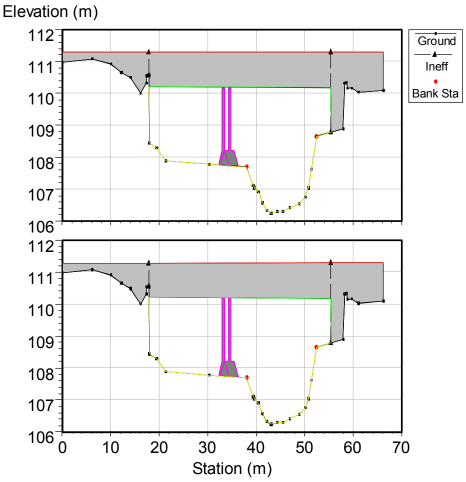

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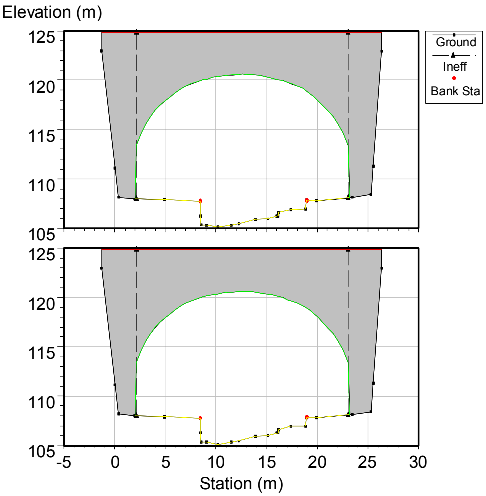

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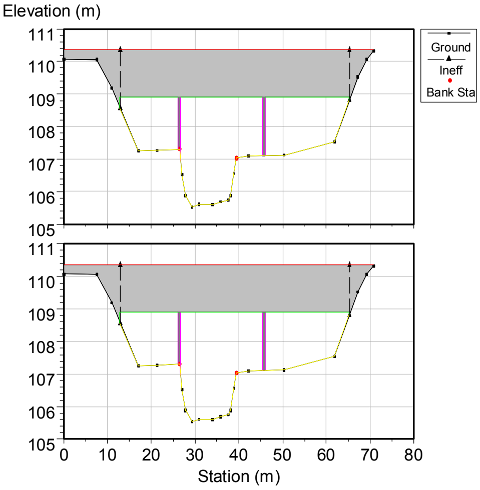

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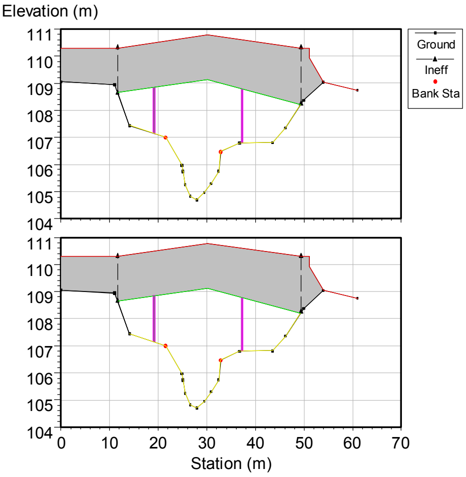

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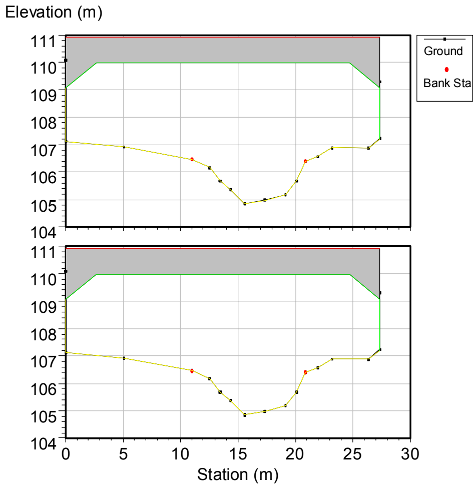

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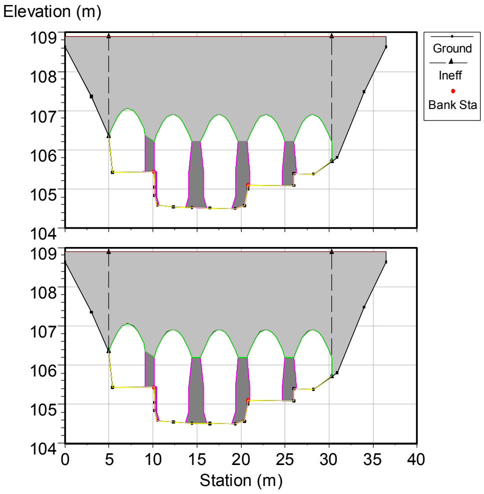

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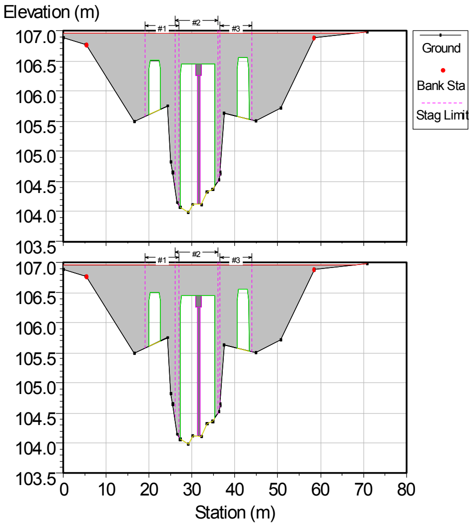

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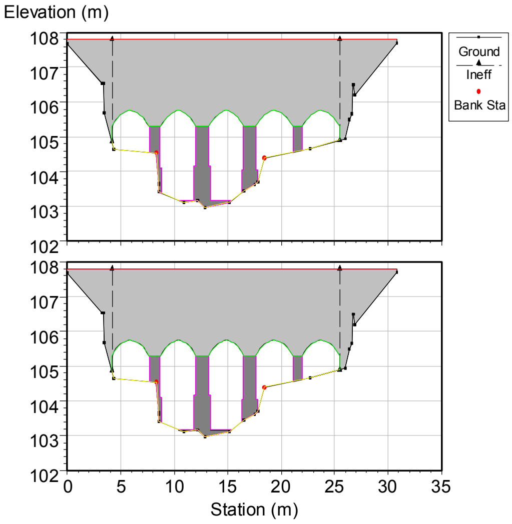

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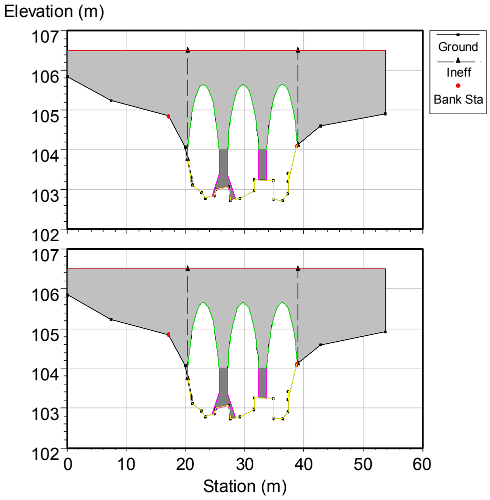

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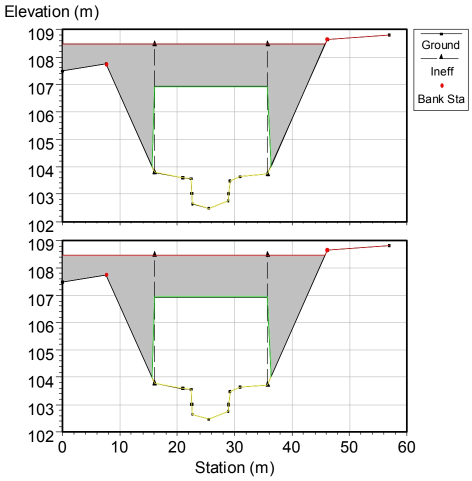

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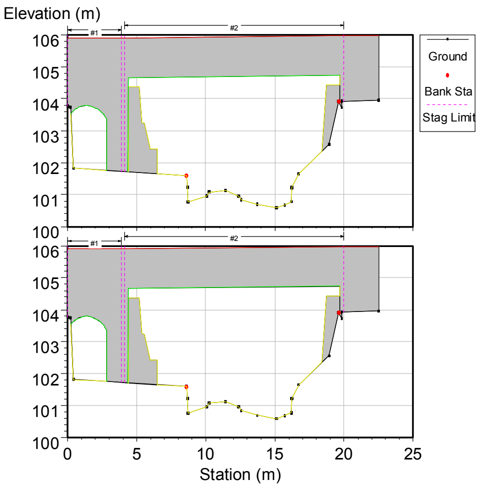

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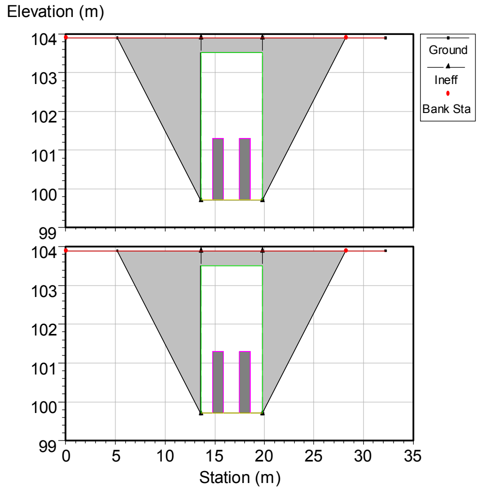

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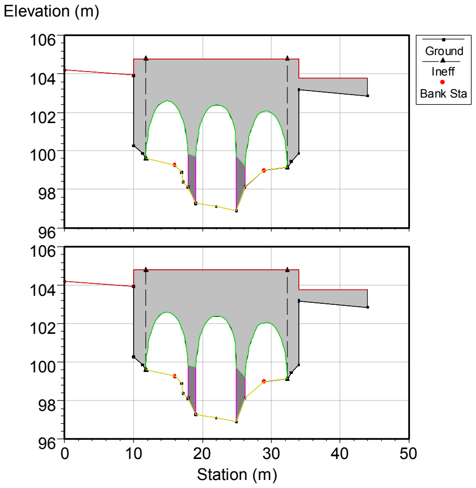

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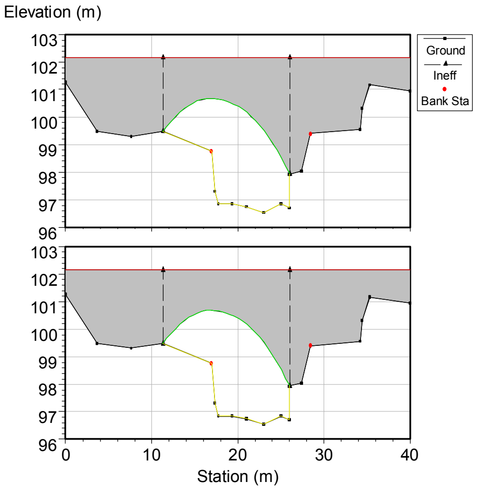

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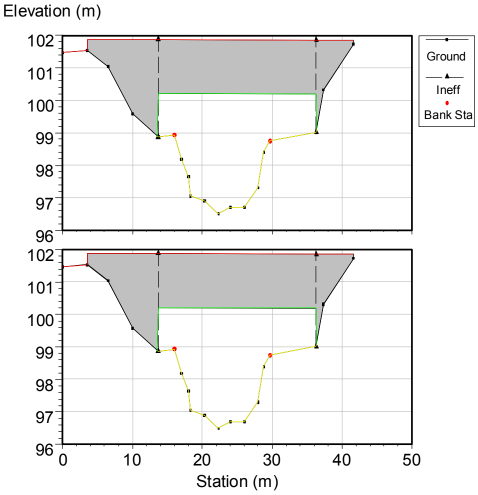

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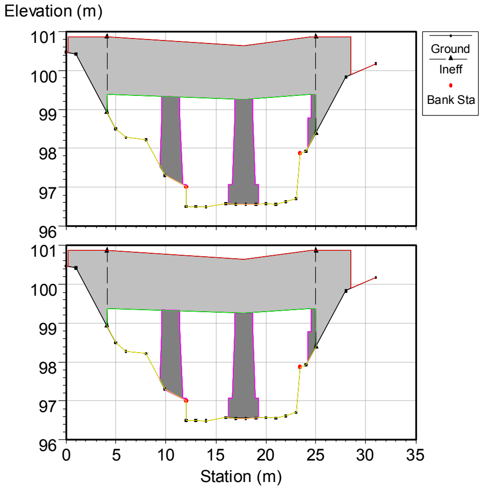

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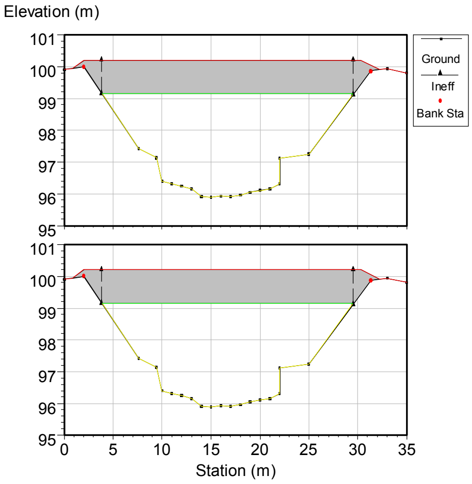

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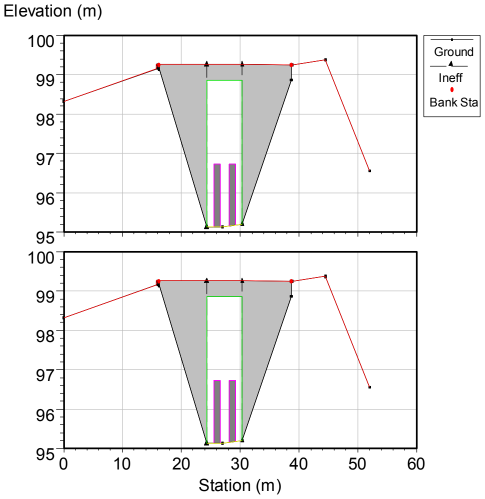

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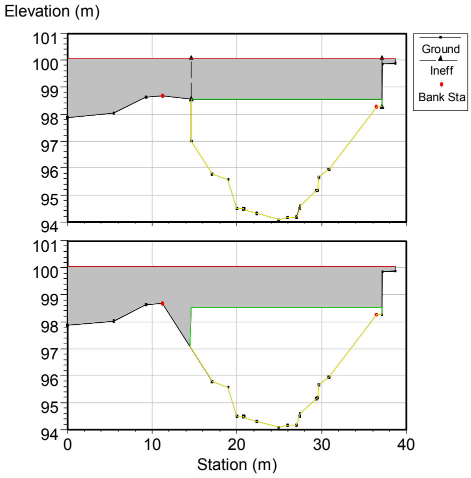

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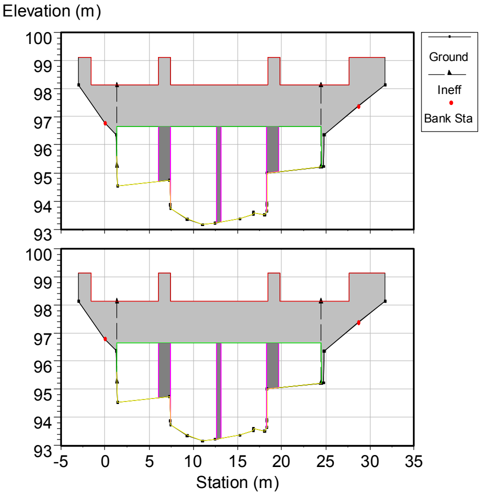

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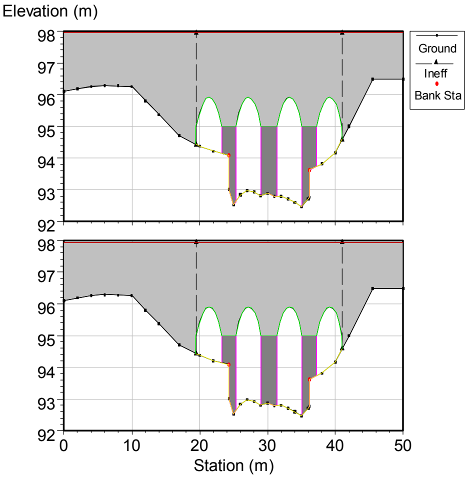

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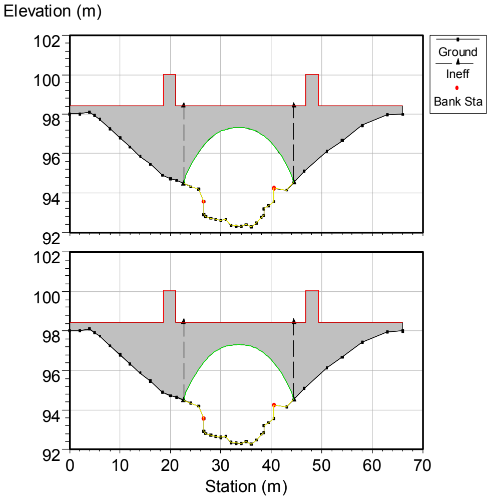

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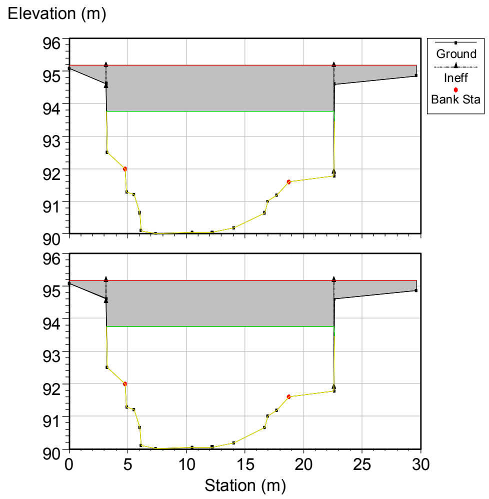

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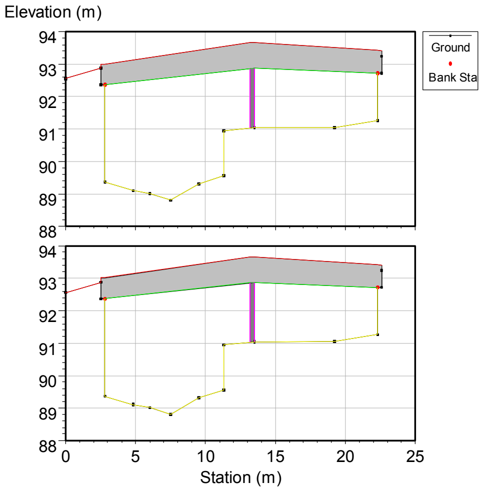

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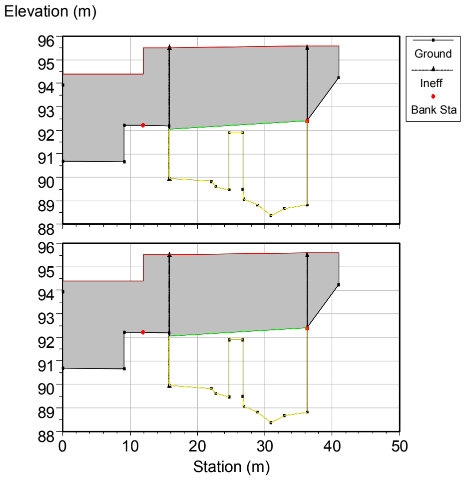

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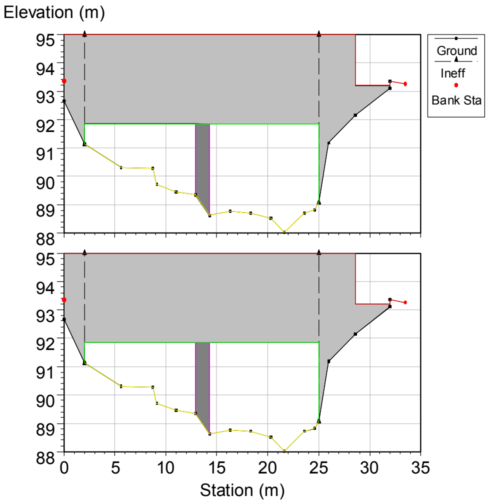

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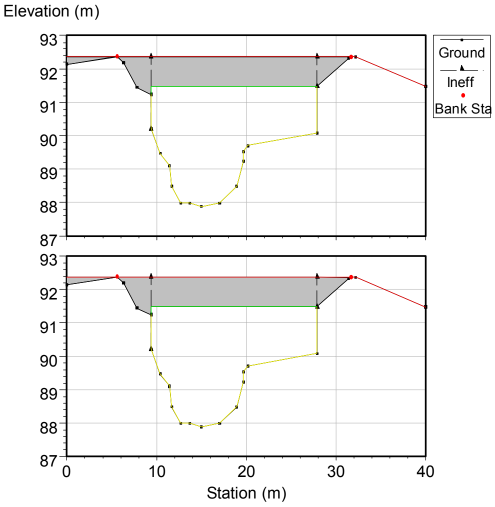

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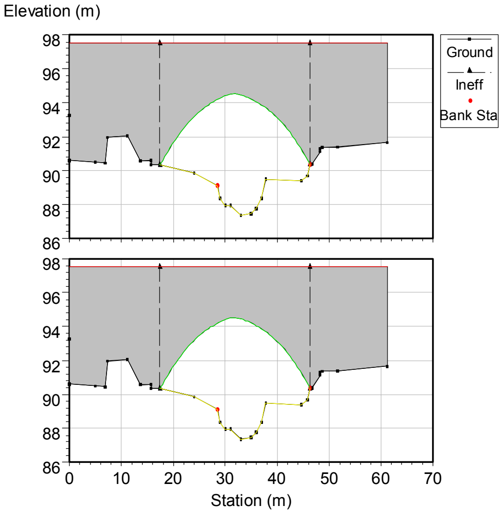

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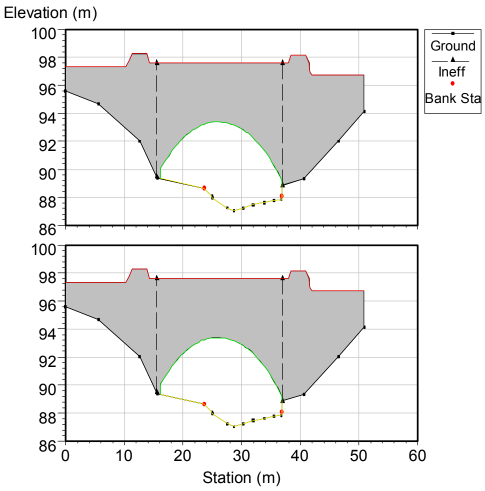

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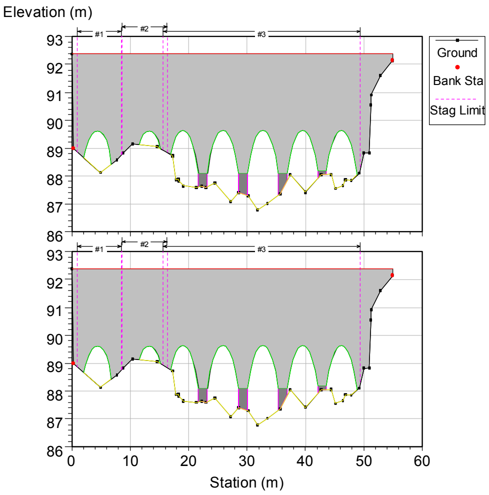

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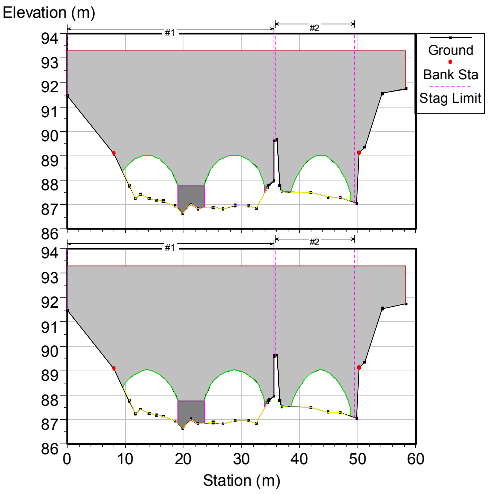

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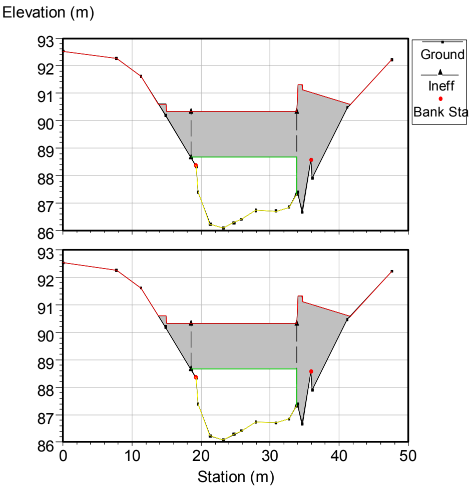

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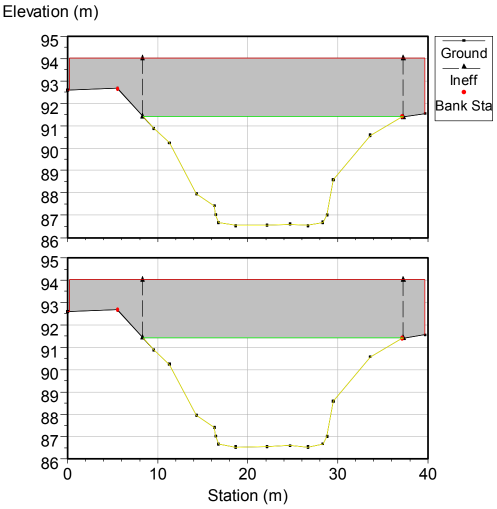

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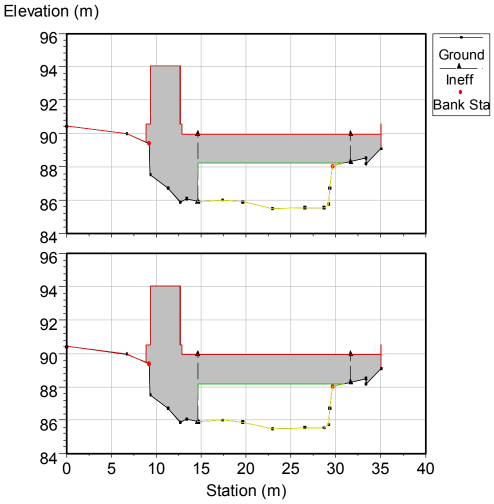

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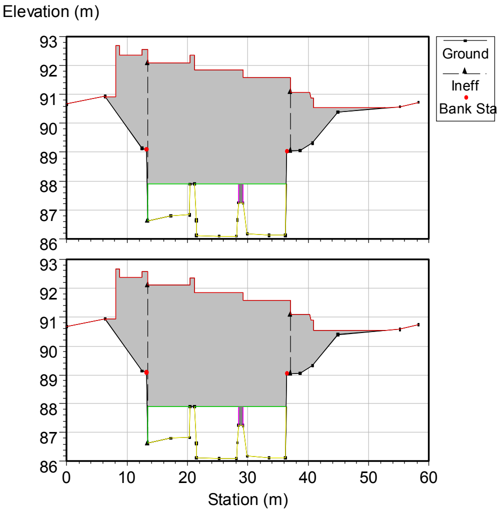

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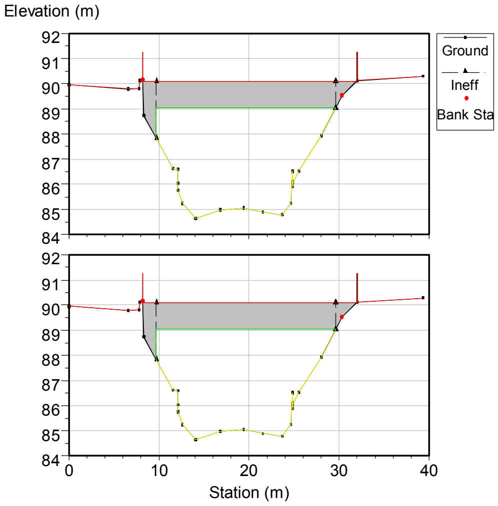

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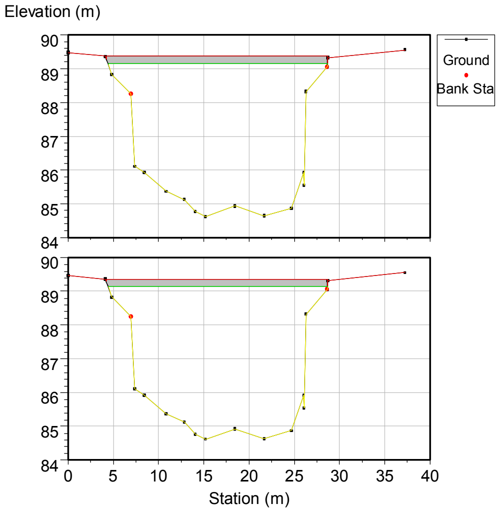

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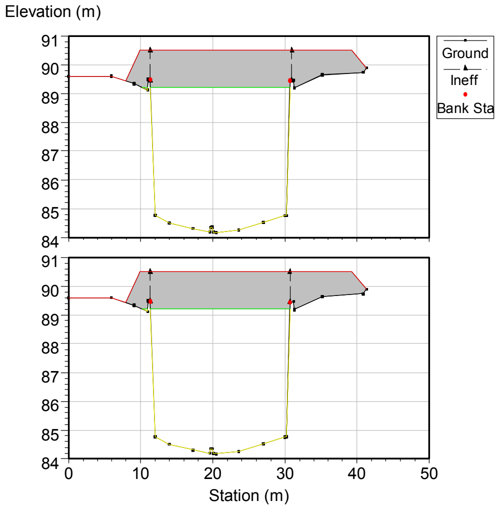

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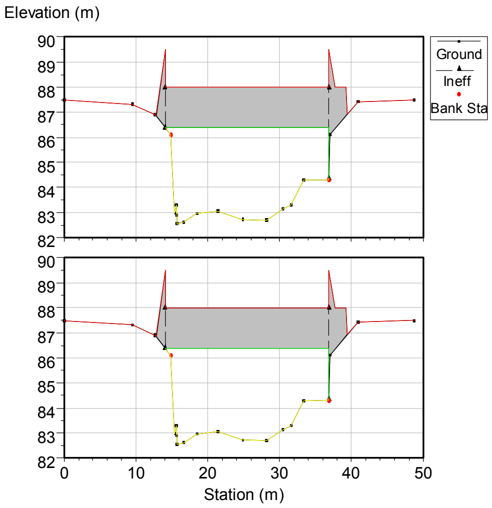

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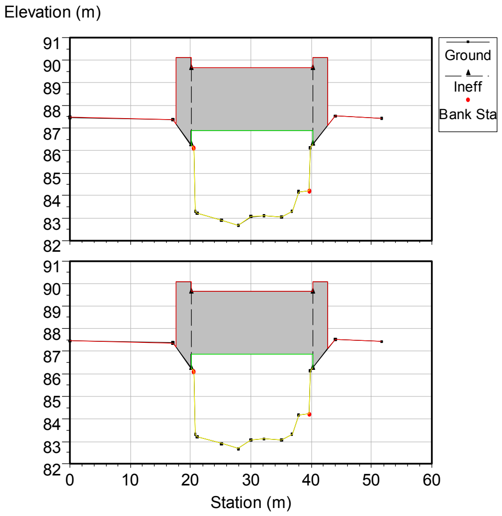

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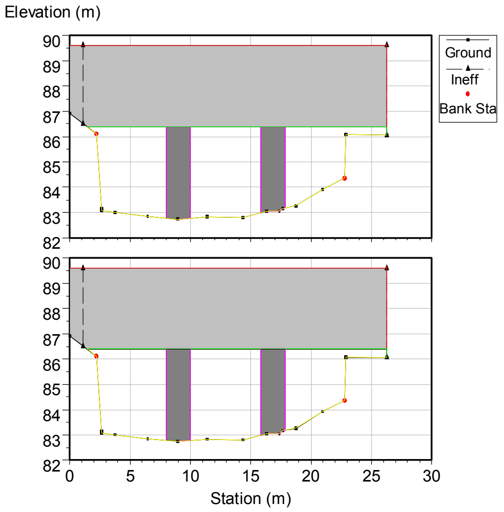

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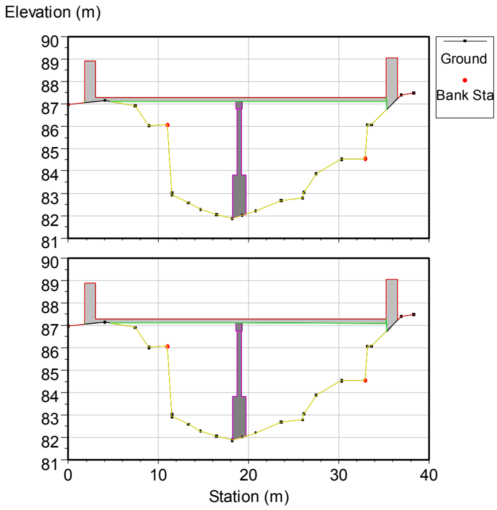

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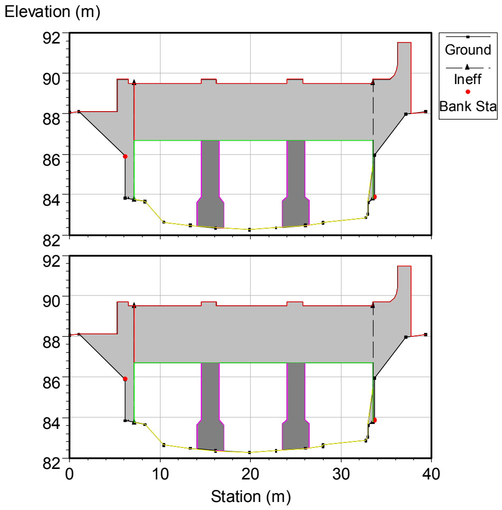

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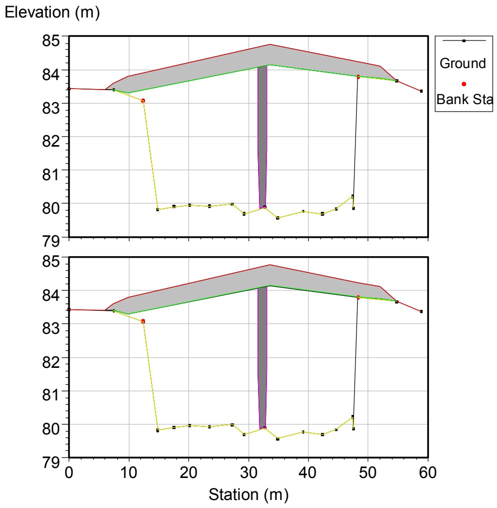

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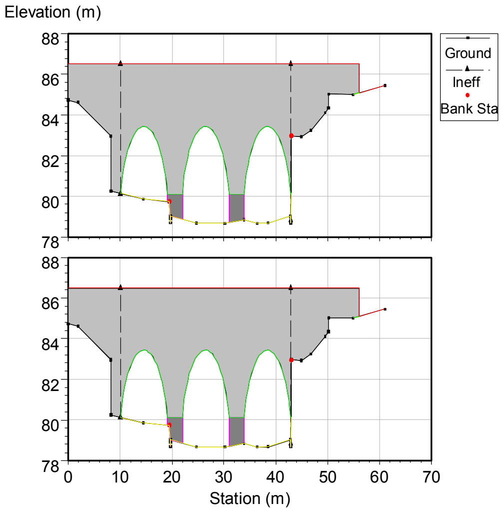

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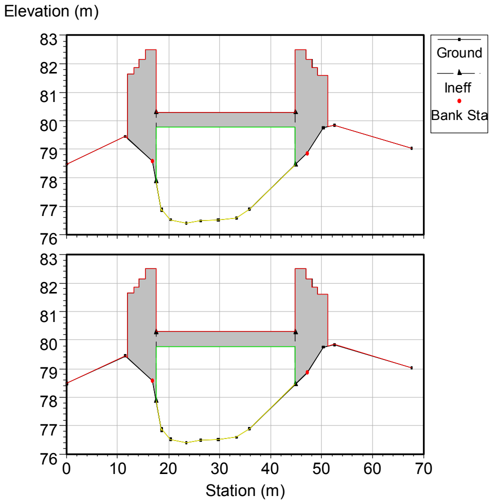

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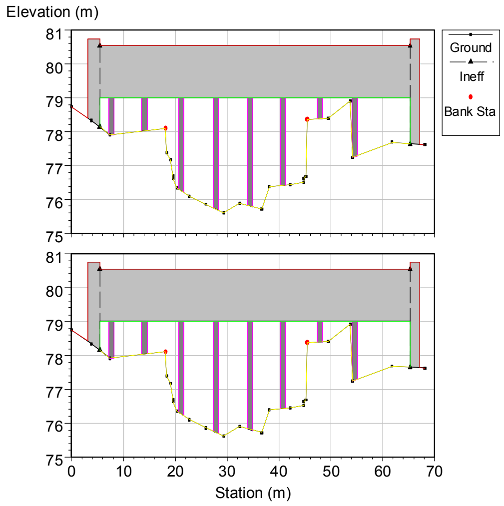

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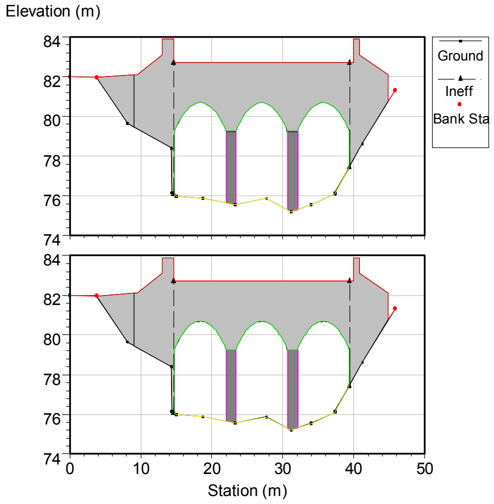

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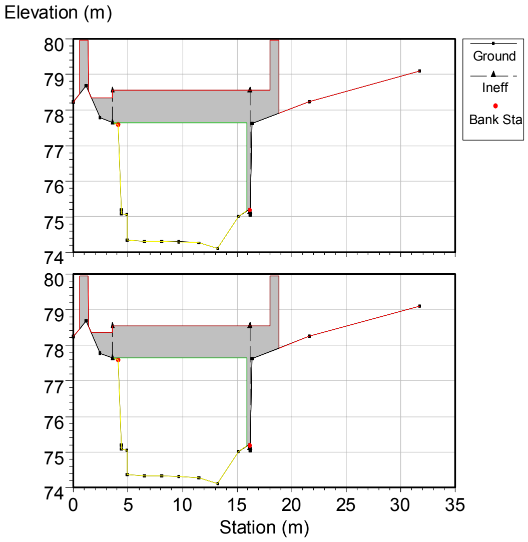

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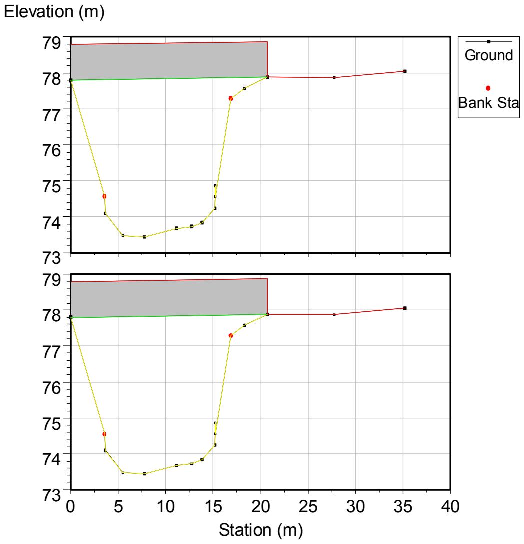

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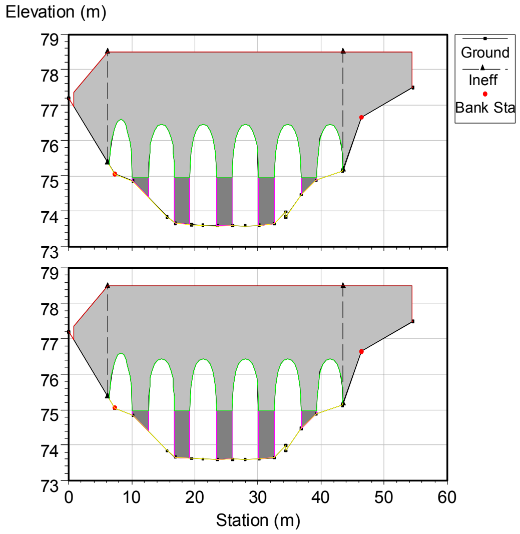

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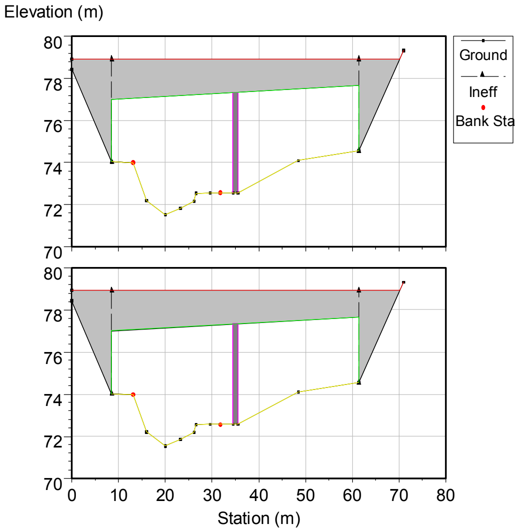
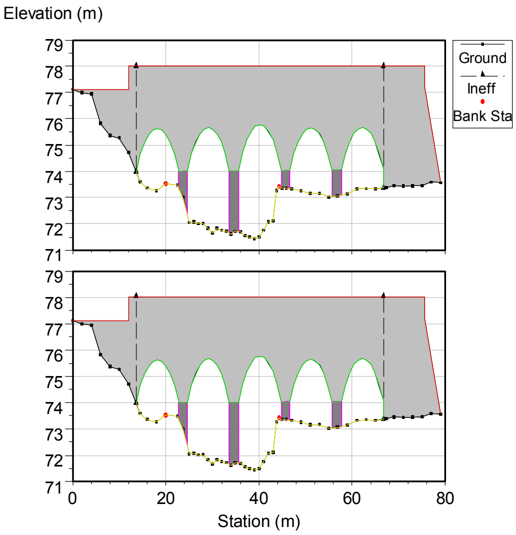
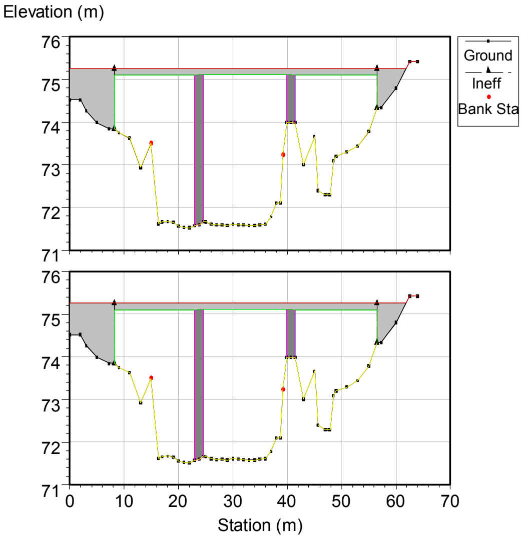


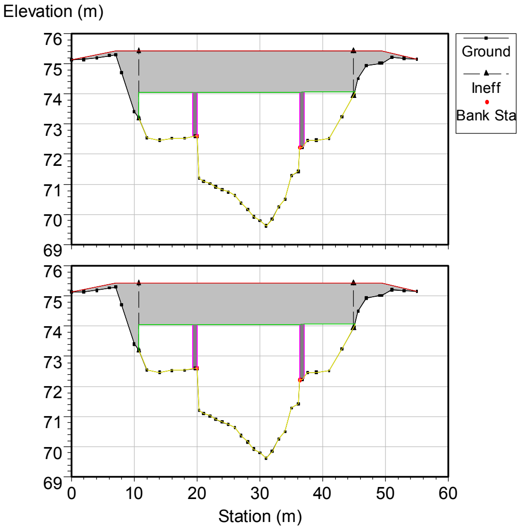
Reach: River Tame, Riv. Sta.: 290 & 280 (Bridge)



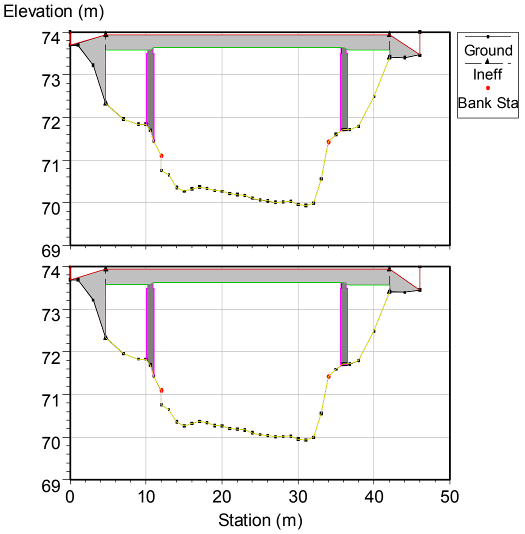
Reach: River Tame, Riv. Sta.: 270 & 260 (Bridge)



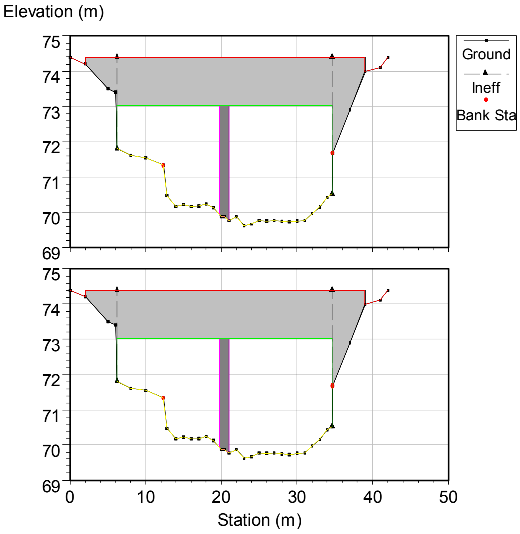
Reach: River Tame, Riv. Sta.: 240 & 230 (Bridge)



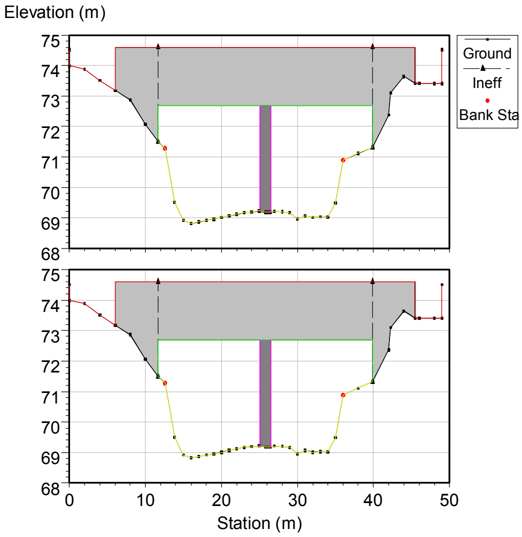
Reach: River Tame, Riv. Sta.: 200 & 190 (Bridge)



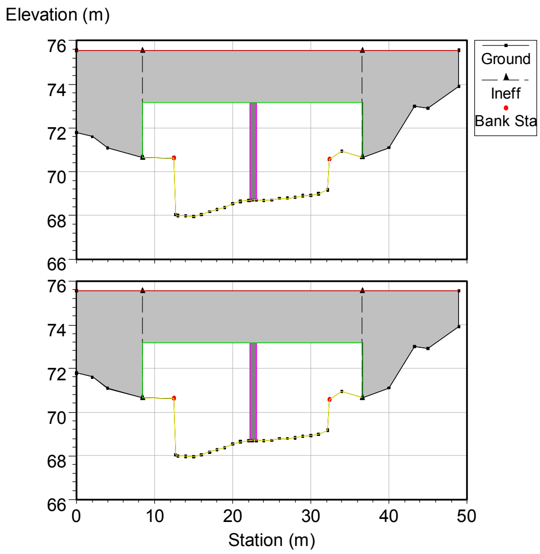
Reach: River Tame, Riv. Sta.: 170 & 160 (Bridge)



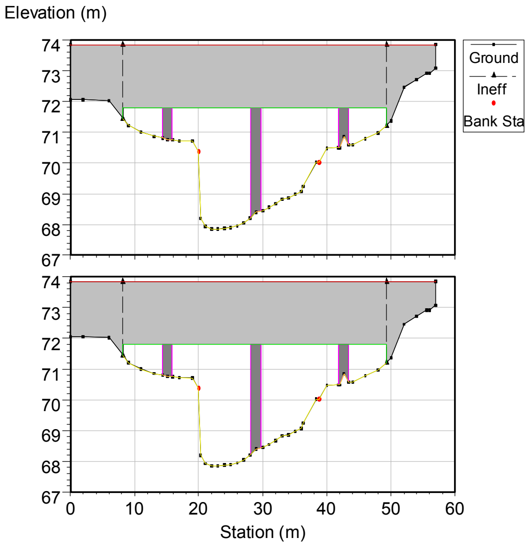
Reach: River Tame, Riv. Sta.: 150 & 140 (Bridge)



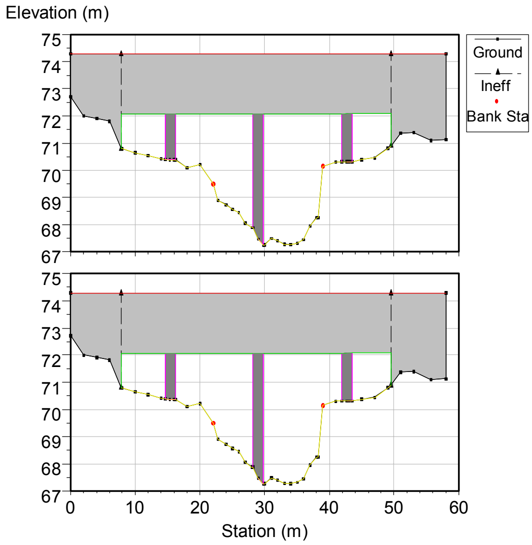
Reach: River Tame, Riv. Sta.: 120 & 110 (Bridge)



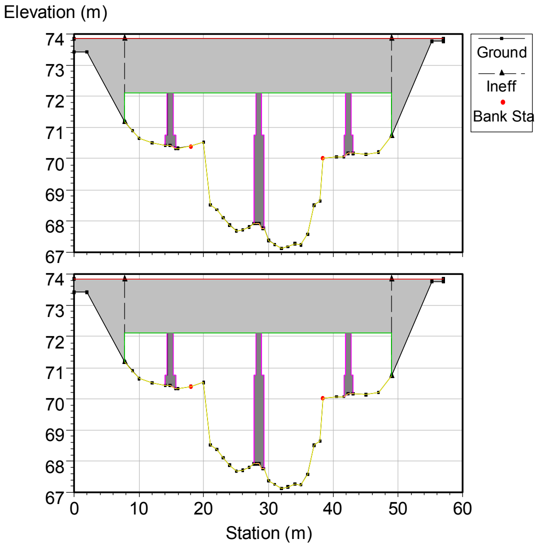
Reach: River Tame, Riv. Sta.: 90 & 80 (Bridge)



Reach: River Tame, Riv. Sta.: 70 & 60 (Bridge)



Reach: River Tame, Riv. Sta.: 40 & 30 (Bridge)



Reach: River Tame, Riv. Sta.: 20 & 10 (Bridge)

PART 2

STEADY MODEL RESULTS

HEC-RAS

TABLE A2: STEADY MODEL RESULTS, CASE 1

Cross-section No:.	Q Total	Min Ch El	W.S. Elev	Vel Total	Cross-Section length	Top Width	Froude # Chl
	(m3/s)	(m)	(m)	(m/s)	(m)	(m)	
25144	105.00	107.07	111.30	1.17	92.000	40.000	0.26
25045	105.00	107.24	111.00	2.05	112.00	25.900	0.42
24940	105.00	106.41	110.78	1.32	193.00	71.680	0.38
24745	105.00	106.94	110.56	1.13	65.000	46.290	0.29
24680	105.00	107.19	110.52	0.82	138.00	97.500	0.26
24537	105.00	106.81	110.40	0.97	80.000	51.970	0.25
24457	105.00	106.49	110.39	0.49	40.000	173.00	0.16
24398	105.00	106.55	110.29	1.27	28.000	36.700	0.27
24370	105.00	106.55	110.26	1.29	180.00	36.690	0.28
24190	105.00	106.11	110.12	0.77	30.000	106.99	0.22
24159	105.00	106.24	110.08	1.05	11.000	45.930	0.23
24148	105.00	106.24	110.07	1.05	110.00	45.170	0.24
24038	105.00	106.14	110.03	0.75	48.000	76.820	0.21
23990	105.00	105.70	109.97	0.96	100.00	73.450	0.27
23890	105.00	105.88	109.85	0.90	170.00	99.950	0.29
23720	105.00	105.72	109.65	1.10	135.00	63.630	0.29
23585	105.00	105.48	109.54	0.86	90.000	94.870	0.26
23494	105.00	105.11	109.09	2.13	29.000	25.060	0.47
23465	105.00	105.11	108.91	2.34	65.000	25.020	0.52
23400	105.00	105.61	108.91	1.22	42.000	47.540	0.33
23355	105.00	105.54	108.87	1.07	10.000	53.490	0.28
23345	105.00	105.54	108.86	1.08	210.00	53.430	0.28
23135	105.00	104.72	108.73	0.81	67.000	69.410	0.21
23050	105.00	104.69	108.53	1.49	6.0000	38.990	0.37
23044	105.00	104.69	108.52	1.50	20.000	38.880	0.38
23024	105.00	104.85	108.39	1.87	6.0000	27.380	0.46
22996	105.00	104.85	108.37	1.89	206.00	27.380	0.47
22790	105.00	104.14	107.93	1.65	116.00	31.290	0.37
22667	105.00	104.50	107.80	1.35	14.000	32.710	0.31
22653	105.00	104.50	107.78	1.36	153.00	32.620	0.32
22500	105.00	103.78	107.72	0.64	72.000	108.630	0.18
22402	105.00	103.98	107.68	0.81	6.0000	70.850	0.19
22396	105.00	103.98	107.67	0.81	96.000	70.850	0.19
22300	105.00	103.78	107.67	0.37	154.00	189.85	0.11
22137	105.00	103.50	107.33	1.37	51.000	66.540	0.40
22104	105.00	103.56	107.13	1.62	38.000	57.310	0.47
22066	105.00	103.47	106.85	2.08	141.00	48.200	0.62
21925	105.00	102.70	106.58	0.83	68.000	113.97	0.28
21831	105.00	102.97	106.18	2.16	11.000	23.300	0.50
21820	105.00	102.97	106.13	2.21	120.00	23.300	0.52
21700	105.00	103.00	105.92	1.31	164.00	63.920	0.39
21539	105.00	102.73	105.53	1.54	7.0000	49.860	0.39
21532	105.00	102.73	105.51	1.56	14.000	49.630	0.40
21518	105.00	102.48	105.33	2.32	25.000	26.390	0.57

TABLE A2 CONTINUED

21493	105.00	102.48	105.09	2.69	33.000	25.360	0.69
21460	105.00	102.27	105.17	0.74	200.00	221.50	0.30
21260	105.00	101.93	105.00	0.50	200.00	286.75	0.22
21060	105.00	101.53	104.93	0.34	330.00	265.37	0.12
20698	105.00	100.59	104.34	1.85	23.000	22.500	0.39
20675	105.00	100.59	104.28	1.89	175.00	22.500	0.40
20470	105.00	100.46	104.09	1.17	200.00	45.560	0.25
20273	105.00	99.800	103.88	1.44	100.00	28.970	0.28
20203	105.00	99.700	103.77	1.51	28.490	28.990	0.29
20124	105.00	99.700	103.66	1.88	5.0000	22.050	0.38
20080	105.00	99.700	103.65	1.88	166.51	22.000	0.38
20000	105.00	98.890	103.40	1.61	100.00	25.770	0.31
19900	105.00	99.290	103.29	1.58	200.00	27.440	0.33
19700	105.00	98.920	103.07	1.39	200.00	37.940	0.30
19500	105.00	98.600	102.85	1.40	200.00	34.650	0.30
19300	105.00	98.170	102.70	1.24	200.00	39.780	0.26
19100	105.00	97.930	102.53	1.22	200.00	37.190	0.26
18900	105.00	98.380	102.46	0.77	200.00	65.000	0.19
18700	105.00	97.470	102.20	1.27	200.00	49.350	0.29
18500	105.00	97.670	102.10	0.85	200.00	68.150	0.20
18300	105.00	97.440	102.01	0.72	100.00	104.20	0.20
18200	105.00	98.750	102.00	0.47	100.00	170.38	0.16
18100	105.00	97.800	101.98	0.32	200.00	199.00	0.10
17900	105.00	97.580	101.93	0.52	100.00	130.80	0.15
17800	105.00	96.650	101.75	1.31	100.00	36.00	0.28
17700	105.00	97.140	101.70	1.05	100.00	43.60	0.23
17600	105.00	97.080	101.63	1.16	50.000	31.00	0.22
17550	105.00	96.850	101.59	1.09	30.000	49.08	0.23
17520	105.00	96.880	101.51	1.46	5.0000	24.00	0.29
17515	105.00	96.880	101.51	1.46	115.00	24.00	0.29
17400	105.00	96.900	101.13	2.22	100.00	18.94	0.42
17300	105.00	97.050	101.11	1.20	100.00	40.26	0.28
17200	105.00	96.460	100.95	1.44	54.000	30.49	0.30
17146	105.00	96.550	100.89	1.40	14.000	34.22	0.30
17138	105.00	96.550	100.87	1.41	8.0000	34.16	0.30
17132	105.00	96.500	100.87	1.35	15.000	32.09	0.28
17117	105.00	96.500	100.86	1.36	117.00	32.01	0.28
17000	105.00	96.490	100.68	1.48	200.00	34.09	0.31
16800	105.00	96.280	100.44	1.58	207.00	26.35	0.31
16593	105.00	96.490	100.18	1.55	10.000	29.50	0.33
16583	105.00	96.490	100.17	1.56	283.00	29.43	0.33
16300	105.00	95.850	99.860	1.40	50.000	32.72	0.30
16250	105.00	95.890	99.830	1.43	2.3500	29.10	0.29
16248	105.00	95.890	99.830	1.43	247.65	29.05	0.29
16000	105.00	95.320	99.570	1.27	100.00	38.60	0.28
15900	105.00	95.310	99.420	1.46	50.000	34.00	0.32
15850	105.00	94.860	99.310	1.61	70.000	32.00	0.36
15780	105.00	95.130	99.270	1.32	5.0000	47.30	0.30
15775	105.00	95.130	99.270	1.33	75.000	47.00	0.30

TABLE A2 CONTINUED

15700	105.00	95.020	99.160	1.31	300.00	38.87	0.30
15400	105.00	94.490	98.930	1.06	300.00	51.05	0.24
15100	105.00	94.500	98.490	1.50	76.000	43.56	0.35
14509	105.00	94.090	98.400	1.60	8.0000	30.28	0.31
14501	105.00	94.090	98.400	1.56	118.00	33.14	0.32
14383	105.00	93.480	98.300	1.37	200.00	28.84	0.26
14183	105.00	93.080	98.150	1.28	106.00	29.77	0.23
14077	105.00	93.160	98.110	1.03	35.000	34.62	0.18
14037	105.00	93.160	98.100	1.03	266.00	34.52	0.18
13900	105.00	93.320	97.450	2.17	200.00	17.38	0.41
13700	105.00	92.880	97.020	2.06	200.00	19.70	0.40
13500	105.00	92.240	96.410	2.35	173.00	19.32	0.47
13327	105.00	92.460	96.200	1.43	5.0000	37.09	0.32
13322	105.00	92.460	96.200	1.43	8.0000	36.83	0.32
13316	105.00	92.280	96.200	1.31	21.000	38.80	0.28
13164	105.00	92.280	96.180	1.32	200.00	38.56	0.29
12964	105.00	91.750	95.710	1.98	100.00	20.12	0.40
12864	105.00	91.440	95.680	1.12	100.00	37.92	0.25
12764	105.00	91.040	95.440	1.57	143.000	31.92	0.33
12621	105.00	91.250	95.200	1.69	200.00	28.92	0.36
12421	105.00	91.000	94.980	1.35	200.00	39.25	0.30
12221	105.00	90.690	94.750	1.48	200.00	29.83	0.31
12021	105.00	90.660	94.530	1.46	200.00	33.10	0.30
11821	105.00	90.580	94.280	1.49	52.000	37.31	0.33
11769	105.00	90.530	94.200	1.49	161.00	37.53	0.33
11608	105.00	90.020	93.990	1.69	18.000	19.47	0.32
11601	105.00	90.020	93.970	1.71	82.000	19.47	0.32
11600	105.00	89.490	93.900	1.49	100.00	23.33	0.29
11500	105.00	89.280	93.640	1.98	85.000	17.77	0.37
11415	105.00	88.810	93.610	1.53	7.0000	22.60	0.27
11408	105.00	88.810	93.600	1.53	114.00	22.60	0.27
11300	105.00	88.880	93.460	1.47	102.00	24.00	0.28
11200	105.00	88.360	93.420	1.27	45.000	24.20	0.23
11142	105.00	88.380	93.430	0.91	18.000	38.94	0.17
11124	105.00	88.380	93.420	0.91	92.000	38.91	0.17
11000	105.00	88.410	93.260	1.58	200.00	26.62	0.29
10800	105.00	88.340	93.050	1.36	200.00	33.68	0.27
10600	105.00	88.250	92.840	1.43	200.00	30.00	0.29
10400	105.00	87.990	92.470	1.93	198.00	22.32	0.36
10202	105.00	88.020	92.300	1.45	13.000	28.63	0.29
10189	105.00	88.020	92.280	1.46	86.000	28.55	0.29
9990	105.00	88.050	92.270	0.85	12.000	49.50	0.17
9978	105.00	88.050	92.260	0.86	85.000	49.49	0.17
9900	105.00	87.550	92.230	0.68	110.00	77.23	0.17
9790	105.00	87.890	91.900	1.93	4.2000	26.48	0.40
9786	105.00	87.890	91.890	1.94	170.00	26.29	0.41
9600	105.00	87.590	91.520	1.54	139.00	43.69	0.39
9461	105.00	87.360	91.310	1.43	3.0000	43.10	0.35
9458	105.00	87.360	91.300	1.43	148.00	43.06	0.35

TABLE A2 CONTINUED

9300	105.00	87.180	90.970	1.70	217.00	33.51	0.39
9098	105.00	87.030	90.570	1.75	30.000	29.03	0.40
9068	105.00	87.030	90.490	1.82	18.000	28.78	0.42
9050	105.00	86.800	90.600	0.80	10.000	51.07	0.16
9040	105.00	86.800	90.600	0.80	96.000	51.07	0.16
8944	105.00	86.640	90.580	0.73	20.000	49.84	0.13
8924	105.00	86.640	90.570	0.73	90.000	49.82	0.13
8834	105.00	86.090	90.420	1.43	2.0000	26.85	0.26
8832	105.00	86.090	90.420	1.43	158.00	26.84	0.26
8676	105.00	85.930	89.750	2.66	56.000	15.93	0.52
8620	105.00	86.540	89.610	2.31	2.5000	19.47	0.48
8618	105.00	86.540	89.600	2.32	13.500	19.43	0.49
8604	105.00	86.200	89.540	2.37	120.00	18.32	0.49
8484	105.00	85.500	89.430	1.37	3.8000	25.98	0.25
8480	105.00	85.500	89.420	1.38	24.200	25.97	0.25
8456	105.00	85.920	89.280	1.83	90.000	23.88	0.38
8366	105.00	85.980	89.010	1.98	30.000	27.75	0.44
8336	105.00	86.100	88.980	1.81	8.0000	23.22	0.37
8328	105.00	86.100	88.950	1.83	194.00	23.21	0.37
8132	105.00	84.650	88.460	1.98	10.000	20.07	0.39
8124	105.00	84.650	88.440	2.00	13.000	19.99	0.39
8111	105.00	85.260	88.450	1.64	145.00	30.01	0.36
7966	105.00	84.810	87.980	1.97	120.00	27.67	0.45
7846	105.00	84.620	87.590	2.20	3.4000	19.16	0.45
7843	105.00	84.620	87.570	2.22	5.6000	19.16	0.45
7837	105.00	84.170	87.620	1.76	2.6000	18.90	0.32
7834	105.00	84.170	87.620	1.77	26.000	18.90	0.32
7724	105.00	83.890	87.610	1.54	79.000	22.72	0.28
7700	105.00	83.570	87.360	2.01	60.000	19.89	0.40
7640	105.00	84.100	87.290	1.50	116.00	28.34	0.30
7524	105.00	84.390	86.920	2.15	200.00	21.92	0.46
7324	105.00	83.590	86.510	1.73	154.00	22.28	0.33
7170	105.00	83.360	86.200	1.87	48.000	22.04	0.37
7122	105.00	82.890	86.090	1.92	164.00	21.66	0.39
6958	105.00	82.550	85.780	1.86	1.0000	22.07	0.37
6957	105.00	82.550	85.770	1.86	10.000	22.07	0.37
6947	105.00	82.680	85.670	2.20	5.0000	19.16	0.45
6942	105.00	82.680	85.650	2.22	12.000	19.16	0.45
6930	105.00	82.750	85.660	2.01	20.000	20.57	0.40
6910	105.00	82.750	85.600	2.06	22.000	20.56	0.42
6888	105.00	81.880	85.590	1.83	2.0000	22.03	0.36
6886	105.00	81.880	85.580	1.84	162.00	22.02	0.36
6724	105.00	79.820	85.310	1.67	81.000	28.02	0.32
6641	105.00	82.270	85.250	1.48	21.000	27.57	0.29
6620	105.00	82.270	85.220	1.50	96.000	27.57	0.30
6524	105.00	81.240	85.140	1.21	200.00	39.62	0.25
6324	105.00	81.390	84.990	1.20	158.00	38.19	0.25
6166	105.00	80.160	84.800	1.58	142.00	19.80	0.27
6024	105.00	80.970	84.610	1.62	100.00	21.87	0.30

TABLE A2 CONTINUED							
5924	105.00	80.890	84.470	1.59	200.00	26.74	0.30
5724	105.00	80.600	84.190	1.56	200.00	29.36	0.30
5524	105.00	80.360	83.900	1.55	200.00	28.79	0.30
5324	105.00	80.130	83.580	1.61	200.00	27.18	0.31
5124	105.00	79.830	83.240	1.61	200.00	30.10	0.32
4924	105.00	79.710	82.900	1.66	53.000	37.15	0.34
4871	105.00	79.570	82.910	1.00	5.0000	35.66	0.19
4866	105.00	79.570	82.910	1.00	142.00	35.65	0.19
4724	105.00	79.180	82.710	1.59	200.00	22.05	0.29
4524	105.00	78.800	82.480	1.53	200.00	22.13	0.28
4324	105.00	78.450	82.210	1.63	147.00	22.05	0.30
4177	105.00	78.670	82.090	1.24	62.000	35.70	0.23
4138	105.00	78.670	82.060	1.04	23.000	34.82	0.20
4115	105.00	78.670	82.050	1.04	18.000	34.82	0.20
4097	105.00	78.620	82.010	1.17	173.00	34.82	0.24
3924	105.00	78.400	81.690	1.60	240.00	33.62	0.36
3684	105.00	78.150	81.300	1.55	160.00	30.00	0.34
3524	105.00	77.620	81.120	1.40	200.00	35.96	0.29
3324	105.00	77.460	80.910	1.39	200.00	44.94	0.29
3124	105.00	77.090	80.730	1.30	200.00	45.43	0.28
2924	105.00	76.690	80.440	1.63	200.00	40.53	0.33
2724	105.00	76.430	80.300	1.03	200.00	50.43	0.24
2524	105.00	76.730	80.120	1.11	200.00	53.25	0.27
2324	105.00	76.520	79.890	1.30	200.00	42.70	0.30
2124	105.00	76.140	79.700	1.15	200.00	46.76	0.27
1924	105.00	75.190	79.530	1.05	84.000	57.94	0.26
1840	105.00	76.400	79.420	1.32	5.0000	56.01	0.30
1835	105.00	76.400	79.420	1.32	111.00	55.76	0.31
1724	105.00	76.020	79.330	1.01	118.00	62.08	0.25
1606	105.00	75.610	79.290	0.76	24.000	68.08	0.17
1582	105.00	75.610	79.280	0.77	54.000	68.08	0.17
1528	105.00	75.600	79.040	1.88	44.000	26.13	0.38
1484	105.00	75.210	79.070	1.24	14.000	30.97	0.24
1470	105.00	75.210	79.060	1.24	143.00	30.90	0.24
1327	105.00	74.620	78.840	1.47	200.00	38.24	0.31
1127	105.00	74.160	78.600	1.60	205.00	31.26	0.30
922	105.00	74.100	78.090	2.31	6.0000	18.34	0.40
916	105.00	74.100	78.070	2.32	188.00	18.18	0.41
728	105.00	74.000	77.820	1.58	212.00	34.90	0.33
516	105.00	73.430	77.330	2.13	5.0000	16.59	0.39
511	**105.00**	**73.430**	**77.320**	**2.14**	**26.000**	**16.52**	**0.39**
480	105.00	73.720	77.190	2.10	158.00	24.35	0.48
400	105.00	73.800	76.980	1.41	200.00	44.79	0.35
390	105.00	73.360	76.500	1.77	50.000	44.03	0.44
380	105.00	73.030	76.380	1.65	73.000	54.30	0.44
370	105.00	73.590	76.350	1.24	5.0000	42.88	0.28
360	105.00	73.590	76.340	1.24	220.00	42.85	0.28
350	105.00	72.240	75.850	1.53	202.50	72.29	0.42
340	105.00	72.250	75.470	1.42	185.00	122.22	0.36

TABLE A2 CONTINUED							
330	105.00	71.270	75.370	0.64	190.00	219.12	0.19
320	105.00	72.030	75.110	1.25	122.50	123.54	0.33
310	105.00	71.500	74.940	1.02	120.00	174.63	0.33
300	105.00	71.510	74.860	0.57	90.000	230.30	0.22
290	105.00	71.530	74.660	1.35	26.000	54.240	0.37
280	105.00	71.530	74.600	1.41	85.000	54.020	0.38
270	105.00	71.440	74.550	0.97	8.9500	66.630	0.26
260	105.00	71.440	74.540	0.97	91.050	66.610	0.26
250	105.00	70.660	74.370	1.41	90.000	44.420	0.32
240	105.00	71.520	74.280	1.22	8.9500	53.420	0.29
230	105.00	71.520	74.270	1.23	90.000	53.340	0.30
220	105.00	70.840	74.190	1.15	311.05	55.930	0.25
210	105.00	69.670	73.740	1.64	10.000	31.910	0.36
200	105.00	69.630	73.740	1.47	10.500	34.870	0.31
190	105.00	69.630	73.730	1.48	479.50	34.800	0.32
180	105.00	69.870	73.050	1.51	100.00	38.410	0.33
170	105.00	69.940	72.930	1.41	4.3400	37.410	0.31
160	105.00	69.940	72.930	1.42	125.66	37.390	0.31
150	105.00	69.620	72.780	1.47	2.0000	30.690	0.30
140	105.00	69.620	72.780	1.48	268.00	30.690	0.30
130	105.00	69.410	72.290	1.78	268.00	31.110	0.39
120	105.00	68.820	71.880	1.57	8.5700	30.490	0.32
110	105.00	68.820	71.870	1.58	11.430	30.430	0.32
100	105.00	68.070	71.860	1.43	201.00	40.060	0.31
90	105.00	67.950	71.610	1.41	5.4700	38.970	0.30
80	105.00	67.950	71.600	1.42	43.530	38.890	0.30
70	105.00	67.850	71.540	1.42	9.1500	42.540	0.31
60	105.00	67.850	71.530	1.43	220.85	42.470	0.31
50	105.00	67.760	71.230	1.47	40.00	42.250	0.33
40	105.00	67.260	71.180	1.40	3.3900	46.240	0.31
30	105.00	67.260	71.170	1.41	1.1300	46.180	0.31
20	105.00	67.120	71.190	1.31	4.7500	42.150	0.28
10	105.00	67.120	71.180	1.32	270.00	42.120	0.28
0	105.00	67.120	70.690	1.76	0.0000	38.980	0.39

TABLE A3: STEADY MODEL RESULTS, CASE 2

Cross-Section No:.	Q Total	Min Ch El	W.S. Elev	Vel Total	Cross-Section length	Top Width	Froude # Chl
	(m3/s)	(m)	(m)	(m/s)	(m)	(m)	
25144	105	107.07	111.58	1.04	92.0	40.00	0.22
25052	105	107.29	111.37	1.67	0.00	43.42	0.36
25050	105		111.37				
25045	105	107.24	111.02	2.18	105	26.53	0.40
24940	105	106.41	110.87	1.22	193	72.22	0.35
24745	105	106.94	110.68	1.07	65.0	46.29	0.27
24680	105	107.19	110.65	0.75	138	97.50	0.23

TABLE A3 CONTINUED

24537	105	106.81	110.55	0.90	80.0	51.970	0.22
24457	105	106.49	110.55	0.44	40.0	173.00	0.14
24398	105	106.55	110.45	1.26	0.00	36.740	0.25
24390	105		110.45				
24370	105	106.55	110.41	1.28	180	36.730	0.26
24190	105	106.11	110.31	0.67	30.0	107.58	0.19
24159	105	106.24	110.27	1.01	0.00	50.190	0.22
24150	105		110.27				
24148	105	106.24	110.24	1.02	110	49.900	0.22
24038	105	106.14	110.20	0.69	48.0	76.820	0.19
23990	105	105.70	110.15	0.85	100	73.660	0.23
23890	105	105.88	110.09	0.75	170	103.22	0.23
23720	105	105.72	109.96	0.91	135	64.340	0.23
23585	105	105.48	109.91	0.66	90	97.520	0.18
23494	105	105.11	109.62	1.85	0.00	25.180	0.35
23490	105		109.62				
23465	105	105.11	109.55	1.90	65.0	25.160	0.37
23400	105	105.61	109.55	0.90	42.0	48.000	0.21
23355	105	105.54	109.53	0.79	0.00	57.620	0.18
23350	105		109.53				
23345	105	105.54	109.48	0.81	210	57.27	0.18
23135	105	104.72	109.43	0.59	67.0	71	0.13
23050	105	104.69	109.35	1.04	0.00	61.04	0.22
23046	105		109.35				
23044	105	104.69	109.28	1.07	20	61.04	0.23
23024	105	104.85	109.21	1.34	0	27.38	0.29
23000	105		109.21				
22996	105	104.85	109.2	1.34	206	27.38	0.29
22790	105	104.14	109.07	1.05	116	31.8	0.21
22667	105	104.5	109.03	0.87	0	36.5	0.17
22655	105		109.03				
22653	105	104.5	108.37	1.23	153	35.33	0.24
22500	105	103.78	108.35	0.45	72	110.12	0.11
22402	105	103.98	108.33	0.6	0	70.85	0.12
22396	105	103.98	108.17	0.64	96	70.85	0.14
22300	105	103.78	108.16	0.27	154	192	0.07
22137	105	103.5	108.06	0.81	51	75.2	0.22
22104	105	103.56	108.03	0.83	38	79.02	0.22
22066	105	103.47	108	0.98	141	50.53	0.24
21925	105	102.7	107.98	0.36	68	116	0.09
21831	105	102.97	107.88	1.11	0	30.85	0.22
21830	105		107.88				
21820	105	102.97	106.71	1.81	120	25.5	0.37
21700	105	103	106.65	0.81	164	70	0.21
21539	105	102.73	106.4	1.68	0	53.71	0.29
21535	105		106.4				
21532	105	102.73	105.64	2.17	14	51.18	0.43
21518	105	102.48	105.54	2.38	0	27.28	0.51
21500	105		105.54				

TABLE A3 CONTINUED

21493	105	102.48	105.39	2.55	33	26.64	0.56
21460	105	102.27	105.47	0.49	200	253.38	0.19
21260	105	101.93	105.41	0.31	200	326.97	0.12
21060	105	101.53	105.39	0.24	330	272.14	0.07
20698	105	100.59	105.09	1.43	0	22.5	0.28
20675	105	100.59	104.87	1.53	175	22.5	0.3
20470	105	100.46	104.78	0.85	200	51.2	0.17
20273	105	99.8	104.68	1.07	100	32	0.19
20203	105	99.7	104.64	0.94	28.49	52.03	0.18
20124	105	99.7	104.6	1.25	0	32.2	0.24
20173	105		104.6				
20080	105	99.7	103.75	4.18	166.51	22.39	0.66
20000	105	98.89	103.68	1.45	100	29.19	0.28
19900	105	99.29	103.6	1.39	200	29	0.28
19700	105	98.92	103.46	1.16	200	38.88	0.25
19500	105	98.6	103.33	1.14	200	35.8	0.24
19300	105	98.17	103.25	0.98	200	41	0.2
19100	105	97.93	103.16	0.95	200	39	0.19
18900	105	98.38	103.14	0.58	200	65	0.13
18700	105	97.47	103.04	0.83	200	55.79	0.18
18500	105	97.67	103.01	0.53	200	90	0.12
18300	105	97.44	102.99	0.4	100	126.7	0.1
18200	105	98.75	102.98	0.27	100	170.5	0.07
18100	105	97.8	102.98	0.2	200	199	0.05
17900	105	97.58	102.97	0.31	100	130.8	0.07
17800	105	96.65	102.9	0.86	100	36	0.16
17700	105	97.14	102.89	0.69	100	43.6	0.13
17600	105	97.08	102.86	0.82	50	31	0.14
17550	105	96.85	102.86	0.66	30	50	0.12
17520	105	96.88	102.8	1.14	0	24	0.18
17518	105		102.8				
17515	105	96.88	102.63	1.18	115	24	0.19
17400	105	96.9	102.51	1.4	100	20.6	0.24
17300	105	97.05	102.53	0.72	100	41.2	0.14
17200	105	96.46	102.49	0.87	54	30.8	0.16
17146	105	96.55	102.48	0.76	0	40	0.14
17140	105		102.48				
17138	105	96.55	101.93	1.68	8	40	0.26
17132	105	96.5	101.98	0.88	0	41.6	0.17
17130	105		101.98				
17117	105	96.5	101.76	1.19	117	41.6	0.2
17000	105	96.49	101.71	0.96	200	39.57	0.19
16800	105	96.28	101.62	1.04	207	31.53	0.19
16593	105	96.49	101.56	0.95	0	31	0.18
16590	105		101.56				
16583	105	96.49	101.34	1.01	283	31	0.19
16300	105	95.85	101.26	0.83	50	37	0.16
16250	105	95.89	101.25	0.85	0	35	0.14
16249	105		101.25				

TABLE A3 CONTINUED

16248	105	95.89	101.23	0.86	247.65	35	0.14
16000	105	95.32	101.18	0.71	100	40	0.14
15900	105	95.31	101.15	0.8	50	34	0.15
15850	105	94.86	101.13	0.85	70	32	0.16
15780	**105**	**95.13**	**101.13**	**0.6**	**0**	**52**	**0.11**
15778	105		101.13				
15775	105	95.13	99.45	1.19	75	52	0.27
15700	105	95.02	99.35	1.19	300	46	0.29
15400	105	94.49	99.15	0.95	300	57.3	0.22
15100	105	94.5	98.87	1.2	76	47.88	0.28
14509	105	94.09	98.8	1.47	0	37.12	0.26
14507	105		98.8				
14501	105	94.09	98.71	1.35	118	37.11	0.27
14383	105	93.48	98.63	1.22	200	28.84	0.22
14183	105	93.08	98.53	1.12	106	29.77	0.2
14077	105	93.16	98.5	0.91	0	34.72	0.15
14070	105		98.5				
14037	105	93.16	98.28	0.97	266	34.72	0.17
13900	105	93.32	97.73	1.97	200	17.8	0.37
13700	105	92.88	97.43	1.77	200	19.7	0.33
13500	105	92.24	97.14	1.74	173	22.59	0.34
13327	105	92.46	97.05	1.33	0	50	0.23
13325	105		97.05				
13322	105	92.46	96.31	1.66	8	45.07	0.32
13316	105	92.28	96.31	1.56	0	39.85	0.29
13200	105		96.31				
13164	105	92.28	96.23	1.6	200	39.09	0.3
12964	105	91.75	95.8	1.91	100	20.43	0.39
12864	105	91.44	95.77	1.08	100	37.92	0.23
12764	105	91.04	95.57	1.48	143	31.92	0.31
12621	105	91.25	95.37	1.57	200	29.37	0.32
12421	105	91	95.21	1.21	200	39.67	0.26
12221	105	90.69	95.03	1.32	200	33.94	0.27
12021	105	90.66	94.88	1.22	200	42.66	0.26
11821	105	90.58	94.73	1.2	52	37.31	0.25
11769	105	90.53	94.69	1.18	161	37.53	0.25
11608	105	90.02	94.57	1.44	0	19.5	0.25
11607	105		94.57				
11601	105	90.02	94.42	1.5	82	19.49	0.26
11600	105	89.49	94.37	1.29	100	23.4	0.24
11500	105	89.28	94.2	1.66	85	19.11	0.3
11415	105	88.81	94.19	1.28	0	22.6	0.21
11410	105		94.19				
11408	105	88.81	94.1	1.31	114	22.6	0.22
11300	105	88.88	94.02	1.24	102	24	0.23
11200	105	88.36	93.99	1.09	45	24.2	0.19
11142	105	88.38	93.97	1.15	0	40.31	0.17
11130	105		93.97				
11124	105	88.38	93.72	1.22	92	39.66	0.19

TABLE A3 CONTINUED

11000	105	88.41	93.62	1.36	200	30.39	0.24
10800	105	88.34	93.49	1.12	200	37.75	0.22
10600	105	88.25	93.36	1.18	200	30	0.22
10400	105	87.99	93.16	1.46	198	26.3	0.27
10202	105	88.02	93.09	1.22	0	31.95	0.2
10196	105		93.09				
10189	105	88.02	92.86	1.3	86	31.13	0.22
9990	105	88.05	92.86	0.68	12	54.5	0.13
9978	105	88.05	92.86	0.69	85	54.5	0.13
9900	105	87.55	92.84	0.52	110	78.41	0.12
9790	105	87.89	92.7	1.27	0	40	0.26
9788	105		92.7				
9786	105	87.89	92.53	1.39	170	40	0.29
9600	105	87.59	92.4	0.94	139	55.88	0.22
9461	105	87.36	92.32	1.13	0	61.2	0.21
9460	105		92.32				
9458	105	87.36	92.31	1.14	148	61.2	0.21
9300	105	87.18	92.24	1	217	34.4	0.2
9098	105	87.03	92.12	1.23	0	34.37	0.21
9070	105		92.12				
9068	105	87.03	92.06	1.25	18	34.08	0.21
9050	105	86.8	92.09	0.5	0	54.65	0.08
9040	105	86.8	91.73	0.55	96	53.24	0.09
8944	105	86.64	91.72	0.51	0	57.83	0.08
8924	105	86.64	91.28	0.58	90	53.16	0.1
8834	105	86.09	91.18	1.1	0	31.44	0.19
8833	105		91.18				
8832	105	86.09	90.79	1.25	158	29.06	0.22
8676	105	85.93	90.4	2.06	56	18.94	0.39
8620	105	86.54	90.35	1.72	0	22.15	0.33
8619	105		90.35				
8618	105	86.54	90.35	1.72	13.5	22.13	0.33
8604	105	86.2	90.33	1.74	120	22.54	0.34
8484	105	85.5	90.28	1.04	0	32.83	0.17
8482	105		90.28				
8480	105	85.5	89.82	1.63	24.2	27.63	0.27
8456	105	85.92	89.8	1.5	90	24.37	0.29
8366	105	85.98	89.68	1.42	30	33.21	0.31
8336	105	86.1	89.67	1.42	0	31.42	0.25
8330	105		89.67				
8328	105	86.1	88.94	1.84	194	23.21	0.37
8132	105	84.65	88.49	1.98	0	20.14	0.38
8130	105		88.49				
8124	105	84.65	88.46	2	13	20.06	0.38
8111	105	85.26	88.46	1.63	145	30.07	0.36
7966	105	84.81	88.01	1.93	120	27.81	0.44
7846	105	84.62	87.65	2.15	0	19.18	0.43
7844	105		87.65				
7843	105	84.62	87.63	2.16	5.6	19.18	0.43

TABLE A3 CONTINUED

7837	105	84.17	87.66	1.74	0	18.91	0.31
7835	105		87.66				
7834	105	84.17	87.66	1.74	26	18.91	0.31
7724	105	83.89	87.65	1.52	79	22.87	0.28
7700	105	83.57	87.4	1.98	60	19.91	0.39
7640	105	84.1	87.34	1.48	116	28.38	0.29
7524	105	84.39	87	2.07	200	21.95	0.43
7324	105	83.59	86.65	1.64	154	22.31	0.31
7170	105	83.36	86.4	1.73	48	22.11	0.33
7122	105	82.89	86.32	1.76	164	21.7	0.34
6958	105	82.55	86.1	1.65	0	22.15	0.31
6957.5	105		86.1				
6957	105	82.55	86.1	1.66	10	22.15	0.31
6947	105	82.68	86.02	1.94	0	19.21	0.37
6945	105		86.02				
6942	105	82.68	86	1.94	12	19.21	0.37
6930	105	82.75	86	1.77	0	20.64	0.33
6920	105		86				
6910	105	82.75	85.72	1.96	22	20.59	0.39
6888	105	81.88	85.7	1.76	0	22.06	0.34
6887	105		85.7				
6886	105	81.88	85.67	1.78	162	22.05	0.35
6724	105	79.82	85.43	1.58	81	28.44	0.3
6641	105	82.27	85.38	1.44	0	27.57	0.28
6630	105		85.38				
6620	105	82.27	85.22	1.53	96	27.57	0.3
6524	105	81.24	85.14	1.21	200	39.64	0.25
6324	105	81.39	84.99	1.19	158	38.2	0.25
6166	105	80.16	84.81	1.58	142	19.8	0.27
6024	105	80.97	84.62	1.62	100	21.88	0.3
5924	105	80.89	84.48	1.59	200	26.77	0.3
5724	105	80.6	84.2	1.55	200	29.57	0.29
5524	105	80.36	83.91	1.55	200	29.13	0.3
5324	105	80.13	83.6	1.6	200	27.96	0.31
5124	105	79.83	83.27	1.59	200	30.22	0.31
4924	105	79.71	82.95	1.61	53	37.66	0.33
4871	105	79.57	82.96	0.98	0	35.7	0.18
4868	105		82.96				
4866	105	79.57	82.96	0.98	142	35.7	0.18
4724	105	79.18	82.74	1.57	200	22.22	0.29
4524	105	78.8	82.53	1.51	200	22.14	0.27
4324	105	78.45	82.28	1.6	147	22.06	0.29
4177	105	78.67	82.17	1.2	62	37.86	0.22
4138	105	78.67	82.14	1.05	0	34.82	0.2
4130	105		82.14				
4115	105	78.67	82.05	1.08	18	34.82	0.21
4097	105	78.62	82.02	1.17	173	34.83	0.24
3924	105	78.4	81.7	1.59	240	33.69	0.36
3684	105	78.15	81.31	1.54	160	30.03	0.33

TABLE A3 CONTINUED

3524	105	77.62	81.14	1.38	200	36.08	0.28
3324	105	77.46	80.94	1.37	200	44.99	0.29
3124	105	77.09	80.76	1.28	200	46.56	0.27
2924	105	76.69	80.49	1.58	200	40.8	0.32
2724	105	76.43	80.36	1	200	50.75	0.23
2524	105	76.73	80.2	1.06	200	53.67	0.25
2324	105	76.52	80	1.23	200	42.7	0.27
2124	105	76.14	79.85	1.07	200	49.9	0.25
1924	105	75.19	79.72	0.95	84	58.4	0.23
1840	105	76.4	79.6	1.45	0	60.45	0.28
1837	105		79.6				
1835	105	76.4	79.6	1.45	111	60.32	0.29
1724	105	76.02	79.54	0.9	118	62.35	0.22
1606	105	75.61	79.5	0.74	0	68.08	0.16
1600	105		79.5				
1582	105	75.61	79.44	0.76	54	68.08	0.16
1528	105	75.6	79.21	1.75	44	26.84	0.34
1484	105	75.21	79.23	1.23	0	32.06	0.21
1480	105		79.23				
1470	105	75.21	79.19	1.25	143	31.77	0.22
1327	105	74.62	79.03	1.34	200	38.94	0.28
1127	105	74.16	78.84	1.44	205	32.05	0.27
922	105	74.1	78.44	2.18	0	23	0.35
920	105		78.44				
916	105	74.1	78.11	2.39	188	18.58	0.4
728	105	74	77.84	1.56	212	35.1	0.32
516	105	73.43	77.38	2.1	0	16.84	0.38
515	105		77.38				
511	105	73.43	77.36	2.11	26	16.76	0.39
480	105	73.72	77.22	2.07	158	24.48	0.47
400	105	73.8	77.03	1.37	200	44.9	0.34
390	105	73.36	76.66	1.58	50	44.64	0.39
380	105	73.03	76.59	1.39	73	56.96	0.37
370	105	73.59	76.56	1.17	0	44.02	0.24
365	105		76.56				
360	105	73.59	76.36	1.27	220	42.94	0.27
350	105	72.24	75.85	1.52	202.5	72.51	0.42
340	105	72.25	75.48	1.39	185	124.43	0.35
330	105	71.27	75.38	0.62	190	221.7	0.19
320	105	72.03	75.14	1.2	122.5	128.18	0.32
310	105	71.5	75	0.94	120	182.13	0.31
300	105	71.51	74.93	0.53	90	237.96	0.2
290	105	71.53	74.75	1.28	0	54.61	0.34
285	105		74.75				
280	105	71.53	74.68	1.34	85	54.33	0.36
270	105	71.44	74.61	1.07	0	66.76	0.26
265	105		74.61				
260	105	71.44	74.56	1.1	91.05	66.65	0.27
250	105	70.66	74.39	1.39	90	44.67	0.31

TABLE A3 CONTINUED

240	105	71.52	74.3	1.23	0	53.58	0.29
235	105		74.3				
230	105	71.52	74.28	1.25	90	53.41	0.29
220	105	70.84	74.2	1.15	311.05	56.1	0.25
210	105	69.67	73.76	1.63	10	32.08	0.35
200	105	69.63	73.76	1.47	0	34.95	0.31
195	105		73.76				
190	105	69.63	73.73	1.49	479.5	34.84	0.31
180	105	69.87	73.09	1.48	100	38.51	0.33
170	105	69.94	72.97	1.39	0	37.58	0.3
165	105		72.97				
160	105	69.94	72.96	1.4	125.66	37.51	0.31
150	105	69.62	72.82	1.48	0	30.76	0.3
145	105		72.82				
140	105	69.62	72.8	1.49	268	30.73	0.3
130	105	69.41	72.34	1.73	268	31.57	0.38
120	105	68.82	71.97	1.52	0	30.94	0.3
115	105		71.97				
110	105	68.82	71.94	1.54	11.43	30.77	0.31
100	105	68.07	71.93	1.37	201	40.16	0.3
90	105	67.95	71.69	1.5	0	39.93	0.29
85	105		71.69				
80	105	67.95	71.67	1.51	43.53	39.67	0.29
70	105	67.85	71.63	1.36	0	43	0.29
65	105		71.63				
60	105	67.85	71.58	1.4	220.85	42.72	0.3
50	105	67.76	71.3	1.41	40	42.64	0.32
40	105	67.26	71.26	1.35	0	47.37	0.29
35	105		71.26				
30	105	67.26	71.22	1.38	1.13	46.82	0.3
20	105	67.12	71.23	1.29	0	42.33	0.27
15	105		71.23				
10	105	67.12	71.2	1.31	270	42.19	0.28
0	105	67.12	70.69	1.76		38.98	0.39

TABLE A4: STEADY MODEL RESULTS, CASE 2, BRIDGES RESULTS ONLY

Cross-Section No:	E.G. Elev	Min El Prs	Opening Area	Prs O WS	Q Total	Min Top Rd	Q Weir
	(m)	(m)	(m2)	(m)	(m3/s)	(m)	(m3/s)
25050	111.53	110.31	35.23		105.00	111.24	15.10
24390	110.53	111.22	101.57		105.00	112.32	
24150	110.33	110.21	97.11		105.00	111.28	
23490	109.82	120.61	248.31		105.00	124.84	
23350	109.57	108.91	97.72	109.53	105.00	110.36	
23046	109.42	109.13	78.17		105.00	110.31	
23000	109.32	109.98	96.96		105.00	110.92	
22655	109.08	107.05	33.61		105.00	108.89	4.75
22400 #1	108.35	106.51	2.28		24.30	106.96	20.54

TABLE A4 CONTINUED

22400 #2	108.35	106.45	16.97		55.38	106.96	23.34
22400 #3	108.35	106.56	2.69		25.32	106.96	20.72
21830	107.96	105.75	25.74		105.00	107.81	2.88
21535	106.55	105.65	33.63	106.43	105.00	106.50	0.90
21500	105.83	106.93	71.48		105.00	108.48	
20690 #1	105.20	103.79	4.70	105.18	7.70	105.91	
20690 #2	105.21	104.73	44.93	105.06	97.30	105.91	
20173	104.69	103.51	20.10		105.00	103.90	35.64
17518	102.87	102.60	60.57	102.80	105.00	104.79	
17140	102.52	100.69	33.69		105.00	102.16	13.58
17130	102.04	100.21	52.84		105.00	101.86	6.25
16590	101.62	99.38	33.58		105.00	100.64	42.57
16249	101.29	99.16	55.31		105.00	100.22	54.12
15778	101.16	98.87	19.20		105.00	99.26	
14507	98.91	98.54	65.55	98.80	105.00	100.07	
14070	98.55	96.67	51.01		105.00	98.13	11.42
13325	97.14	95.91	32.38	97.05	105.00	97.95	
13200	96.44	97.33	71.87		105.00	98.44	
11607	94.68	93.76	57.39	94.57	105.00	95.18	
11410	94.28	92.88	47.60		105.00	92.55	32.95
11130	94.04	92.39	52.05	93.97	105.00	95.50	
10196	93.17	91.86	53.59	93.09	105.00	95.00	
9788	92.80	91.49	44.60		105.00	92.38	24.05
9460	92.40	94.52	113.94		105.00	97.52	
9070	92.21	93.37	84.89		105.00	97.61	
9045 #1	92.11	89.62	4.52	92.11	9.87	92.38	
9045 #2	92.12	89.62	1.35	92.12	2.93	92.38	
9045 #3	92.10	89.64	41.89	92.08	92.20	92.38	
8930 #1	91.73	89.03	31.57	91.71	75.92	93.30	
8930 #2	91.74	89.04	12.09	91.73	29.08	93.30	
8833	91.25	88.67	30.11		105.00	90.32	32.59
8619	90.50	91.42	88.04		105.00	94.02	
8482	90.34	88.20	36.74		105.00	89.95	10.98
8330	89.78	87.90	32.50	89.67	105.00	91.08	
8130	88.69	89.04	63.88		105.00	90.09	
7844	87.88	89.15	80.25		105.00	89.13	
7835	87.82	89.21	89.80		105.00	90.50	
6957.5	86.24	86.39	69.95		105.00	88.00	
6945	86.21	86.87	71.30		105.00	89.65	
6920	86.16	86.40	54.83		105.00	89.60	
6887	85.86	87.27	91.42		105.00	86.98	
6630	85.48	86.70	87.15		105.00	89.51	
4868	83.01	84.15	133.31		105.00	83.37	
4130	82.20	85.10	92.36		105.00	86.50	
1837	79.71	79.77	77.02		105.00	80.29	
1600	79.54	79.00	94.71	79.50	105.00	80.55	
1480	79.31	80.70	96.08		105.00	82.72	
920	78.68	77.63	37.33		105.00	78.35	4.94
515	77.62	77.88	58.47		105.00	77.87	
365	76.63	76.59	48.91		105.00	78.50	

TABLE A4 CONTINUED

285	74.87	77.66	213.62		105.00	78.93	
265	74.68	75.77	108.84		105.00	78.02	
235	74.40	75.12	117.07		105.00	75.25	
195	73.90	74.08	79.75		105.00	75.43	
165	73.09	73.63	95.43		105.00	73.94	
145	72.94	73.03	72.64		105.00	74.40	
115	72.10	72.69	84.36		105.00	74.60	
85	71.82	73.17	107.60		105.00	75.55	
65	71.75	71.80	75.29		105.00	73.84	
35	71.38	72.10	99.00		105.00	74.28	
15	71.33	72.12	108.46		105.00	73.85	
USING THE ATTENUATED PEAK DISCHARGE, BRIDGES RESULTS ONLY							
25050	111.27	110.31	35.23		88.20	111.24	2.66
24390	110.23	111.22	101.57		88.20	112.32	
24150	110.02	110.21	97.11		88.20	111.28	
23490	109.38	120.61	248.31		88.20	124.84	
23350	109.08	108.91	97.72		88.20	110.36	
23046	108.92	109.13	78.17		88.20	110.31	
23000	108.84	109.98	96.96		88.20	110.92	
22655	108.55	107.05	33.61	108.50	88.20	108.89	
22400 #1	107.97	106.51	2.28		17.36	106.96	13.02
22400 #2	107.97	106.45	16.97		52.58	106.96	14.59
22400 #3	107.97	106.56	2.69		18.26	106.96	13.01
21830	107.35	105.75	25.74	107.25	88.20	107.81	
21535	106.23	105.65	33.63	106.11	88.20	106.50	
21500	105.56	106.93	71.48		88.20	108.48	
20690 #1	104.84	103.79	4.70	104.83	6.05	105.91	
20690 #2	104.86	104.73	44.93	104.86	82.15	105.91	
20173	104.44	103.51	20.10	105.57	88.20	103.90	20.39
17518	102.26	102.60	60.57		88.20	104.79	
17140	101.99	100.69	33.69	101.88	88.20	102.16	
17130	101.54	100.21	52.84	101.48	88.20	101.86	
16590	101.17	99.38	33.58		88.20	100.64	15.58
16249	100.73	99.16	55.31		88.20	100.22	23.20
15778	100.53	98.87	19.20	101.31	88.20	99.26	
14507	98.38	98.54	65.55		88.20	100.07	
14070	98.07	96.67	51.01	98.02	88.20	98.13	
13325	96.53	95.91	32.38	96.43	88.20	97.95	
13200	96.07	97.33	71.87		88.20	98.44	
11607	94.13	93.76	57.39	94.01	88.20	95.18	
11410	93.78	92.88	47.60		88.20	92.55	11.38
11130	93.49	92.39	52.05	93.43	88.20	95.50	
10196	92.60	91.86	53.59	92.52	88.20	95.00	
9788	92.29	91.49	44.60	92.17	88.20	92.38	
9460	91.79	94.52	113.94		88.20	97.52	
9070	91.55	93.37	84.89		88.20	97.61	
9045 #1	91.47	89.62	4.52	91.46	8.29	92.38	
9045 #2	91.47	89.62	1.35	91.47	2.45	92.38	
9045 #3	91.46	89.64	41.89	91.44	77.46	92.38	

TABLE A4 CONTINUED

8930 #1	91.20	89.03	31.57	91.18	63.77	93.30	
8930 #2	91.20	89.04	12.09	91.19	24.43	93.30	
8833	90.85	88.67	30.11		88.20	90.32	12.36
8619	90.01	91.42	88.04		88.20	94.02	
8482	89.83	88.20	36.74	89.72	88.20	89.95	
8330	89.26	87.90	32.50	89.15	88.20	91.08	
8130	88.40	89.04	63.88		88.20	90.09	
7844	87.57	89.15	80.25		88.20	89.13	
7835	87.51	89.21	89.80		88.20	90.50	
6957.5	85.91	86.39	69.95		88.20	88.00	
6945	85.88	86.87	71.30		88.20	89.65	
6920	85.83	86.40	54.83		88.20	89.60	
6887	85.54	87.27	91.42		88.20	86.98	
6630	85.17	86.70	87.15		88.20	89.51	
4868	82.68	84.15	133.31		88.20	83.37	
4130	81.90	85.10	92.36		88.20	86.50	
1837	79.37	79.77	77.02		88.20	80.29	
1600	79.18	79.00	94.71		88.20	80.55	
1480	78.95	80.70	96.08		88.20	82.72	
920	78.28	77.63	37.33	78.07	88.20	78.35	
515	77.36	77.88	58.47		88.20	77.87	
365	76.37	76.59	48.91		88.20	78.50	
285	74.62	77.66	213.62		88.20	78.93	
265	74.42	75.77	108.84		88.20	78.02	
235	74.14	75.12	117.07		88.20	75.25	
195	73.64	74.08	79.75		88.20	75.43	
165	72.83	73.63	95.43		88.20	73.94	
145	72.68	73.03	72.64		88.20	74.40	
115	71.84	72.69	84.36		88.20	74.60	
85	71.57	73.17	107.60		88.20	75.55	
65	71.51	71.80	75.29		88.20	73.84	
35	71.16	72.10	99.00		88.20	74.28	
15	71.11	72.12	108.46		88.20	73.85	

TABLE A5: STEADY MODEL RESULTS, CASE 3

Cross-Section No:.	Q Total	Min Ch El	W.S. Elev	Vel Total	Cross-Section length	Top Width	Froude # Chl
	(m3/s)	(m)	(m)	(m/s)	(m)	(m)	
25144	105.00	107.07	111.48	1.08	92.00	40.00	0.23
25045	105.00	107.24	111.22	1.81	112.00	40.97	0.37
24940	105.00	106.41	111.01	1.10	193.00	73.10	0.30
24745	105.00	106.94	110.76	1.03	65.00	46.29	0.24
24680	105.00	107.19	110.71	0.72	138.00	97.50	0.20
24537	105.00	106.81	110.58	0.89	80.00	51.97	0.21
24457	105.00	106.49	110.56	0.43	40.00	173.00	0.13
24398	105.00	106.55	110.48	1.17	28.00	36.74	0.24
24370	105.00	106.55	110.44	1.19	180.00	36.73	0.25

TABLE A5 CONTINUED

24190	105.00	106.11	110.29	0.68	30.00	107.50	0.18
24159	105.00	106.24	110.24	0.97	11.00	49.91	0.21
24148	105.00	106.24	110.23	0.98	110.00	49.83	0.21
24038	105.00	106.14	110.17	0.70	48.00	76.82	0.18
23990	105.00	105.70	110.11	0.87	100.00	73.62	0.23
23890	105.00	105.88	110.00	0.80	170.00	102.11	0.24
23720	105.00	105.72	109.79	1.01	135.00	63.94	0.26
23585	105.00	105.48	109.65	0.79	90.00	95.66	0.22
23494	105.00	105.11	109.32	1.91	29.00	25.11	0.39
23465	105.00	105.11	109.16	2.06	65.00	25.08	0.44
23400	105.00	105.61	109.09	1.11	42.00	48.00	0.27
23355	105.00	105.54	109.04	0.98	10.00	54.50	0.24
23345	105.00	105.54	109.03	0.98	210.00	54.43	0.24
23135	105.00	104.72	108.87	0.75	67.00	70.08	0.18
23050	105.00	104.69	108.72	1.35	6.00	40.54	0.31
23044	105.00	104.69	108.71	1.36	20.00	40.43	0.32
23024	105.00	104.85	108.60	1.70	6.00	27.38	0.39
22996	105.00	104.85	108.58	1.71	206.00	27.38	0.39
22790	105.00	104.14	108.05	1.56	116.00	31.47	0.33
22667	105.00	104.50	107.86	1.31	14.00	33.00	0.28
22653	105.00	104.50	107.84	1.33	153.00	32.90	0.29
22500	105.00	103.78	107.73	0.63	72.00	108.67	0.18
22402	105.00	103.98	107.67	0.82	6.00	70.85	0.19
22396	105.00	103.98	107.67	0.82	96.00	70.85	0.19
22300	105.00	103.78	107.64	0.37	154.00	189.46	0.11
22137	105.00	103.50	107.46	1.23	51.00	68.03	0.35
22104	105.00	103.56	107.27	1.44	38.00	60.65	0.40
22066	105.00	103.47	107.04	1.76	141.00	48.59	0.50
21925	105.00	102.70	106.71	0.75	68.00	114.65	0.23
21831	105.00	102.97	106.40	1.95	11.00	23.95	0.42
21820	105.00	102.97	106.35	1.99	120.00	23.79	0.44
21700	105.00	103.00	106.10	1.15	164.00	65.68	0.32
21539	105.00	102.73	105.66	1.40	7.00	51.48	0.34
21532	105.00	102.73	105.64	1.42	14.00	51.22	0.35
21518	105.00	102.48	105.48	2.14	25.00	26.99	0.51
21493	105.00	102.48	105.23	2.47	33.00	25.93	0.62
21460	105.00	102.27	105.25	0.66	200.00	229.98	0.25
21260	105.00	101.93	105.06	0.46	200.00	293.79	0.18
21060	105.00	101.53	104.98	0.33	330.00	266.09	0.11
20698	105.00	100.59	104.68	1.63	23.00	22.50	0.31
20675	105.00	100.59	104.63	1.66	175.00	22.50	0.31
20470	105.00	100.46	104.44	0.98	200.00	51.20	0.20
20273	105.00	99.80	104.23	1.25	100.00	32.00	0.23
20203	105.00	99.70	104.12	1.25	28.49	52.03	0.24
20124	105.00	99.70	104.03	1.60	5.00	32.20	0.34
20080	105.00	99.70	104.02	1.61	166.51	32.20	0.34
20000	105.00	98.89	103.71	1.44	100.00	30.04	0.27
19900	105.00	99.29	103.58	1.41	200.00	28.88	0.28
19700	105.00	98.92	103.34	1.22	200.00	38.60	0.25
19500	105.00	98.60	103.11	1.25	200.00	35.27	0.25

TABLE A5 CONTINUED

19300	105.00	98.17	102.93	1.12	200.00	40.41	0.23
19100	105.00	97.93	102.75	1.12	200.00	37.81	0.22
18900	105.00	98.38	102.65	0.71	200.00	65.00	0.16
18700	105.00	97.47	102.45	1.10	200.00	51.29	0.23
18500	105.00	97.67	102.33	0.75	200.00	73.62	0.17
18300	105.00	97.44	102.24	0.61	100.00	110.66	0.16
18200	105.00	98.75	102.22	0.40	100.00	170.50	0.12
18100	105.00	97.80	102.21	0.28	200.00	199.00	0.07
17900	105.00	97.58	102.17	0.45	100.00	130.80	0.12
17800	105.00	96.65	102.04	1.16	100.00	36.00	0.23
17700	105.00	97.14	101.98	0.93	100.00	43.60	0.19
17600	105.00	97.08	101.90	1.06	50.00	31.00	0.20
17550	105.00	96.85	101.86	0.95	30.00	50.00	0.19
17520	105.00	96.88	101.79	1.34	5.00	24.00	0.25
17515	105.00	96.88	101.78	1.34	115.00	24.00	0.25
17400	105.00	96.90	101.47	1.95	100.00	19.89	0.36
17300	105.00	97.05	101.40	1.06	100.00	40.81	0.23
17200	105.00	96.46	101.26	1.28	54.00	30.80	0.25
17146	105.00	96.55	101.20	1.21	14.00	39.83	0.24
17138	105.00	96.55	101.18	1.23	8.00	39.80	0.24
17132	105.00	96.50	101.17	1.20	15.00	34.22	0.23
17117	105.00	96.50	101.16	1.20	117.00	34.08	0.23
17000	105.00	96.49	101.01	1.28	200.00	37.26	0.25
16800	105.00	96.28	100.74	1.41	207.00	27.46	0.27
16593	105.00	96.49	100.47	1.37	10.00	31.00	0.27
16583	105.00	96.49	100.46	1.38	283.00	30.75	0.27
16300	105.00	95.85	100.13	1.25	50.00	34.47	0.25
16250	105.00	95.89	100.08	1.28	2.35	35.00	0.25
16248	105.00	95.89	100.08	1.28	247.65	35.00	0.25
16000	105.00	95.32	99.81	1.14	100.00	40.00	0.24
15900	105.00	95.31	99.67	1.31	50.00	34.00	0.27
15850	105.00	94.86	99.58	1.42	70.00	32.00	0.29
15780	105.00	95.13	99.51	1.15	5.00	52.00	0.26
15775	105.00	95.13	99.50	1.15	75.00	52.00	0.26
15700	105.00	95.02	99.41	1.15	300.00	46.00	0.25
15400	105.00	94.49	99.21	0.95	300.00	57.30	0.20
15100	105.00	94.50	98.89	1.26	76.00	46.86	0.29
14509	105.00	94.09	98.76	1.43	8.00	35.25	0.29
14501	105.00	94.09	98.75	1.39	118.00	35.62	0.28
14383	105.00	93.48	98.59	1.27	200.00	28.84	0.23
14183	105.00	93.08	98.39	1.20	106.00	29.77	0.22
14077	105.00	93.16	98.31	0.98	35.00	34.72	0.17
14037	105.00	93.16	98.29	0.99	266.00	34.72	0.17
13900	105.00	93.32	98.01	1.93	200.00	17.90	0.34
13700	105.00	92.88	97.51	1.85	200.00	19.70	0.34
13500	105.00	92.24	96.98	2.07	173.00	21.08	0.39
13327	105.00	92.46	96.55	1.25	5.00	45.40	0.26
13322	105.00	92.46	96.54	1.25	8.00	45.38	0.26
13316	105.00	92.28	96.53	1.17	21.00	41.18	0.24
13164	105.00	92.28	96.50	1.18	200.00	40.94	0.24

TABLE A5 CONTINUED

12964	105.00	91.75	96.20	1.75	100.00	23.99	0.33
12864	105.00	91.44	96.01	1.01	100.00	37.92	0.21
12764	105.00	91.04	95.88	1.36	143.00	31.92	0.26
12621	105.00	91.25	95.66	1.46	200.00	29.78	0.29
12421	105.00	91.00	95.40	1.16	200.00	39.85	0.24
12221	105.00	90.69	95.18	1.29	200.00	35.16	0.25
12021	105.00	90.66	94.95	1.24	200.00	42.66	0.25
11821	105.00	90.58	94.72	1.26	52.00	37.31	0.26
11769	105.00	90.53	94.66	1.25	161.00	37.53	0.26
11608	105.00	90.02	94.47	1.53	18.00	19.49	0.26
11601	105.00	90.02	94.45	1.54	82.00	19.49	0.27
11600	105.00	89.49	94.34	1.34	100.00	23.40	0.25
11500	105.00	89.28	94.20	1.76	85.00	18.65	0.31
11415	105.00	88.81	94.04	1.38	7.00	22.60	0.24
11408	105.00	88.81	94.03	1.38	114.00	22.60	0.24
11300	105.00	88.88	93.90	1.33	102.00	24.00	0.24
11200	105.00	88.36	93.80	1.17	45.00	24.20	0.20
11142	105.00	88.38	93.76	0.83	18.00	39.67	0.15
11124	105.00	88.38	93.75	0.83	92.00	39.64	0.15
11000	105.00	88.41	93.67	1.39	200.00	30.30	0.25
10800	105.00	88.34	93.43	1.20	200.00	37.53	0.23
10600	105.00	88.25	93.21	1.29	200.00	30.00	0.25
10400	105.00	87.99	92.92	1.72	198.00	25.55	0.31
10202	105.00	88.02	92.58	1.35	13.00	29.55	0.26
10189	105.00	88.02	92.56	1.36	86.00	29.45	0.27
9990	105.00	88.05	92.46	0.80	12.00	49.82	0.16
9978	105.00	88.05	92.45	0.80	85.00	49.81	0.16
9900	105.00	87.55	92.41	0.63	110.00	77.52	0.15
9790	105.00	87.89	92.32	1.69	4.20	30.86	0.35
9786	105.00	87.89	92.30	1.71	170.00	30.32	0.36
9600	105.00	87.59	91.89	1.32	139.00	47.13	0.31
9461	105.00	87.36	91.65	1.23	3.00	52.83	0.29
9458	105.00	87.36	91.64	1.24	148.00	52.63	0.29
9300	105.00	87.18	91.37	1.49	217.00	33.90	0.32
9098	105.00	87.03	90.92	1.60	30.00	29.69	0.34
9068	105.00	87.03	90.86	1.66	18.00	29.43	0.36
9050	105.00	86.80	90.79	0.75	10.00	51.12	0.14
9040	105.00	86.80	90.79	0.75	96.00	51.12	0.15
8944	105.00	86.64	90.75	0.69	20.00	50.55	0.12
8924	105.00	86.64	90.74	0.70	90.00	50.52	0.12
8834	105.00	86.09	90.69	1.34	2.00	27.80	0.24
8832	105.00	86.09	90.69	1.34	158.00	27.79	0.24
8676	105.00	85.93	90.39	2.30	56.00	17.62	0.44
8620	105.00	86.54	90.15	2.01	2.50	20.60	0.40
8618	105.00	86.54	90.14	2.02	13.50	20.57	0.41
8604	105.00	86.20	90.09	2.07	120.00	20.06	0.42
8484	105.00	85.50	89.78	1.26	3.80	27.10	0.22
8480	105.00	85.50	89.78	1.26	24.20	27.09	0.22
8456	105.00	85.92	89.74	1.62	90.00	24.17	0.31
8366	105.00	85.98	89.52	1.65	30.00	30.94	0.34
8336	105.00	86.10	89.43	1.58	8.00	28.71	0.30

TABLE A5 CONTINUED

8328	105.00	86.10	89.41	1.59	194.00	28.46	0.31
8132	105.00	84.65	88.91	1.79	10.00	20.90	0.34
8124	105.00	84.65	88.88	1.81	13.00	20.82	0.35
8111	105.00	85.26	88.83	1.45	145.00	31.18	0.30
7966	105.00	84.81	88.48	1.66	120.00	29.03	0.35
7846	105.00	84.62	88.11	1.95	3.40	19.26	0.37
7843	105.00	84.62	88.09	1.96	5.60	19.25	0.37
7837	105.00	84.17	88.06	1.61	2.60	18.98	0.28
7834	105.00	84.17	88.06	1.61	26.00	18.98	0.28
7724	105.00	83.89	88.01	1.40	79.00	24.02	0.24
7700	105.00	83.57	87.86	1.77	60.00	21.40	0.34
7640	105.00	84.10	87.69	1.34	116.00	28.60	0.25
7524	105.00	84.39	87.48	1.83	200.00	22.03	0.36
7324	105.00	83.59	87.00	1.52	154.00	22.37	0.28
7170	105.00	83.36	86.71	1.63	48.00	22.16	0.30
7122	105.00	82.89	86.61	1.67	164.00	21.72	0.31
6958	105.00	82.55	86.28	1.62	1.00	22.39	0.30
6957	105.00	82.55	86.28	1.62	10.00	22.38	0.30
6947	105.00	82.68	86.26	1.90	5.00	19.22	0.36
6942	105.00	82.68	86.24	1.91	12.00	19.21	0.36
6930	105.00	82.75	86.20	1.74	20.00	20.65	0.33
6910	105.00	82.75	86.16	1.77	22.00	20.64	0.33
6888	105.00	81.88	86.11	1.60	2.00	22.15	0.30
6886	105.00	81.88	86.10	1.60	162.00	22.15	0.30
6724	105.00	79.82	85.83	1.41	81.00	29.40	0.26
6641	105.00	82.27	85.72	1.29	21.00	27.58	0.24
6620	105.00	82.27	85.69	1.30	96.00	27.58	0.24
6524	105.00	81.24	85.59	1.03	200.00	41.56	0.20
6324	105.00	81.39	85.38	1.02	158.00	39.69	0.20
6166	105.00	80.16	85.20	1.41	142.00	20.45	0.23
6024	105.00	80.97	85.00	1.43	100.00	22.75	0.25
5924	105.00	80.89	84.85	1.37	200.00	28.85	0.25
5724	105.00	80.60	84.56	1.32	200.00	33.92	0.24
5524	105.00	80.36	84.26	1.32	200.00	35.23	0.25
5324	105.00	80.13	83.93	1.37	200.00	35.11	0.26
5124	105.00	79.83	83.58	1.36	200.00	40.17	0.26
4924	105.00	79.71	83.23	1.37	53.00	43.55	0.27
4871	105.00	79.57	83.22	0.90	5.00	38.05	0.16
4866	105.00	79.57	83.22	0.90	142.00	38.01	0.16
4724	105.00	79.18	83.05	1.40	200.00	35.63	0.25
4524	105.00	78.80	82.79	1.37	200.00	28.05	0.24
4324	105.00	78.45	82.48	1.49	147.00	22.18	0.27
4177	105.00	78.67	82.33	1.12	62.00	38.80	0.20
4138	105.00	78.67	82.29	0.96	23.00	34.83	0.18
4115	105.00	78.67	82.27	0.97	18.00	34.83	0.18
4097	105.00	78.62	82.24	1.08	173.00	35.43	0.21
3924	105.00	78.40	82.00	1.37	240.00	40.85	0.28
3684	105.00	78.15	81.61	1.36	160.00	30.69	0.28
3524	105.00	77.62	81.42	1.21	200.00	39.08	0.24
3324	105.00	77.46	81.21	1.19	200.00	45.41	0.24

3124	105.00	77.09	81.01	1.11	200.00	49.07	0.23

TABLE A5 CONTINUED

2924	105.00	76.69	80.74	1.37	200.00	42.09	0.28
2724	105.00	76.43	80.57	0.90	200.00	53.88	0.20
2524	105.00	76.73	80.40	0.96	200.00	54.66	0.22
2324	105.00	76.52	80.17	1.13	200.00	42.70	0.24
2124	105.00	76.14	79.98	1.00	200.00	50.25	0.22
1924	105.00	75.19	79.80	0.90	84.00	58.63	0.21
1840	105.00	76.40	79.70	1.09	5.00	62.62	0.25
1835	105.00	76.40	79.69	1.10	111.00	62.49	0.25
1724	105.00	76.02	79.60	0.87	118.00	62.35	0.20
1606	105.00	75.61	79.55	0.68	24.00	68.08	0.14
1582	105.00	75.61	79.54	0.68	54.00	68.08	0.15
1528	105.00	75.60	79.37	1.63	44.00	27.52	0.31
1484	105.00	75.21	79.37	1.11	14.00	32.96	0.21
1470	105.00	75.21	79.36	1.12	143.00	32.88	0.21
1327	105.00	74.62	79.16	1.25	200.00	39.26	0.25
1127	105.00	74.16	78.89	1.40	205.00	32.21	0.26
922	105.00	74.10	78.40	2.03	6.00	22.35	0.35
916	105.00	74.10	78.38	2.04	188.00	22.05	0.35
728	105.00	74.00	78.06	1.40	212.00	35.87	0.28
516	105.00	73.43	77.51	2.01	5.00	17.69	0.36
511	105.00	73.43	77.50	2.02	26.00	17.59	0.36
480	105.00	73.72	77.41	1.89	158.00	25.16	0.40
400	105.00	73.80	77.14	1.29	200.00	45.11	0.30
390	105.00	73.36	76.67	1.57	50.00	44.66	0.38
380	105.00	73.03	76.55	1.44	73.00	56.71	0.36
370	105.00	73.59	76.45	1.17	5.00	43.43	0.26
360	105.00	73.59	76.44	1.18	220.00	43.40	0.26
350	105.00	72.24	76.03	1.27	202.50	81.67	0.33
340	105.00	72.25	75.63	1.08	185.00	170.51	0.30
330	105.00	71.27	75.48	0.55	190.00	239.58	0.16
320	105.00	72.03	75.29	0.97	122.50	152.05	0.28
310	105.00	71.50	75.13	0.76	120.00	201.93	0.26
300	105.00	71.51	75.04	0.46	90.00	251.93	0.17
290	105.00	71.53	74.91	1.15	26.00	55.21	0.28
280	105.00	71.53	74.86	1.19	85.00	55.03	0.29
270	105.00	71.44	74.79	0.84	8.95	67.27	0.21
260	105.00	71.44	74.78	0.84	91.05	67.24	0.21
250	105.00	70.66	74.63	1.21	90.00	47.77	0.26
240	105.00	71.52	74.54	1.05	8.95	58.46	0.24
230	105.00	71.52	74.53	1.05	90.00	58.40	0.24
220	105.00	70.84	74.45	0.99	311.05	59.00	0.21
210	105.00	69.67	74.04	1.40	10.00	40.90	0.29
200	105.00	69.63	74.04	1.28	10.50	36.06	0.26
190	105.00	69.63	74.03	1.29	479.50	36.01	0.26
180	105.00	69.87	73.34	1.30	100.00	39.28	0.27
170	105.00	69.94	73.21	1.23	4.34	38.56	0.26
160	105.00	69.94	73.21	1.24	125.66	38.53	0.26
150	105.00	69.62	73.04	1.32	2.00	31.21	0.26
140	105.00	69.62	73.04	1.32	268.00	31.21	0.26

130	105.00	69.41	72.58	1.53	268.00	33.83	0.32
120	105.00	68.82	72.13	1.41	8.57	31.66	0.28

TABLE A5 CONTINUED

110	105.00	68.82	72.11	1.42	11.43	31.60	0.28
100	105.00	68.07	72.10	1.26	201.00	40.38	0.26
90	105.00	67.95	71.82	1.27	5.47	41.24	0.26
80	105.00	67.95	71.81	1.28	43.53	41.22	0.26
70	105.00	67.85	71.74	1.27	9.15	43.66	0.27
60	105.00	67.85	71.73	1.28	220.85	43.58	0.27
50	105.00	67.76	71.36	1.36	40.00	42.94	0.30
40	105.00	67.26	71.29	1.31	3.39	47.89	0.28
30	105.00	67.26	71.29	1.31	1.13	47.81	0.28
20	105.00	67.12	71.30	1.24	4.75	42.66	0.26
10	105.00	67.12	71.29	1.25	270.00	42.63	0.26
0	105.00	67.12	70.69	1.76		38.98	0.38

TABLE A6: STEADY MODEL RESULTS, CASE 4

Plan: Plan 11 Reach: River TameRiver Sta.	Q Total	Min Ch El	W.S. Elev	Vel Total	Length Chnl	Top Width	Froude # Chl
	(m3/s)	(m)	(m)	(m/s)	(m)	(m)	
25144	105.00	107.07	111.78	0.96	92.00	40.00	0.20
25052	105.00	107.29	111.58	1.46	0.00	44.80	0.31
25050	105.00		111.58				
25045	105.00	107.24	111.32	1.68	105.00	43.06	0.35
24940	105.00	106.41	111.15	0.99	193.00	73.10	0.27
24745	105.00	106.94	110.94	0.95	65.00	46.30	0.23
24680	105.00	107.19	110.91	0.64	138.00	97.50	0.17
24537	105.00	106.81	110.81	0.81	80.00	51.97	0.19
24457	105.00	106.49	110.79	0.37	40.00	173.00	0.10
24398	105.00	106.55	110.71	1.14	0.00	36.80	0.22
24390	105.00		110.71				
24370	105.00	106.55	110.66	1.16	180.00	36.79	0.22
24190	105.00	106.11	110.56	0.57	30.00	108.34	0.15
24159	105.00	106.24	110.51	0.93	0.00	51.99	0.19
24150	105.00		110.51				
24148	105.00	106.24	110.47	0.94	110.00	51.67	0.19
24038	105.00	106.14	110.42	0.62	48.00	76.82	0.16
23990	105.00	105.70	110.38	0.75	100.00	73.92	0.19
23890	105.00	105.88	110.32	0.64	170.00	105.00	0.18
23720	105.00	105.72	110.19	0.81	135.00	64.85	0.19
23585	105.00	105.48	110.13	0.58	90.00	99.09	0.15
23494	105.00	105.11	109.85	1.71	0.00	25.23	0.31
23490	105.00		109.85				
23465	105.00	105.11	109.77	1.76	65.00	25.21	0.33
23400	105.00	105.61	109.74	0.83	42.00	48.00	0.19

23355	105.00	105.54	109.72	0.74	0.00	59.04	0.16
23350	105.00		109.72				
23345	105.00	105.54	109.66	0.75	210.00	58.59	0.16
23135	105.00	104.72	109.59	0.55	67.00	71.00	0.12

TABLE A6 CONTINUED							
23050	105.00	104.69	109.52	0.98	0.00	61.04	0.20
23046	105.00		109.52				
23044	105.00	104.69	109.43	1.01	20.00	61.04	0.21
23024	105.00	104.85	109.36	1.27	0.00	27.39	0.27
23000	105.00		109.36				
22996	105.00	104.85	109.35	1.28	206.00	27.39	0.27
22790	105.00	104.14	109.16	1.02	116.00	31.80	0.19
22667	105.00	104.50	109.10	0.85	0.00	36.50	0.17
22655	105.00		109.10				
22653	105.00	104.50	108.48	1.19	153.00	35.80	0.22
22500	105.00	103.78	108.43	0.43	72.00	110.29	0.10
22402	105.00	103.98	108.41	0.58	0.00	70.85	0.12
22396	105.00	103.98	108.29	0.61	96.00	70.85	0.13
22300	105.00	103.78	108.28	0.26	154.00	192.00	0.07
22137	105.00	103.50	108.17	0.77	51.00	76.47	0.20
22104	105.00	103.56	108.13	0.78	38.00	81.41	0.20
22066	105.00	103.47	108.09	0.94	141.00	52.22	0.22
21925	105.00	102.70	108.05	0.36	68.00	116.00	0.08
21831	105.00	102.97	107.94	1.08	0.00	30.85	0.21
21830	105.00		107.94				
21820	105.00	102.97	106.81	1.74	120.00	26.07	0.34
21700	105.00	103.00	106.70	0.79	164.00	70.00	0.20
21539	105.00	102.73	106.57	0.85	0.00	53.71	0.18
21535	105.00		106.57				
21532	105.00	102.73	105.89	1.98	14.00	53.71	0.37
21518	105.00	102.48	105.82	2.12	0.00	28.44	0.43
21500	105.00		105.82				
21493	105.00	102.48	105.69	2.24	33.00	27.88	0.46
21460	105.00	102.27	105.73	0.38	200.00	255.00	0.13
21260	105.00	101.93	105.69	0.24	200.00	343.28	0.08
21060	105.00	101.53	105.67	0.21	330.00	274.05	0.06
20698	105.00	100.59	105.35	1.32	0.00	22.50	0.24
20675	105.00	100.59	105.11	1.41	175.00	22.50	0.27
20470	105.00	100.46	104.99	0.78	200.00	51.20	0.15
20273	105.00	99.80	104.87	1.00	100.00	32.00	0.17
20203	105.00	99.70	104.82	0.87	28.49	52.03	0.17
20124	105.00	99.70	104.78	1.17	0.00	32.20	0.22
20173	105.00		104.78				
20080	105.00	99.70	104.21	1.47	166.51	32.20	0.30
20000	105.00	98.89	103.96	1.28	100.00	38.08	0.25
19900	105.00	99.29	103.86	1.27	200.00	31.40	0.25
19700	105.00	98.92	103.68	1.06	200.00	39.40	0.22
19500	105.00	98.60	103.52	1.07	200.00	36.24	0.22
19300	105.00	98.17	103.40	0.93	200.00	41.00	0.18
19100	105.00	97.93	103.29	0.91	200.00	39.00	0.18

18900	105.00	98.38	103.24	0.56	200.00	65.00	0.12
18700	105.00	97.47	103.12	0.80	200.00	56.41	0.17
18500	105.00	97.67	103.06	0.52	200.00	90.00	0.12
18300	105.00	97.44	103.03	0.39	100.00	126.70	0.10
18200	105.00	98.75	103.03	0.26	100.00	170.50	0.07

TABLE A6 CONTINUED

18100	105.00	97.80	103.02	0.20	200.00	199.00	0.04
17900	105.00	97.58	103.01	0.31	100.00	130.80	0.07
17800	105.00	96.65	102.93	0.86	100.00	36.00	0.16
17700	105.00	97.14	102.91	0.69	100.00	43.60	0.13
17600	105.00	97.08	102.87	0.81	50.00	31.00	0.14
17550	105.00	96.85	102.86	0.66	30.00	50.00	0.12
17520	105.00	96.88	102.80	1.14	0.00	24.00	0.18
17518	105.00		102.80				
17515	105.00	96.88	102.63	1.18	115.00	24.00	0.19
17400	105.00	96.90	102.47	1.41	100.00	20.60	0.24
17300	105.00	97.05	102.46	0.73	100.00	41.20	0.14
17200	105.00	96.46	102.40	0.89	54.00	30.80	0.16
17146	105.00	96.55	102.39	0.78	0.00	40.00	0.14
17140	105.00		102.39				
17138	105.00	96.55	101.78	1.75	8.00	40.00	0.27
17132	105.00	96.50	101.81	1.18	0.00	41.60	0.19
17130	105.00		101.81				
17117	105.00	96.50	101.58	1.25	117.00	41.15	0.21
17000	105.00	96.49	101.50	1.04	200.00	38.89	0.20
16800	105.00	96.28	101.32	1.14	207.00	30.92	0.21
16593	105.00	96.49	101.18	1.07	0.00	31.00	0.20
16590	105.00		101.18				
16583	105.00	96.49	100.75	1.42	283.00	31.00	0.25
16300	105.00	95.85	100.49	1.08	50.00	37.00	0.22
16250	105.00	95.89	100.46	1.10	0.00	35.00	0.20
16249	105.00		100.46				
16248	105.00	95.89	100.30	1.17	247.65	35.00	0.22
16000	105.00	95.32	100.09	1.01	100.00	40.00	0.21
15900	105.00	95.31	99.98	1.15	50.00	34.00	0.24
15850	105.00	94.86	99.91	1.24	70.00	32.00	0.26
15780	105.00	95.13	99.87	0.95	0.00	52.00	0.21
15778	105.00		99.87				
15775	105.00	95.13	99.82	0.98	75.00	52.00	0.21
15700	105.00	95.02	99.74	0.99	300.00	46.00	0.22
15400	105.00	94.49	99.55	0.79	300.00	57.30	0.17
15100	105.00	94.50	99.30	0.96	76.00	54.00	0.22
14509	105.00	94.09	99.21	1.30	0.00	37.14	0.22
14507	105.00		99.21				
14501	105.00	94.09	99.10	1.14	118.00	37.13	0.22
14383	105.00	93.48	99.01	1.08	200.00	28.84	0.18
14183	105.00	93.08	98.90	1.01	106.00	29.77	0.17
14077	105.00	93.16	98.86	0.82	0.00	34.72	0.13
14070	105.00		98.86				
14037	105.00	93.16	98.72	0.85	266.00	34.72	0.14

13900	105.00	93.32	98.20	1.68	200.00	23.00	0.31
13700	105.00	92.88	97.88	1.54	200.00	19.70	0.28
13500	105.00	92.24	97.60	1.48	173.00	23.39	0.27
13327	105.00	92.46	97.47	1.19	0.00	50.00	0.19
13325	105.00		97.47				
13322	105.00	92.46	96.71	1.46	8.00	50.00	0.26

TABLE A6 CONTINUED							
13316	105.00	92.28	96.71	1.38	0.00	43.82	0.24
13200	105.00		96.71				
13164	105.00	92.28	96.62	1.41	200.00	43.02	0.25
12964	105.00	91.75	96.20	1.63	100.00	24.35	0.33
12864	105.00	91.44	96.14	0.94	100.00	37.92	0.19
12764	105.00	91.04	95.98	1.25	143.00	31.92	0.25
12621	105.00	91.25	95.78	1.32	200.00	30.42	0.26
12421	105.00	91.00	95.61	1.02	200.00	40.39	0.21
12221	105.00	90.69	95.43	1.12	200.00	36.16	0.23
12021	105.00	90.66	95.28	1.02	200.00	42.66	0.21
11821	105.00	90.58	95.13	1.03	52.00	37.31	0.21
11769	105.00	90.53	95.09	1.01	161.00	37.53	0.20
11608	105.00	90.02	94.95	1.30	0.00	28.77	0.21
11607	105.00		94.95				
11601	105.00	90.02	94.78	1.36	82.00	25.49	0.23
11600	105.00	89.49	94.72	1.17	100.00	23.40	0.21
11500	105.00	89.28	94.55	1.49	85.00	19.96	0.26
11415	105.00	88.81	94.52	1.18	0.00	22.60	0.19
11410	105.00		94.52				
11408	105.00	88.81	94.47	1.19	114.00	22.60	0.19
11300	105.00	88.88	94.38	1.12	102.00	24.00	0.20
11200	105.00	88.36	94.34	1.00	45.00	24.20	0.17
11142	105.00	88.38	94.32	1.06	0.00	41.00	0.15
11130	105.00		94.32				
11124	105.00	88.38	94.05	1.13	92.00	40.51	0.17
11000	105.00	88.41	93.96	1.18	200.00	37.00	0.21
10800	105.00	88.34	93.81	0.99	200.00	38.19	0.19
10600	105.00	88.25	93.67	1.07	200.00	30.00	0.20
10400	105.00	87.99	93.45	1.32	198.00	26.30	0.24
10202	105.00	88.02	93.33	1.15	0.00	33.18	0.18
10196	105.00		93.33				
10189	105.00	88.02	93.10	1.22	86.00	31.98	0.20
9990	105.00	88.05	93.08	0.63	12.00	54.50	0.12
9978	105.00	88.05	93.08	0.64	85.00	54.50	0.12
9900	105.00	87.55	93.06	0.48	110.00	78.84	0.10
9790	105.00	87.89	92.93	1.15	0.00	40.00	0.23
9788	105.00		92.93				
9786	105.00	87.89	92.83	1.20	170.00	40.00	0.24
9600	105.00	87.59	92.69	0.82	139.00	59.70	0.19
9461	105.00	87.36	92.59	1.05	0.00	61.20	0.19
9460	105.00		92.59				
9458	105.00	87.36	92.57	1.05	148.00	61.20	0.19
9300	105.00	87.18	92.49	0.92	217.00	34.40	0.18
9098	105.00	87.03	92.35	1.16	0.00	35.44	0.19

9070	105.00		92.35				
9068	105.00	87.03	92.27	1.18	18.00	35.08	0.19
9050	105.00	86.80	92.30	0.47	0.00	54.87	0.08
9040	105.00	86.80	91.93	0.52	96.00	54.03	0.09
8944	105.00	86.64	91.92	0.49	0.00	58.32	0.08
8924	105.00	86.64	91.48	0.55	90.00	54.10	0.09
8834	105.00	86.09	91.38	1.03	0.00	32.70	0.18

TABLE A6 CONTINUED

8833	105.00		91.38				
8832	105.00	86.09	91.14	1.11	158.00	31.21	0.19
8676	105.00	85.93	90.76	1.81	56.00	20.57	0.33
8620	105.00	86.54	90.69	1.53	0.00	24.01	0.29
8619	105.00		90.69				
8618	105.00	86.54	90.68	1.53	13.50	23.97	0.29
8604	105.00	86.20	90.66	1.54	120.00	24.48	0.29
8484	105.00	85.50	90.58	0.95	0.00	35.05	0.15
8482	105.00		90.58				
8480	105.00	85.50	90.26	1.05	24.20	32.53	0.17
8456	105.00	85.92	90.19	1.32	90.00	24.74	0.24
8366	105.00	85.98	90.07	1.20	30.00	36.00	0.25
8336	105.00	86.10	90.05	1.26	0.00	34.16	0.21
8330	105.00		90.05				
8328	105.00	86.10	89.30	1.61	194.00	28.67	0.31
8132	105.00	84.65	88.82	1.76	0.00	21.01	0.32
8130	105.00		88.82				
8124	105.00	84.65	88.79	1.78	13.00	20.97	0.33
8111	105.00	85.26	88.79	1.41	145.00	31.48	0.30
7966	105.00	84.81	88.40	1.61	120.00	29.34	0.34
7846	105.00	84.62	88.04	1.87	0.00	19.29	0.35
7844	105.00		88.04				
7843	105.00	84.62	88.03	1.87	5.60	19.29	0.35
7837	105.00	84.17	88.04	1.56	0.00	19.01	0.26
7835	105.00		88.04				
7834	105.00	84.17	88.04	1.56	26.00	19.00	0.26
7724	105.00	83.89	88.02	1.35	79.00	24.50	0.23
7700	105.00	83.57	87.78	1.72	60.00	21.41	0.33
7640	105.00	84.10	87.69	1.29	116.00	28.69	0.24
7524	105.00	84.39	87.40	1.76	200.00	22.06	0.34
7324	105.00	83.59	87.02	1.45	154.00	22.53	0.26
7170	105.00	83.36	86.77	1.53	48.00	22.23	0.28
7122	105.00	82.89	86.68	1.56	164.00	21.75	0.28
6958	105.00	82.55	86.44	1.48	0.00	24.08	0.26
6957.5	105.00		86.44				
6957	105.00	82.55	86.43	1.48	10.00	24.04	0.26
6947	105.00	82.68	86.37	1.72	0.00	20.71	0.31
6945	105.00		86.37				
6942	105.00	82.68	86.35	1.72	12.00	20.65	0.31
6930	105.00	82.75	86.35	1.56	0.00	24.71	0.28
6920	105.00		86.35				
6910	105.00	82.75	86.11	1.70	22.00	24.08	0.32
6888	105.00	81.88	86.09	1.54	0.00	24.84	0.28

6887	105.00		86.09				
6886	105.00	81.88	86.07	1.55	162.00	24.32	0.28
6724	105.00	79.82	85.83	1.34	81.00	29.80	0.25
6641	105.00	82.27	85.76	1.27	0.00	27.58	0.23
6630	105.00		85.76				
6620	105.00	82.27	85.63	1.32	96.00	27.58	0.24
6524	105.00	81.24	85.55	1.02	200.00	41.69	0.20
6324	105.00	81.39	85.41	1.01	158.00	39.78	0.20

TABLE A6 CONTINUED

6166	105.00	80.16	85.22	1.40	142.00	20.47	0.23
6024	105.00	80.97	85.02	1.42	100.00	22.79	0.25
5924	105.00	80.89	84.87	1.36	200.00	28.96	0.24
5724	105.00	80.60	84.59	1.31	200.00	34.08	0.24
5524	105.00	80.36	84.30	1.30	200.00	35.32	0.24
5324	105.00	80.13	83.98	1.34	200.00	35.24	0.25
5124	105.00	79.83	83.66	1.31	200.00	40.44	0.25
4924	105.00	79.71	83.35	1.28	53.00	49.23	0.26
4871	105.00	79.57	83.34	0.87	0.00	39.90	0.15
4868	105.00		83.34				
4866	105.00	79.57	83.34	0.87	142.00	39.81	0.15
4724	105.00	79.18	83.14	1.34	200.00	37.01	0.24
4524	105.00	78.80	82.91	1.32	200.00	28.06	0.23
4324	105.00	78.45	82.64	1.42	147.00	23.57	0.25
4177	105.00	78.67	82.51	1.04	62.00	40.12	0.19
4138	105.00	78.67	82.47	0.95	0.00	34.84	0.17
4130	105.00		82.47				
4115	105.00	78.67	82.38	0.97	18.00	34.83	0.18
4097	105.00	78.62	82.35	1.04	173.00	35.73	0.20
3924	105.00	78.40	82.06	1.32	240.00	40.85	0.29
3684	105.00	78.15	81.67	1.33	160.00	30.81	0.27
3524	105.00	77.62	81.49	1.18	200.00	39.80	0.24
3324	105.00	77.46	81.28	1.14	200.00	45.54	0.23
3124	105.00	77.09	81.11	1.06	200.00	51.43	0.22
2924	105.00	76.69	80.85	1.29	200.00	42.67	0.26
2724	105.00	76.43	80.70	0.85	200.00	53.88	0.19
2524	105.00	76.73	80.56	0.89	200.00	55.48	0.20
2324	105.00	76.52	80.37	1.04	200.00	42.70	0.22
2124	105.00	76.14	80.22	0.90	200.00	50.25	0.20
1924	105.00	75.19	80.09	0.79	84.00	58.82	0.18
1840	105.00	76.40	79.99	1.27	0.00	67.63	0.23
1837	105.00		79.99				
1835	105.00	76.40	79.92	1.29	111.00	67.63	0.24
1724	105.00	76.02	79.86	0.77	118.00	62.35	0.18
1606	105.00	75.61	79.81	0.66	0.00	68.08	0.13
1600	105.00		79.81				
1582	105.00	75.61	79.74	0.67	54.00	68.08	0.14
1528	105.00	75.60	79.56	1.51	44.00	28.31	0.29
1484	105.00	75.21	79.56	1.13	0.00	34.21	0.19
1480	105.00		79.56				
1470	105.00	75.21	79.51	1.14	143.00	33.90	0.19
1327	105.00	74.62	79.37	1.14	200.00	40.39	0.23

1127	105.00	74.16	79.15	1.26	205.00	32.55	0.23
922	105.00	74.10	78.76	1.73	0.00	27.77	0.30
920	105.00		78.76				
916	105.00	74.10	78.47	2.16	188.00	23.55	0.35
728	105.00	74.00	78.16	1.33	212.00	36.18	0.27
516	105.00	73.43	77.65	1.91	0.00	18.78	0.34
515	105.00		77.65				
511	105.00	73.43	77.64	1.92	26.00	18.65	0.34
480	105.00	73.72	77.55	1.77	158.00	28.32	0.38

TABLE A6 CONTINUED

400	105.00	73.80	77.33	1.16	200.00	45.49	0.27
390	105.00	73.36	77.00	1.28	50.00	45.89	0.30
380	105.00	73.03	76.94	1.10	73.00	58.73	0.27
370	105.00	73.59	76.88	1.03	0.00	47.51	0.20
365	105.00		76.88				
360	105.00	73.59	76.53	1.18	220.00	43.85	0.24
350	105.00	72.24	76.07	1.22	202.50	83.62	0.34
340	105.00	72.25	75.70	0.95	185.00	191.65	0.28
330	105.00	71.27	75.57	0.49	190.00	254.67	0.15
320	105.00	72.03	75.37	0.87	122.50	164.85	0.25
310	105.00	71.50	75.25	0.64	120.00	220.18	0.22
300	105.00	71.51	75.19	0.40	90.00	267.92	0.14
290	105.00	71.53	75.05	1.08	0.00	55.77	0.26
285	105.00		75.05				
280	105.00	71.53	74.99	1.11	85.00	55.55	0.28
270	105.00	71.44	74.91	0.92	0.00	67.71	0.21
265	105.00		74.91				
260	105.00	71.44	74.87	0.94	91.05	67.54	0.22
250	105.00	70.66	74.72	1.15	90.00	49.19	0.25
240	105.00	71.52	74.64	1.03	0.00	59.04	0.23
235	105.00		74.64				
230	105.00	71.52	74.62	1.04	90.00	58.93	0.23
220	105.00	70.84	74.54	0.94	311.05	59.00	0.20
210	105.00	69.67	74.13	1.34	10.00	41.21	0.28
200	105.00	69.63	74.13	1.25	0.00	36.29	0.25
195	105.00		74.13				
190	105.00	69.63	74.08	1.27	479.50	36.16	0.26
180	105.00	69.87	73.45	1.23	100.00	39.61	0.26
170	105.00	69.94	73.34	1.18	0.00	39.35	0.24
165	105.00		73.34				
160	105.00	69.94	73.32	1.19	125.66	39.25	0.25
150	105.00	69.62	73.18	1.29	0.00	31.48	0.24
145	105.00		73.18				
140	105.00	69.62	73.11	1.33	268.00	31.34	0.25
130	105.00	69.41	72.66	1.47	268.00	34.64	0.31
120	105.00	68.82	72.27	1.36	0.00	32.29	0.26
115	105.00		72.27				
110	105.00	68.82	72.24	1.37	11.43	32.15	0.26
100	105.00	68.07	72.23	1.19	201.00	40.54	0.25
90	105.00	67.95	71.96	1.35	0.00	41.48	0.25
85	105.00		71.96				

80	105.00	67.95	71.94	1.37	43.53	41.45	0.26
70	105.00	67.85	71.89	1.19	0.00	44.47	0.25
65	105.00		71.89				
60	105.00	67.85	71.83	1.23	220.85	44.11	0.26
50	105.00	67.76	71.51	1.25	40.00	45.00	0.28
40	105.00	67.26	71.45	1.22	0.00	51.36	0.26
35	105.00		71.45				
30	105.00	67.26	71.42	1.24	1.13	51.31	0.26
20	105.00	67.12	71.43	1.17	0.00	43.26	0.24
15	105.00		71.43				

TABLE A6 CONTINUED							
10	105.00	67.12	71.40	1.19	270.00	43.14	0.24
0	105.00	67.12	70.69	1.76		38.98	0.38

TABLE A7: STEADY MODEL RESULTS, DECREASING THE ROUGHNESS VALUES

Cross-Section No:	Q Total	Min Ch El	W.S. Elev	Vel Total	Length Chnl	Top Width	Froude # Chl
	(m3/s)	(m)	(m)	(m/s)	(m)	(m)	
25144	105.00	107.07	110.93	1.39	92.00	37.45	0.34
25045	105.00	107.24	110.70	2.35	112.00	19.73	0.50
24940	105.00	106.41	110.09	2.90	193.00	32.43	0.75
24745	105.00	106.94	110.07	1.50	65.00	46.28	0.45
24680	105.00	107.19	109.91	1.52	138.00	93.26	0.58
24537	105.00	106.81	109.90	1.28	80.00	51.97	0.39
24457	105.00	106.49	109.88	0.84	40.00	173.00	0.36
24398	105.00	106.55	109.83	1.60	28.00	36.58	0.38
24370	105.00	106.55	109.81	1.61	180.00	36.58	0.39
24190	105.00	106.11	109.72	1.09	30.00	97.17	0.35
24159	105.00	106.24	109.73	1.22	11.00	40.32	0.31
24148	105.00	106.24	109.72	1.23	110.00	40.32	0.31
24038	105.00	106.14	109.71	0.92	48.00	76.82	0.31
23990	105.00	105.70	109.62	1.25	100.00	73.06	0.41
23890	105.00	105.88	109.22	1.81	170.00	87.39	0.61
23720	105.00	105.72	109.17	1.62	135.00	62.55	0.48
23585	105.00	105.48	109.15	1.22	90.00	92.06	0.41
23494	105.00	105.11	108.66	2.72	29.00	24.97	0.64
23465	105.00	105.11	108.32	3.49	65.00	24.21	0.82
23400	105.00	105.61	108.39	1.68	42.00	45.14	0.54
23355	105.00	105.54	108.41	1.42	10.00	50.76	0.42
23345	105.00	105.54	108.40	1.43	210.00	50.72	0.43
23135	105.00	104.72	108.37	1.00	67.00	67.29	0.30
23050	105.00	104.69	108.09	1.96	6.00	36.07	0.55
23044	105.00	104.69	108.08	1.97	20.00	36.01	0.55
23024	105.00	104.85	107.77	2.68	6.00	27.37	0.77
22996	105.00	104.85	107.66	2.90	206.00	27.37	0.96
22790	105.00	104.14	107.38	2.23	116.00	28.84	0.56
22667	105.00	104.50	107.42	1.60	14.00	31.01	0.42
22653	105.00	104.50	107.41	1.60	153.00	30.97	0.42

22500	105.00	103.78	107.44	0.78	72.00	107.64	0.26
22402	105.00	103.98	107.43	0.94	6.00	70.85	0.23
22396	105.00	103.98	107.43	0.94	96.00	70.85	0.23
22300	105.00	103.78	107.44	0.43	154.00	186.24	0.16
22137	105.00	103.50	107.07	1.76	51.00	63.44	0.55
22104	105.00	103.56	106.76	2.37	38.00	52.09	0.71
22066	105.00	103.47	106.69	2.45	141.00	47.87	0.76
21925	105.00	102.70	105.97	1.73	68.00	87.59	1.12
21831	105.00	102.97	105.67	2.86	11.00	23.20	0.75
21820	105.00	102.97	105.45	3.32	120.00	22.69	0.90
21700	105.00	103.00	105.36	2.30	164.00	59.20	0.78

TABLE A7 CONTINUED							
21539	105.00	102.73	105.22	1.97	7.00	45.93	0.52
21532	105.00	102.73	105.21	1.99	14.00	45.66	0.52
21518	105.00	102.48	105.02	2.82	25.00	25.05	0.74
21493	105.00	102.48	104.72	3.52	33.00	23.78	1.00
21460	105.00	102.27	104.69	2.02	200.00	135.24	0.66
21260	105.00	101.93	104.33	1.68	200.00	166.83	0.74
21060	105.00	101.53	104.26	0.80	330.00	229.91	0.38
20698	105.00	100.59	103.33	2.91	23.00	19.07	0.76
20675	105.00	100.59	103.18	3.17	175.00	18.97	0.86
20470	105.00	100.46	103.14	1.93	200.00	31.68	0.47
20273	105.00	99.80	102.94	2.19	100.00	21.58	0.47
20203	105.00	99.70	102.87	2.17	28.49	21.61	0.46
20124	105.00	99.70	102.58	3.05	5.00	17.73	0.70
20080	105.00	99.70	102.57	3.07	166.51	17.66	0.70
20000	105.00	98.89	102.39	2.53	100.00	20.50	0.54
19900	105.00	99.29	102.26	2.56	200.00	22.33	0.60
19700	105.00	98.92	102.09	2.33	200.00	24.59	0.54
19500	105.00	98.60	101.94	2.17	200.00	25.00	0.50
19300	105.00	98.17	101.89	1.82	200.00	29.67	0.42
19100	105.00	97.93	101.79	1.71	200.00	29.75	0.38
18900	105.00	98.38	101.78	1.13	200.00	59.47	0.32
18700	105.00	97.47	101.37	2.21	200.00	32.59	0.49
18500	105.00	97.67	101.42	1.28	200.00	54.10	0.32
18300	105.00	97.44	101.30	1.31	100.00	81.79	0.36
18200	105.00	98.75	101.30	0.91	100.00	140.75	0.40
18100	105.00	97.80	101.32	0.54	200.00	194.81	0.22
17900	105.00	97.58	101.14	1.03	100.00	112.55	0.36
17800	105.00	96.65	100.88	2.08	100.00	31.98	0.48
17700	105.00	97.14	100.90	1.57	100.00	39.99	0.39
17600	105.00	97.08	100.87	1.56	50.00	31.00	0.35
17550	105.00	96.85	100.78	1.70	30.00	38.04	0.41
17520	105.00	96.88	100.74	1.96	5.00	24.00	0.44
17515	105.00	96.88	100.73	1.97	115.00	24.00	0.44
17400	105.00	96.90	100.09	3.55	100.00	15.05	0.75
17300	105.00	97.05	100.19	2.04	100.00	36.76	0.57
17200	105.00	96.46	99.98	2.36	54.00	27.96	0.57
17146	105.00	96.55	99.90	2.45	14.00	31.53	0.58
17138	105.00	96.55	99.86	2.54	8.00	31.43	0.60

17132	105.00	96.50	99.96	2.07	15.00	27.96	0.48
17117	105.00	96.50	99.95	2.09	117.00	27.91	0.48
17000	105.00	96.49	99.62	2.68	200.00	22.50	0.58
16800	105.00	96.28	99.46	2.46	207.00	22.75	0.55
16593	105.00	96.49	99.23	2.42	10.00	23.26	0.58
16583	105.00	96.49	99.21	2.45	283.00	23.18	0.59
16300	105.00	95.85	99.02	2.07	50.00	24.95	0.48
16250	105.00	95.89	99.05	2.00	2.35	25.26	0.44
16248	105.00	95.89	99.05	2.00	247.65	25.25	0.44
16000	105.00	95.32	98.82	1.91	100.00	32.94	0.44
15900	105.00	95.31	98.63	2.21	50.00	28.60	0.52
15850	105.00	94.86	98.48	2.43	70.00	24.73	0.58

TABLE A7 CONTINUED

15780	105.00	95.13	98.58	2.03	5.00	30.88	0.47
15775	105.00	95.13	98.57	2.03	75.00	30.76	0.47
15700	105.00	95.02	98.37	2.05	300.00	34.59	0.53
15400	105.00	94.49	98.30	1.52	300.00	41.79	0.36
15100	105.00	94.50	97.31	3.19	76.00	22.62	0.79
14509	105.00	94.09	97.48	2.44	8.00	19.91	0.53
14501	105.00	94.09	97.48	2.43	118.00	20.91	0.54
14383	105.00	93.48	97.47	1.91	200.00	23.13	0.39
14183	105.00	93.08	97.40	1.72	106.00	25.04	0.34
14077	105.00	93.16	97.41	1.32	35.00	30.23	0.26
14037	105.00	93.16	97.40	1.33	266.00	30.17	0.26
13900	105.00	93.32	96.44	3.32	200.00	15.80	0.70
13700	105.00	92.88	96.21	2.93	200.00	17.67	0.63
13500	105.00	92.24	95.26	4.05	173.00	14.36	0.92
13327	105.00	92.46	95.33	2.30	5.00	28.55	0.58
13322	105.00	92.46	95.31	2.32	8.00	28.47	0.58
13316	105.00	92.28	95.37	2.05	21.00	31.27	0.48
13164	105.00	92.28	95.34	2.08	200.00	31.06	0.49
12964	105.00	91.75	94.64	3.16	100.00	17.32	0.75
12864	105.00	91.44	94.81	1.72	100.00	36.29	0.46
12764	105.00	91.04	94.36	2.87	143.00	18.12	0.63
12621	105.00	91.25	94.13	2.87	200.00	20.55	0.67
12421	105.00	91.00	93.95	2.53	200.00	23.92	0.56
12221	105.00	90.69	93.67	2.55	200.00	24.84	0.61
12021	105.00	90.66	93.50	2.43	200.00	23.90	0.57
11821	105.00	90.58	93.21	2.62	52.00	22.19	0.64
11769	105.00	90.53	93.09	2.69	161.00	21.86	0.64
11608	105.00	90.02	92.96	2.51	18.00	19.42	0.55
11601	105.00	90.02	92.93	2.55	82.00	19.42	0.56
11600	105.00	89.49	92.90	2.18	100.00	21.51	0.49
11500	105.00	89.28	92.53	2.98	85.00	14.95	0.63
11415	105.00	88.81	92.64	2.23	7.00	20.50	0.46
11408	105.00	88.81	92.64	2.23	114.00	20.45	0.46
11300	105.00	88.88	92.48	2.15	102.00	21.10	0.46
11200	105.00	88.36	92.52	1.72	45.00	22.86	0.35
11142	105.00	88.38	92.56	1.28	18.00	36.74	0.28
11124	105.00	88.38	92.56	1.28	92.00	36.72	0.28

11000	105.00	88.41	92.35	2.19	200.00	18.67	0.44
10800	105.00	88.34	92.04	2.34	200.00	30.64	0.51
10600	105.00	88.25	91.87	2.33	200.00	26.85	0.49
10400	105.00	87.99	91.60	2.74	198.00	16.34	0.55
10202	105.00	88.02	91.63	1.94	13.00	25.83	0.43
10189	105.00	88.02	91.62	1.94	86.00	25.79	0.43
9990	105.00	88.05	91.67	1.12	12.00	48.30	0.26
9978	105.00	88.05	91.66	1.12	85.00	48.29	0.26
9900	105.00	87.55	91.62	0.98	110.00	74.70	0.30
9790	105.00	87.89	91.24	2.62	4.20	18.50	0.57
9786	105.00	87.89	91.24	2.62	170.00	18.50	0.57
9600	105.00	87.59	90.69	2.81	139.00	32.64	0.76
9461	105.00	87.36	90.60	2.40	3.00	39.81	0.64

TABLE A7 CONTINUED							
9458	105.00	87.36	90.59	2.42	148.00	38.60	0.65
9300	105.00	87.18	90.12	2.93	217.00	25.62	0.72
9098	105.00	87.03	89.82	2.68	30.00	26.54	0.69
9068	105.00	87.03	89.54	3.30	18.00	25.59	0.88
9050	105.00	86.80	89.97	1.06	10.00	50.94	0.24
9040	105.00	86.80	89.97	1.06	96.00	50.94	0.24
8944	105.00	86.64	89.96	0.92	20.00	46.92	0.18
8924	105.00	86.64	89.96	0.92	90.00	46.91	0.18
8834	105.00	86.09	89.77	1.84	2.00	23.95	0.36
8832	105.00	86.09	89.76	1.84	158.00	23.95	0.36
8676	105.00	85.93	88.81	3.98	56.00	12.67	0.88
8620	105.00	86.54	88.80	3.40	2.50	16.75	0.80
8618	105.00	86.54	88.78	3.43	13.50	16.69	0.81
8604	105.00	86.20	88.75	3.42	120.00	16.33	0.80
8484	105.00	85.50	88.91	1.67	3.80	25.50	0.32
8480	105.00	85.50	88.91	1.67	24.20	25.50	0.32
8456	105.00	85.92	88.62	2.49	90.00	22.44	0.59
8366	105.00	85.98	88.06	3.35	30.00	21.43	0.91
8336	105.00	86.10	88.23	2.58	8.00	23.10	0.62
8328	105.00	86.10	88.21	2.62	194.00	23.10	0.64
8132	105.00	84.65	87.96	2.43	10.00	18.56	0.51
8124	105.00	84.65	87.94	2.45	13.00	18.52	0.51
8111	105.00	85.26	87.96	2.11	145.00	27.95	0.52
7966	105.00	84.81	87.16	3.27	120.00	24.46	1.03
7846	105.00	84.62	86.82	3.18	3.40	18.95	0.77
7843	105.00	84.62	86.80	3.21	5.60	18.94	0.78
7837	105.00	84.17	86.99	2.21	2.60	18.75	0.44
7834	105.00	84.17	86.98	2.21	26.00	18.75	0.44
7724	105.00	83.89	87.01	1.91	79.00	22.06	0.39
7700	105.00	83.57	86.75	2.61	60.00	19.73	0.58
7640	105.00	84.10	86.80	1.87	116.00	26.74	0.40
7524	105.00	84.39	86.00	3.62	200.00	21.66	1.04
7324	105.00	83.59	85.69	2.46	154.00	22.10	0.56
7170	105.00	83.36	85.41	2.71	48.00	21.77	0.65
7122	105.00	82.89	85.30	2.81	164.00	21.54	0.68
6958	105.00	82.55	85.10	2.53	1.00	21.90	0.58

6957	105.00	82.55	85.10	2.53	10.00	21.90	0.59
6947	105.00	82.68	84.76	3.46	5.00	19.05	0.88
6942	105.00	82.68	84.63	3.79	12.00	19.03	1.00
6930	105.00	82.75	84.76	3.11	20.00	20.40	0.77
6910	105.00	82.75	84.49	3.70	22.00	20.35	1.00
6888	105.00	81.88	84.56	3.02	2.00	21.69	0.76
6886	105.00	81.88	84.55	3.04	162.00	21.69	0.77
6724	105.00	79.82	84.19	3.09	81.00	23.03	0.60
6641	105.00	82.27	84.22	2.46	21.00	27.54	0.63
6620	105.00	82.27	84.17	2.55	96.00	27.54	0.67
6524	105.00	81.24	84.07	2.14	200.00	32.23	0.52
6324	105.00	81.39	83.91	2.11	158.00	32.14	0.50
6166	105.00	80.16	83.79	2.24	142.00	19.26	0.46
6024	105.00	80.97	83.58	2.47	100.00	21.29	0.56

TABLE A7 CONTINUED

5924	105.00	80.89	83.45	2.44	200.00	21.94	0.56
5724	105.00	80.60	83.19	2.40	200.00	21.95	0.54
5524	105.00	80.36	82.92	2.44	200.00	21.84	0.55
5324	105.00	80.13	82.61	2.54	200.00	22.00	0.59
5124	105.00	79.83	82.28	2.58	200.00	21.83	0.60
4924	105.00	79.71	81.87	2.80	53.00	22.05	0.69
4871	105.00	79.57	82.02	1.43	5.00	34.82	0.31
4866	105.00	79.57	82.02	1.43	142.00	34.82	0.31
4724	105.00	79.18	81.72	2.35	200.00	21.81	0.53
4524	105.00	78.80	81.57	2.16	200.00	21.95	0.46
4324	105.00	78.45	81.36	2.30	147.00	21.84	0.51
4177	105.00	78.67	81.34	1.64	62.00	27.72	0.35
4138	105.00	78.67	81.34	1.38	23.00	34.79	0.31
4115	105.00	78.67	81.33	1.39	18.00	34.79	0.31
4097	105.00	78.62	81.26	1.65	173.00	32.79	0.39
3924	105.00	78.40	80.76	2.62	240.00	24.41	0.67
3684	105.00	78.15	80.32	2.65	160.00	26.93	0.69
3524	105.00	77.62	80.20	2.36	200.00	30.43	0.53
3324	105.00	77.46	80.02	2.35	200.00	26.11	0.53
3124	105.00	77.09	79.85	2.09	200.00	31.71	0.49
2924	105.00	76.69	79.55	2.70	200.00	20.06	0.57
2724	105.00	76.43	79.51	1.64	200.00	46.36	0.43
2524	105.00	76.73	79.30	1.87	200.00	42.06	0.51
2324	105.00	76.52	79.05	2.16	200.00	34.12	0.53
2124	105.00	76.14	78.89	1.88	200.00	39.84	0.50
1924	105.00	75.19	78.75	1.78	84.00	47.40	0.46
1840	105.00	76.40	78.63	2.27	5.00	31.13	0.58
1835	105.00	76.40	78.62	2.28	111.00	30.92	0.58
1724	105.00	76.02	78.54	1.83	118.00	48.78	0.49
1606	105.00	75.61	78.56	1.18	24.00	63.23	0.29
1582	105.00	75.61	78.56	1.18	54.00	63.09	0.29
1528	105.00	75.60	78.04	3.16	44.00	17.91	0.74
1484	105.00	75.21	78.24	1.71	14.00	26.27	0.36
1470	105.00	75.21	78.23	1.71	143.00	26.26	0.36
1327	105.00	74.62	77.84	2.74	200.00	21.42	0.57

1127	105.00	74.16	77.71	2.40	205.00	17.47	0.48
922	105.00	74.10	77.25	3.13	6.00	12.21	0.60
916	105.00	74.10	77.24	3.14	188.00	12.21	0.61
728	105.00	74.00	77.18	2.28	212.00	29.49	0.49
516	105.00	73.43	76.98	2.42	5.00	15.78	0.46
511	105.00	73.43	76.97	2.42	26.00	15.77	0.46
480	105.00	73.72	76.38	3.34	158.00	21.41	0.92
400	105.00	73.80	76.43	2.03	200.00	30.33	0.53
390	105.00	73.36	75.85	3.02	50.00	28.80	0.75
380	105.00	73.03	75.56	3.40	73.00	25.01	0.92
370	105.00	73.59	75.81	1.68	5.00	39.99	0.42
360	105.00	73.59	75.80	1.68	220.00	39.97	0.42
350	105.00	72.24	74.95	3.17	202.50	25.87	0.82
340	105.00	72.25	74.78	2.61	185.00	20.86	0.59
330	105.00	71.27	74.80	1.45	190.00	76.59	0.31

TABLE A7 CONTINUED

320	105.00	72.03	74.52	2.29	122.50	24.23	0.53
310	105.00	71.50	74.40	2.33	120.00	20.00	0.50
300	105.00	71.51	73.99	2.96	90.00	53.05	0.73
290	105.00	71.53	73.93	2.37	26.00	33.78	0.70
280	105.00	71.53	73.80	2.63	85.00	32.50	0.79
270	105.00	71.44	73.81	1.74	8.95	64.97	0.55
260	105.00	71.44	73.79	1.78	91.05	64.92	0.57
250	105.00	70.66	73.56	2.44	90.00	33.45	0.59
240	105.00	71.52	73.52	2.10	8.95	38.90	0.55
230	105.00	71.52	73.50	2.12	90.00	38.67	0.56
220	105.00	70.84	73.49	1.80	311.05	35.60	0.40
210	105.00	69.67	72.85	2.80	10.00	27.94	0.68
200	105.00	69.63	72.91	2.39	10.50	30.78	0.55
190	105.00	69.63	72.89	2.42	479.50	30.69	0.56
180	105.00	69.87	72.23	2.66	100.00	33.66	0.62
170	105.00	69.94	72.18	2.22	4.34	33.43	0.55
160	105.00	69.94	72.17	2.23	125.66	33.38	0.55
150	105.00	69.62	72.09	2.08	2.00	29.30	0.48
140	105.00	69.62	72.09	2.08	268.00	29.30	0.48
130	105.00	69.41	71.47	2.94	268.00	23.11	0.74
120	105.00	68.82	71.24	2.17	8.57	26.50	0.49
110	105.00	68.82	71.23	2.18	11.43	26.41	0.49
100	105.00	68.07	71.14	2.29	201.00	37.32	0.52
90	105.00	67.95	71.04	1.99	5.47	34.86	0.43
80	105.00	67.95	71.03	1.99	43.53	34.78	0.43
70	105.00	67.85	70.98	2.05	9.15	36.64	0.46
60	105.00	67.85	70.97	2.07	220.85	36.43	0.46
50	105.00	67.76	70.83	1.90	40.00	39.53	0.45
40	105.00	67.26	70.82	1.77	3.39	41.28	0.39
30	105.00	67.26	70.81	1.77	1.13	41.26	0.39
20	105.00	67.12	70.85	1.59	4.75	40.02	0.35
10	105.00	67.12	70.85	1.60	270.00	40.01	0.35
0	105.00	67.12	70.69	1.76		38.98	0.39

PART 3

UNSTEADY MODEL RESULTS

ISIS

TABLE A8: MAXIMUM OF ALL VARIABLES CASE 1, ISIS, RUN TIME STEP 60 SEC

Label (HEC-RAS)	Label (ISIS)	Flow (m^3s^{-1})	Stage (m) above datum	Froude no	Velocity (ms^{-1})
25144	TM24413	104.998	111.216	0.273	1.213
25045	TM24314	104.988	110.823	0.491	2.310
24940	TM24940	104.969	110.757	0.634	1.569
24745	TM23982	104.922	110.495	0.296	1.170
24680	TM24680	104.903	110.464	0.544	1.359
24537	TM23802	104.858	110.323	0.380	1.005
24457	TM24457	104.817	110.316	0.670	1.499
24398	TM23692	104.796	110.204	0.402	1.319
24370	TM23664	104.793	110.169	0.445	1.341
24190	TM24190	104.787	110.061	0.475	1.169
24159	TM23454	104.786	110.010	0.255	1.078
24148	TM23443	104.785	110.002	0.258	1.081
24038	TM23333	104.781	109.963	0.408	1.099
23990	TM23990	104.777	109.900	0.492	1.335
23890	TM23890	104.767	109.797	0.587	1.444
23720	TM23720	104.744	109.562	0.496	1.285
23585	TM23585	104.719	109.435	0.564	1.522
23494	TM22795	104.705	108.983	0.572	2.247
23465	TM22768	104.703	108.796	0.701	2.499
23400	TM23400	104.701	108.855	0.558	1.343
23355	TM22660	104.701	108.824	0.431	1.094
23345	TM22650	104.701	108.818	0.439	1.098
23135	TM23135	104.702	108.686	0.338	0.823
23050	TM22381	104.701	108.519	0.453	1.499
23044	TM22375	104.701	108.506	0.464	1.510
23024	TM22355	104.701	108.396	0.535	1.862
22996	TM22327	104.700	108.302	0.621	1.951
22790	TM22790	104.697	107.837	0.417	1.725
22667	TM22005	104.692	107.696	0.318	1.401
22653	TM21991	104.692	107.676	0.349	1.414
22500	TM22500	104.676	107.625	0.332	0.813
22402	TM21770	104.666	107.572	0.266	0.861
22396	TM21764	104.666	107.568	0.267	0.863
223000	TM22300	104.648	107.562	0.520	1.141
22137	TM21516	104.641	107.261	0.581	1.474
22104	TM21466	104.642	107.048	0.675	1.770
22066	TM21428	104.642	106.771	0.927	2.485
21925	TM21925	104.641	106.525	0.718	1.529
21831	TM21219	104.64	106.118	0.520	2.218
21820	TM21208	104.64	106.061	0.542	2.282
21700	TM21700	104.638	105.880	0.687	1.624
21539	TM20928	104.631	105.443	0.480	1.631
21532	TM20921	104.631	105.421	0.492	1.658
21518	TM20907	104.631	105.189	0.624	2.492
21493	TM20882	104.63	104.912	0.924	2.998

TABLE A8 CONTINUED

21460	TM21460	104.607	105.134	0.619	1.224
21260	TM21260	104.297	104.945	0.891	1.572
21060	TM21060	103.965	104.855	0.565	1.164
20698	TM20160	103.790	104.241	0.453	1.902
20675	TM20137	103.788	104.174	0.549	1.956
20470	TM20500	103.768	104.000	0.380	1.212
20273	TM20300	103.737	103.768	0.324	1.488
20203	TM19962	103.724	103.647	0.305	1.564
20124	TM20175	103.720	103.534	0.397	1.945
20080	TM20170	103.720	103.523	0.400	1.955
20000	TM20000	103.697	103.312	0.353	1.651
19900	TM19900	103.679	103.190	0.358	1.627
19700	TM19700	103.657	102.971	0.355	1.463
19500	TM19500	103.624	102.738	0.348	1.474
19300	TM19300	103.584	102.557	0.291	1.319
19100	TM19100	103.536	102.388	0.290	1.291
18900	TM18900	103.456	102.313	0.361	0.935
18700	TM18700	103.349	102.074	0.427	1.450
18500	TM18500	103.271	101.96	0.263	0.951
18300	TM18300	103.137	101.868	0.417	1.063
18200	TM18200	103.025	101.855	0.693	1.671
18100	TM18100	102.877	101.839	0.491	1.047
17900	TM17900	102.729	101.774	0.508	1.238
17800	TM17800	102.687	101.609	0.426	1.372
17700	TM17700	102.666	101.560	0.297	1.090
17600	TM17600	102.655	101.478	0.279	1.196
17550	TM17550	102.656	101.445	0.326	1.158
17520	TM17520	102.656	101.364	0.305	1.499
17515	TM17515	102.656	101.358	0.306	1.502
17400	TM17400	102.655	100.975	0.487	2.313
17300	TM17300	102.651	101.002	0.514	1.467
17200	TM17200	102.648	100.848	0.420	1.473
17146	TM17146	102.645	100.783	0.493	1.543
17138	TM17138	102.644	100.762	0.503	1.581
17132	TM17132	102.643	100.764	0.355	1.375
17117	TM17117	102.642	100.748	0.359	1.384
17000	TM17000	102.634	100.598	0.407	1.518
16800	TM16800	102.617	100.343	0.342	1.589
16593	TM16593	102.597	100.083	0.354	1.579
16583	TM16583	102.595	100.067	0.361	1.590
16300	TM16300	102.556	99.7470	0.324	1.435
16250	TM16250	102.548	99.6850	0.312	1.474
16248	TM16248	102.548	99.6820	0.314	1.476
16000	TM16000	102.501	99.4470	0.351	1.319
15900	TM15900	102.498	99.3030	0.405	1.512
15850	TM15850	102.496	99.2020	0.406	1.655
15780	TM15780	102.492	99.1420	0.376	1.442
15775	TM15775	102.491	99.1380	0.370	1.425
15700	TM15700	102.484	99.0530	0.404	1.381

TABLE A8 CONTINUED

15400	TM15400	102.446	98.8120	0.310	1.120
15100	TM15100	102.389	98.4150	0.532	1.749
14509	TM14509	102.375	98.2690	0.433	1.672
14501	TM14501	102.374	98.2650	0.488	1.642
14383	TM14383	102.353	98.1570	0.285	1.412
14183	TM14183	102.335	98.0020	0.267	1.316
14077	TM14077	102.338	97.9700	0.198	1.048
14037	TM14037	102.339	97.9530	0.199	1.054
13900	TM13900	102.342	97.3610	0.442	2.186
13700	TM13700	102.342	96.9030	0.448	2.096
13500	TM13500	102.337	96.2670	0.544	2.440
13327	TM13327	102.325	96.0730	0.571	1.486
13322	TM13322	102.325	96.0650	0.820	1.492
13316	TM13316	102.324	96.0770	0.372	1.351
13164	TM13164	102.322	96.0520	0.381	1.370
12964	TM12964	102.303	95.5800	0.440	2.019
12864	TM12864	102.291	95.5660	0.334	1.145
12764	TM12764	102.276	95.3600	0.425	1.605
12621	TM12621	102.254	95.1000	0.405	1.728
12421	TM12421	102.215	94.9030	0.407	1.444
12221	TM12221	102.210	94.6570	0.365	1.496
12021	TM12021	102.207	94.4250	0.350	1.496
11821	TM11821	102.197	94.1540	0.408	1.587
11769	TM11769	102.193	94.0800	0.434	1.615
11608	TM11608	102.182	93.8310	0.394	1.738
11601	TM11590	102.181	93.8030	0.512	1.754
11600	TM11600	102.175	93.7410	0.363	1.529
11500	**TM11500**	**102.167**	**93.5000**	**0.395**	**2.015**
11415	TM11415	102.161	93.4580	0.368	1.563
11408	TM11408	102.160	93.4490	0.376	1.568
11300	TM11300	102.149	93.3360	0.302	1.495
11200	TM11200	102.137	93.2860	0.238	1.288
11142	TM11142	102.131	93.3030	0.203	0.926
11124	TM11124	102.128	93.2940	0.204	0.929
11000	TM11000	102.114	93.1290	0.296	1.606
10800	TM10800	102.085	92.9470	0.412	1.379
10600	TM10600	102.055	92.7270	0.357	1.457
10400	TM10400	102.059	92.3580	0.416	1.962
10202	TM10202	102.058	92.1600	0.303	1.488
10189	TM10189	102.058	92.1420	0.332	1.498
9990	TM9990	102.057	92.1450	0.255	0.872
9978	TM9978	102.056	92.1390	0.254	0.874
9900	TM9900	102.053	92.1160	0.340	0.890
9790	TM9790	102.047	91.7770	0.429	1.952
9786	TM9786	102.047	91.7640	0.432	1.964
9600	TM9600	102.038	91.4550	0.476	1.569
9461	TM9461	102.025	91.2130	0.481	1.524
9458	TM9458	102.025	91.2070	0.488	1.536
9300	TM9300	102.008	90.8820	0.479	1.755

TABLE A8 CONTINUED

9098	TM9098	101.980	90.4260	0.611	1.938
9068	TM9068	101.976	90.3420	0.874	2.497
9050	TM9050	101.973	90.4850	0.453	0.860
9040	TM9040	101.970	90.4810	0.535	0.954
8944	TM8944	101.946	90.4600	0.265	0.738
8924	TM8924	101.941	90.4550	0.309	0.739
8834	TM8834	101.951	90.3140	0.302	1.480
8832	TM8832	101.951	90.3120	0.302	1.481
8676	TM8676	101.958	89.5890	0.561	2.742
8620	TM8620	101.959	89.4440	0.513	2.405
8618	TM8618	101.959	89.4310	0.517	2.420
8604	TM8604	101.960	89.3700	0.518	2.466
8484	TM8484	101.963	89.3170	0.266	1.387
8480	TM8480	101.963	89.3130	0.267	1.388
8456	TM8456	101.963	89.1990	0.396	1.837
8366	TM8366	101.966	88.9170	0.506	2.019
8336	TM8336	101.966	88.8660	0.510	1.842
8328	TM8328	101.966	88.8420	0.695	1.861
8132	TM8134	101.970	88.3480	0.398	2.003
8124	TM8124	101.970	88.3190	0.404	2.025
8111	TM8111	101.970	88.3580	0.376	1.665
7966	TM7966	101.970	87.9120	0.583	1.967
7846	TM7846	101.968	87.4480	0.709	2.267
7843	TM7843	101.968	87.4330	0.986	2.281
7837	TM7837	101.968	87.5060	0.326	1.780
7834	TM7834	101.968	87.5010	0.327	1.783
7724	TM7724	101.967	87.5060	0.287	1.546
7700	TM7700	101.966	87.2430	0.411	2.041
7640	TM7640	101.965	87.2040	0.315	1.514
7524	TM7524	101.961	86.8180	0.544	2.18
7324	TM7324	101.951	86.4240	0.339	1.729
7170	TM7170	101.942	86.1060	0.645	1.885
7122	TM7122	101.939	85.9930	0.403	1.943
6958	TM6958	101.926	85.6490	0.433	1.902
6957	TM6957	101.926	85.6470	0.435	1.904
6947	TM6947	101.925	85.5470	0.551	2.254
6942	TM6942	101.925	85.5270	0.608	2.273
6930	TM6930	101.924	85.5450	0.510	2.044
6910	TM6910	101.922	85.4850	1.136	2.096
6888	TM6888	101.920	85.4860	0.395	1.854
6886	TM6886	101.919	85.4810	0.397	1.857
6724	TM6724	101.897	85.2430	0.414	1.662
6641	TM6641	101.884	85.1650	0.413	1.485
6620	TM6620	101.881	85.1380	0.653	1.502
6524	TM6524	101.864	85.0840	0.318	1.209
6324	TM6324	101.865	84.9310	0.346	1.188
6166	TM6166	101.864	84.7350	0.274	1.562
6024	TM6024	101.862	84.5430	0.301	1.609
5924	TM5924	101.859	84.4000	0.310	1.587

TABLE A8 CONTINUED					
5724	TM5724	101.850	84.1180	0.326	1.552
5524	TM5524	101.837	83.8220	0.326	1.558
5324	TM5324	101.819	83.4890	0.345	1.624
5124	TM5124	101.796	83.1390	0.379	1.639
4924	TM4924	101.762	82.7650	0.557	1.736
4871	TM4871	101.752	82.8060	0.318	1.004
4866	TM4866	101.750	82.8040	0.341	1.005
4724	TM4724	101.747	82.6050	0.299	1.593
4524	TM4524	101.749	82.3720	0.284	1.538
4324	TM4324	101.748	82.0910	0.315	1.649
4177	TM4177	101.744	81.9810	0.233	1.247
4138	TM4138	101.742	81.9630	0.202	1.041
4115	TM4115	101.741	81.9490	0.203	1.046
4097	TM4097	101.741	81.9210	0.247	1.178
3924	TM3924	101.730	81.6170	0.390	1.604
3684	TM3684	101.707	81.2100	0.442	1.559
3524	TM3524	101.687	81.0330	0.345	1.405
3324	TM3324	101.649	80.8130	0.375	1.442
3124	TM3124	101.605	80.6280	0.312	1.323
2924	TM2924	101.588	80.3260	0.473	1.720
2724	TM2724	101.569	80.2020	0.283	1.044
2524	TM2524	101.541	80.0220	0.385	1.137
2324	TM2324	101.507	79.7840	0.348	1.335
2124	TM2124	101.467	79.5880	0.349	1.184
1924	TM1924	101.410	79.4060	0.344	1.123
1840	TM1840	101.382	79.2660	0.402	1.470
1835	TM1835	101.382	79.2580	0.413	1.480
1724	TM1724	101.377	79.1760	0.474	1.427
1606	TM1606	101.371	79.1190	0.283	0.980
1582	TM1582	101.370	79.1070	0.308	0.993
1528	TM1528	101.367	78.8780	0.688	1.966
1484	TM1484	101.365	78.9330	0.366	1.252
1470	TM1470	101.365	78.9220	0.440	1.257
1327	TM1327	101.356	78.7400	0.427	1.594
1127	TM1127	101.342	78.4540	0.389	1.658
922	TM922	101.332	77.9160	0.478	2.369
916	TM916	101.331	77.8960	0.481	2.389
728	TM728	101.318	77.6620	0.421	1.651
516	TM516	101.304	77.1160	0.425	2.215
511	**TM511**	**101.304**	**77.1010**	**0.427**	**2.227**
480	TM480	101.303	77.0660	0.490	2.056
400	TM328	101.289	76.8900	0.402	1.436
390	TM128	101.291	76.3650	0.604	1.902
380	TM78	101.293	76.2380	0.680	2.001
370	TM5	101.296	76.1650	0.470	1.310
360	TM0	101.296	76.1580	0.532	1.315
350	TL30121	101.300	75.7980	0.578	1.684
340	TL29919	101.276	75.3420	0.725	1.809
330	TL29734	101.204	75.2810	0.384	0.955

TABLE A8 CONTINUED					
320	TL29544	101.091	75.0260	0.605	1.616
310	TL29421	101.058	74.8440	0.678	1.707
300	TL29301	100.993	74.7650	0.769	1.592
290	TL29211	100.951	74.5470	0.426	1.416
280	TL29185	100.946	74.4860	0.539	1.490
270	TL29100	100.923	74.4250	0.489	1.301
260	TL29091	100.921	74.4160	0.505	1.333
250	TL29000	100.897	74.2450	0.409	1.461
240	TL28910	100.875	74.1590	0.441	1.256
230	TL28901	100.875	74.1470	0.558	1.268
220	TL28590	100.877	74.0620	0.355	1.214
210	TL28500	100.876	73.6570	0.410	1.641
200	TL28490	100.876	73.6730	0.364	1.460
190	TL28480	100.875	73.6580	0.370	1.471
180	TL28000	100.850	72.9820	0.429	1.504
170	TL27900	100.842	72.8620	0.352	1.406
160	TL27896	100.842	72.8560	0.354	1.410
150	TL27770	100.831	72.7000	0.318	1.466
140	TL27768	100.831	72.6980	0.319	1.468
130	TL27500	100.805	72.2090	0.444	1.780
120	TL27020	100.776	71.7900	0.499	1.566
110	TL27011	100.776	71.7770	0.979	1.575
100	TL27000	100.777	71.7870	0.433	1.451
90	TL26799	100.786	71.5340	0.368	1.414
80	TL26794	100.786	71.5270	0.370	1.419
70	TL26750	100.788	71.4740	0.403	1.456
60	TL26741	100.788	71.4610	0.406	1.471
50	TL26500	100.792	71.1520	0.913	1.760
40	TL26460	100.793	71.1100	0.427	1.591
30	TL26459	100.793	71.0980	0.426	1.604
20	TL26450	100.793	71.1130	0.362	1.414
10	TL26445	100.793	71.1070	0.364	1.419
0	TL26180	100.796	70.6650	0.598	2.036

TABLE A9: MAXIMUM OF ALL VARIABLES CASE 2, ISIS. RUN TIME STEP 60 SEC.

Label (HEC-RAS)	Label (ISIS)	Flow (m^{3}s^{-1})	Stage (m)	Froude no	Velocity (ms^{-1})
25144	TM24413	105.000	111.363	0.258	1.138
25052	TM24321	104.979	111.063	0.489	2.084
25045	TM24314	104.979	110.829	0.490	2.304
24940	TM24940	104.959	110.766	0.634	1.572
24745	TM23982	104.910	110.507	0.297	1.163
24680	TM24680	104.889	110.478	0.551	1.368
24537	TM23802	104.835	110.341	0.388	0.996
24457	TM24457	104.787	110.335	0.688	1.518
24398	TM23692	104.771	110.225	0.414	1.307
24370	TM23664	104.771	110.190	0.439	1.328

TABLE A9 CONTINUED

24190	TM24190	104.759	110.087	0.470	1.165
24159	TM23454	104.756	110.036	0.245	1.066
24148	TM23443	104.756	110.019	0.259	1.074
24038	TM23333	104.746	109.981	0.411	1.108
23990	TM23990	104.739	109.922	0.494	1.345
23890	TM23890	104.723	109.825	0.592	1.457
23720	TM23720	104.681	109.605	0.504	1.309
23585	TM23585	104.639	109.492	0.589	1.599
23494	TM22795	104.622	109.098	0.656	2.143
23465	TM22768	104.622	109.009	0.664	2.236
23400	TM23400	104.618	109.065	0.534	1.356
23355	TM22660	104.613	109.045	0.389	1.009
23345	TM22650	104.613	109.027	0.425	1.079
23135	TM23135	104.587	108.935	0.324	0.839
23050	TM22381	104.578	108.822	0.416	1.281
23044	TM22375	104.578	108.804	0.508	1.311
23024	TM22355	104.576	108.724	0.561	1.605
22996	TM22327	104.576	108.703	0.601	1.620
22790	TM22790	104.555	108.488	0.331	1.290
22667	TM22005	104.540	108.432	0.286	1.050
22653	TM21991	104.540	107.832	0.339	1.326
22500	TM22500	104.473	107.799	0.319	0.774
22402	TM21770	104.441	107.759	0.251	0.784
22396	TM21764	104.441	107.715	0.263	0.808
223000	TM22300	104.388	107.713	0.519	1.145
22137	TM21516	104.293	107.531	0.555	1.419
22104	TM21466	104.274	107.447	0.595	1.699
22066	TM21428	104.271	107.359	0.844	2.363
21925	TM21925	104.249	107.310	0.583	1.366
21831	TM21219	104.237	107.166	0.345	1.443
21820	TM21208	104.237	106.205	0.523	2.154
21700	TM21700	104.221	106.107	0.719	1.659
21539	TM20928	104.182	105.887	0.488	1.542
21532	TM20921	104.182	105.312	0.569	1.832
21518	TM20907	104.179	105.043	0.909	2.833
21493	TM20882	104.179	105.010	0.909	2.957
21460	TM21460	104.076	105.295	0.618	1.241
21260	TM21260	103.069	105.202	0.913	1.594
21060	TM21060	102.168	105.163	0.565	1.160
20698	TM20160	101.708	104.833	0.509	1.545
20675	TM20137	101.708	104.698	0.539	1.614
20470	TM20500	101.696	104.638	0.354	0.994
20273	TM20300	101.685	104.534	0.241	1.126
20203	TM19962	101.679	104.504	0.271	1.155
20124	TM20175	101.677	104.448	0.315	1.402
20080	TM20170	101.677	103.635	0.394	1.882
20000	TM20000	101.590	103.469	0.345	1.577
19900	TM19900	101.521	103.379	0.352	1.553
19700	TM19700	101.322	103.236	0.339	1.397

TABLE A9 CONTINUED

19500	TM19500	101.049	103.094	0.319	1.367
19300	TM19300	100.751	103.002	0.280	1.220
19100	TM19100	100.412	102.918	0.270	1.174
18900	TM18900	99.9290	102.889	0.358	0.932
18700	TM18700	99.3240	102.807	0.394	1.341
18500	TM18500	98.6320	102.773	0.243	0.854
18300	TM18300	97.5520	102.752	0.391	1.015
18200	TM18200	96.8300	102.750	0.693	1.651
18100	TM18100	95.9990	102.748	0.474	1.013
17900	TM17900	94.7870	102.735	0.451	1.153
17800	TM17800	94.5130	102.684	0.362	1.210
17700	TM17700	94.3920	102.674	0.265	0.863
17600	TM17600	94.3210	102.646	0.244	0.816
17550	TM17550	94.2820	102.647	0.281	0.940
17520	TM17520	94.2600	102.612	0.271	1.000
17515	TM17515	94.2600	101.736	0.306	1.310
17400	TM17400	94.1950	101.554	0.439	1.971
17300	TM17300	94.1110	101.587	0.516	1.491
17200	TM17200	94.0110	101.523	0.421	1.330
17146	TM17146	93.9560	101.505	0.485	1.536
17138	TM17138	93.9560	101.154	0.485	1.536
17132	TM17132	93.9490	101.153	0.345	1.220
17117	TM17117	93.9490	100.964	0.350	1.238
17000	TM17000	93.8880	100.875	0.386	1.434
16800	TM16800	93.8390	100.727	0.326	1.358
16593	TM16593	93.7700	100.602	0.331	1.308
16583	TM16583	93.7700	100.227	0.352	1.402
16300	TM16300	93.7740	100.022	0.289	1.212
16250	TM16250	93.7740	99.9840	0.308	1.228
16248	TM16248	93.7740	99.8380	0.313	1.273
16000	TM16000	93.7560	99.6880	0.310	1.136
15900	TM15900	93.7460	99.6030	0.347	1.249
15850	TM15850	93.7410	99.5480	0.339	1.329
15780	**TM15780**	**93.7330**	**99.5300**	**0.299**	**1.155**
15775	TM15775	93.7330	99.0410	0.359	1.385
15700	TM15700	93.7080	98.9640	0.401	1.368
15400	TM15400	93.6020	98.7410	0.313	1.110
15100	TM15100	93.5430	98.3970	0.533	1.740
14509	TM14509	93.5270	98.2780	0.482	1.570
14501	TM14501	93.5270	98.2830	0.490	1.541
14383	TM14383	93.5020	98.1980	0.263	1.277
14183	TM14183	93.4580	98.0790	0.243	1.182
14077	TM14077	93.4300	98.0560	0.184	0.933
14037	TM14037	93.4300	97.8660	0.189	0.992
13900	TM13900	93.4100	97.3780	0.430	1.988
13700	TM13700	93.3970	97.0480	0.426	1.829
13500	TM13500	93.3730	96.7170	0.457	1.983
13327	TM13327	93.3250	96.6590	0.413	1.266
13322	**TM13322**	**93.3250**	**95.9740**	**0.991**	**1.578**

TABLE A9 CONTINUED					
13316	TM13316	93.3220	95.9850	0.386	1.317
13164	TM13164	93.3220	95.9260	0.386	1.348
12964	TM12964	93.2670	95.5070	0.441	1.913
12864	TM12864	93.2310	95.4910	0.338	1.097
12764	TM12764	93.1790	95.3120	0.423	1.587
12621	TM12621	93.0990	95.1000	0.392	1.646
12421	TM12421	92.9600	94.9490	0.401	1.430
12221	TM12221	92.7960	94.7710	0.361	1.415
12021	TM12021	92.6130	94.6200	0.340	1.418
11821	TM11821	92.3620	94.4760	0.395	1.479
11769	TM11769	92.2850	94.4410	0.415	1.513
11608	TM11608	92.0930	94.3040	0.503	1.503
11601	TM11590	92.0930	94.2140	0.512	1.518
11600	TM11600	92.0420	94.1870	0.360	1.324
11500	TM11500	91.9770	94.0680	0.369	1.686
11415	TM11415	91.9190	94.0570	0.368	1.328
11408	TM11408	91.9190	93.7230	0.371	1.376
11300	TM11300	91.8420	93.6590	0.288	1.300
11200	TM11200	91.7670	93.6300	0.235	1.104
11142	TM11142	91.7230	93.6430	0.200	0.803
11124	TM11124	91.7230	93.3810	0.203	0.858
11000	TM11000	91.6410	93.2650	0.277	1.461
10800	TM10800	91.4530	93.1520	0.408	1.344
10600	TM10600	91.2620	93.0230	0.351	1.359
10400	TM10400	91.0610	92.8410	0.355	1.717
10202	TM10202	90.8210	92.7620	0.322	1.285
10189	TM10189	90.8210	92.6290	0.334	1.306
9990	TM9990	90.6860	92.6360	0.259	0.771
9978	TM9978	90.6860	92.6280	0.260	0.777
9900	TM9900	90.5040	92.6220	0.354	0.900
9790	TM9790	90.2880	92.5010	0.364	1.689
9786	TM9786	90.2880	92.3370	0.364	1.689
9600	TM9600	90.0330	92.2570	0.473	1.457
9461	TM9461	89.7480	92.2120	0.529	1.494
9458	TM9458	89.7480	92.1770	0.529	1.495
9300	TM9300	89.5440	92.1120	0.479	1.625
9098	TM9098	89.3200	92.0500	0.870	2.390
9068	TM9068	89.3200	91.9980	0.870	2.390
9050	TM9050	89.2950	92.0250	0.447	0.889
9040	TM9040	89.2950	91.7600	0.448	0.892
8944	TM8944	89.1260	91.7560	0.187	0.555
8924	TM8924	89.1260	91.4280	0.308	0.582
8834	**TM8834**	**89.0000**	**91.3830**	**0.270**	**1.147**
8832	TM8832	89.0000	90.4850	0.282	1.272
8676	TM8676	88.9390	90.1670	0.448	2.128
8620	TM8620	88.9190	90.1360	0.518	1.868
8618	TM8618	88.9190	90.1360	0.518	1.870
8604	TM8604	88.9160	90.1160	0.451	1.876
8484	TM8484	88.8810	90.1080	0.215	1.009

TABLE A9 CONTINUED					
8480	TM8480	88.8810	89.5080	0.231	1.141
8456	TM8456	88.8770	89.4420	0.372	1.496
8366	TM8366	88.8610	89.3300	0.503	1.643
8336	TM8336	88.8550	89.3030	0.517	1.449
8328	TM8328	88.8550	88.6280	0.696	1.796
8132	TM8134	88.8540	88.1440	0.387	1.900
8124	TM8124	88.8540	88.1440	0.387	1.900
8111	TM8111	88.8540	88.1710	0.372	1.594
7966	TM7966	88.8520	87.7090	0.581	1.924
7846	**TM7846**	**88.8500**	**87.2480**	**0.983**	**2.159**
7843	**TM7843**	**88.8500**	**87.2280**	**0.983**	**2.179**
7837	TM7837	88.8500	87.2990	0.316	1.665
7834	TM7834	88.8500	87.2970	0.316	1.667
7724	TM7724	88.8500	87.2980	0.278	1.450
7700	TM7700	88.8480	87.0520	0.403	1.925
7640	TM7640	88.8470	87.0070	0.307	1.434
7524	TM7524	88.8420	86.6300	0.544	2.082
7324	TM7324	88.8340	86.2410	0.330	1.619
7170	TM7170	88.8260	85.9470	0.644	1.756
7122	TM7122	88.8230	85.8430	0.398	1.805
6958	TM6958	88.8100	85.5350	0.448	1.739
6957	TM6957	88.8100	85.5210	0.449	1.750
6947	TM6947	88.8100	85.4380	0.828	2.060
6942	TM6942	88.8100	85.4130	0.828	2.083
6930	TM6930	88.8090	85.4260	0.767	1.873
6910	TM6910	88.8090	85.3200	1.150	1.969
6888	TM6888	88.8070	85.3180	0.395	1.732
6886	TM6886	88.8070	85.2690	0.419	1.770
6724	TM6724	88.7900	85.0290	0.406	1.595
6641	TM6641	88.7890	84.9540	0.571	1.415
6620	TM6620	88.7890	84.9010	0.654	1.448
6524	TM6524	88.7890	84.8390	0.315	1.186
6324	TM6324	88.7850	84.6810	0.346	1.163
6166	TM6166	88.7820	84.4980	0.266	1.468
6024	TM6024	88.7790	84.3110	0.296	1.524
5924	TM5924	88.7770	84.1700	0.294	1.503
5724	TM5724	88.7700	83.8910	0.318	1.494
5524	TM5524	88.7590	83.6020	0.322	1.491
5324	TM5324	88.7450	83.2780	0.340	1.555
5124	TM5124	88.7260	82.9300	0.371	1.586
4924	TM4924	88.7200	82.5580	0.544	1.681
4871	TM4871	88.7200	82.5960	0.332	0.945
4866	TM4866	88.7200	82.5900	0.340	0.947
4724	TM4724	88.7180	82.4080	0.289	1.490
4524	TM4524	88.7140	82.1950	0.271	1.425
4324	TM4324	88.7090	81.9430	0.298	1.518
4177	TM4177	88.7040	81.8430	0.218	1.141
4138	TM4138	88.7010	81.8250	0.190	0.955
4115	TM4115	88.7010	81.7350	0.200	0.989

TABLE A9 CONTINUED

4097	TM4097	88.7000	81.7080	0.244	1.125
3924	TM3924	88.6940	81.4090	0.368	1.561
3684	TM3684	88.6970	81.0130	0.442	1.494
3524	TM3524	88.6960	80.8380	0.338	1.347
3324	TM3324	88.6910	80.6200	0.352	1.405
3124	TM3124	88.6830	80.4450	0.307	1.260
2924	TM2924	88.6740	80.1500	0.410	1.659
2724	TM2724	88.6590	80.0300	0.280	1.000
2524	TM2524	88.6360	79.8560	0.382	1.091
2324	TM2324	88.6130	79.6350	0.342	1.262
2124	TM2124	88.5860	79.4550	0.348	1.111
1924	TM1924	88.5720	79.2920	0.336	1.101
1840	TM1840	88.5680	79.1670	0.404	1.402
1835	TM1835	88.5680	79.1650	0.415	1.402
1724	TM1724	88.5610	79.0930	0.445	1.382
1606	TM1606	88.5490	79.0440	0.298	0.942
1582	TM1582	88.5490	78.9830	0.307	0.957
1528	TM1528	88.5440	78.7920	0.678	1.811
1484	TM1484	88.5420	78.8380	0.344	1.133
1470	TM1470	88.5420	78.7310	0.439	1.181
1327	TM1327	88.5320	78.5530	0.420	1.561
1127	TM1127	88.5160	78.2830	0.361	1.584
922	TM922	88.5030	77.8420	0.427	2.135
916	TM916	88.5030	77.7140	0.433	2.245
728	TM728	88.4950	77.4750	0.413	1.598
516	TM516	88.4950	77.0130	0.389	2.007
511	TM511	88.4950	76.9780	0.396	2.032
480	TM480	88.4960	76.9360	0.467	1.918
400	TM328	88.4980	76.7680	0.395	1.360
390	TM128	88.4990	76.3500	0.553	1.748
380	TM78	88.4980	76.2660	0.600	1.764
370	TM5	88.4960	76.2140	0.343	1.115
360	TM0	88.4960	76.0180	0.532	1.242
350	TL30121	88.4860	75.6610	0.561	1.653
340	TL29919	88.4710	75.2350	0.609	1.728
330	TL29734	88.4420	75.1940	0.374	0.944
320	TL29544	88.4020	74.9190	0.583	1.555
310	TL29421	88.3830	74.7390	0.635	1.627
300	TL29301	88.3390	74.6680	0.791	1.590
290	TL29211	88.3110	74.4840	0.542	1.373
280	TL29185	88.3110	74.3980	0.547	1.413
270	TL29100	88.2960	74.3440	0.468	1.288
260	TL29091	88.2960	74.2790	0.489	1.312
250	TL29000	88.2800	74.1190	0.390	1.383
240	TL28910	88.2670	74.0370	0.497	1.189
230	TL28901	88.2670	73.9900	0.557	1.227
220	TL28590	88.2690	73.9070	0.355	1.171
210	TL28500	88.2700	73.5420	0.388	1.524
200	TL28490	88.2700	73.5560	0.345	1.357

TABLE A9 CONTINUED

190	TL28480	88.2700	73.5000	0.363	1.399
180	TL28000	88.2520	72.8700	0.411	1.407
170	TL27900	88.2460	72.7640	0.332	1.294
160	TL27896	88.2460	72.7200	0.344	1.326
150	TL27770	88.2370	72.5820	0.301	1.354
140	TL27768	88.2370	72.5450	0.308	1.378
130	TL27500	88.2170	72.1050	0.427	1.649
120	TL27020	88.1930	71.7560	0.703	1.392
110	TL27011	88.1930	71.7210	0.922	1.416
100	TL27000	88.1920	71.7280	0.408	1.377
90	TL26799	88.1950	71.5310	0.333	1.266
80	TL26794	88.1950	71.4930	0.339	1.291
70	TL26750	88.1970	71.4520	0.367	1.358
60	TL26741	88.1970	71.3750	0.384	1.414
50	TL26500	88.1990	71.1240	0.913	1.737
40	TL26460	88.1990	71.0920	0.393	1.500
30	TL26459	88.1990	71.0110	0.412	1.550
20	TL26450	88.1990	71.0240	0.351	1.369
10	TL26445	88.1990	70.9620	0.363	1.412
0	TL26180	88.1990	70.5650	0.606	2.035

TABLE A10: MAXIMUM OF ALL VARIABLES CASE 3, ISIS, RUN TIME STEP 20SEC.

Label (HEC-RAS)	Label	Flow	Stage	Froude no	Velocity
25144	TM24413	104.999	111.490	0.227	1.077
25045	TM24314	104.987	111.143	0.491	1.961
24940	TM24940	104.964	111.016	0.503	1.253
24745	TM23982	104.914	110.734	0.242	1.042
24680	TM24680	104.888	110.700	0.451	1.097
24537	TM23802	104.834	110.564	0.307	0.897
24457	TM24457	104.789	110.548	0.547	1.205
24398	TM23692	104.783	110.451	0.328	1.184
24370	TM23664	104.783	110.414	0.363	1.203
24190	TM24190	104.768	110.287	0.385	0.969
24159	TM23454	104.765	110.237	0.219	0.972
24148	TM23443	104.764	110.228	0.220	0.976
24038	TM23333	104.752	110.176	0.332	0.833
23990	TM23990	104.745	110.121	0.404	1.077
23890	TM23890	104.727	110.025	0.478	1.170
23720	TM23720	104.690	109.808	0.406	1.046
23585	TM23585	104.661	109.682	0.464	1.230
23494	TM22795	104.663	109.297	0.457	1.922
23465	TM22768	104.663	109.149	0.534	2.063
23400	TM23400	104.662	109.128	0.448	1.083
23355	TM22660	104.661	109.092	0.373	0.950
23345	TM22650	104.661	109.086	0.382	0.953
23135	TM23135	104.646	108.942	0.282	0.722

TABLE A10 CONTINUED

23050	TM22381	104.643	108.798	0.387	1.291
23044	TM22375	104.642	108.786	0.372	1.300
23024	TM22355	104.642	108.687	0.430	1.630
22996	TM22327	104.640	108.598	0.498	1.694
22790	TM22790	104.631	108.088	0.348	1.528
22667	TM22005	104.623	107.903	0.271	1.285
22653	TM21991	104.622	107.880	0.274	1.297
22500	TM22500	104.597	107.793	0.278	0.674
22402	TM21770	104.586	107.737	0.220	0.785
22396	TM21764	104.586	107.733	0.219	0.787
223000	TM22300	104.583	107.717	0.430	0.941
22137	TM21516	104.582	107.432	0.468	1.239
22104	TM21466	104.579	107.245	0.531	1.470
22066	TM21428	104.576	107.015	0.769	1.948
21925	TM21925	104.560	106.732	0.581	1.228
21831	TM21219	104.551	106.374	0.436	1.965
21820	TM21208	104.551	106.319	0.451	2.014
21700	TM21700	104.536	106.079	0.557	1.296
21539	TM20928	104.494	105.635	0.411	1.435
21532	TM20921	104.493	105.613	0.421	1.460
21518	TM20907	104.490	105.418	0.530	2.202
21493	TM20882	104.484	105.148	0.717	2.728
21460	TM21460	104.423	105.355	0.505	1.003
21260	TM21260	103.709	105.221	0.720	1.227
21060	TM21060	103.132	105.163	0.471	0.947
20698	TM20160	102.866	104.620	0.343	1.631
20675	TM20137	102.864	104.559	0.413	1.667
20470	TM20500	102.824	104.364	0.301	1.013
20273	TM20300	102.788	104.141	0.267	1.269
20203	TM19962	102.777	104.027	0.324	1.326
20124	TM20175	102.772	103.925	0.384	1.664
20080	TM20170	102.772	103.913	0.385	1.671
20000	TM20000	102.749	103.669	0.303	1.431
19900	TM19900	102.733	103.540	0.294	1.396
19700	TM19700	102.686	103.309	0.294	1.226
19500	TM19500	102.624	103.070	0.294	1.254
19300	TM19300	102.541	102.879	0.264	1.134
19100	TM19100	102.444	102.700	0.253	1.126
18900	TM18900	102.350	102.605	0.304	0.768
18700	TM18700	102.219	102.395	0.354	1.211
18500	TM18500	102.047	102.262	0.226	0.823
18300	TM18300	101.750	102.170	0.363	0.898
18200	TM18200	101.603	102.154	0.529	1.305
18100	TM18100	101.393	102.140	0.404	0.858
17900	TM17900	101.123	102.091	0.435	1.009
17800	TM17800	101.084	101.958	0.352	1.156
17700	TM17700	101.062	101.896	0.242	0.929
17600	TM17600	101.041	101.813	0.228	1.050
17550	TM17550	101.027	101.785	0.268	0.966

TABLE A10 CONTINUED

17520	TM17520	101.021	101.710	0.250	1.315
17515	TM17515	101.020	101.704	0.251	1.318
17400	TM17400	101.004	101.378	0.401	1.943
17300	TM17300	100.981	101.345	0.414	1.172
17200	TM17200	100.953	101.204	0.339	1.255
17146	TM17146	100.937	101.142	0.400	1.248
17138	TM17138	100.935	101.122	0.408	1.274
17132	TM17132	100.935	101.117	0.284	1.177
17117	TM17117	100.934	101.101	0.289	1.184
17000	TM17000	100.928	100.961	0.333	1.259
16800	TM16800	100.917	100.699	0.280	1.366
16593	TM16593	100.895	100.433	0.290	1.342
16583	TM16583	100.894	100.418	0.293	1.350
16300	TM16300	100.849	100.084	0.269	1.222
16250	TM16250	100.839	100.020	0.269	1.268
16248	TM16248	100.838	100.017	0.270	1.269
16000	TM16000	100.770	99.7690	0.290	1.115
15900	TM15900	100.740	99.6350	0.331	1.274
15850	TM15850	100.724	99.5450	0.334	1.386
15780	TM15780	100.696	99.4830	0.310	1.196
15775	TM15775	100.694	99.4780	0.307	1.182
15700	TM15700	100.666	99.3910	0.331	1.141
15400	TM15400	100.600	99.1380	0.259	0.938
15100	TM15100	100.496	98.7870	0.422	1.412
14509	TM14509	100.471	98.6420	0.338	1.385
14501	TM14501	100.469	98.6370	0.366	1.353
14383	TM14383	100.439	98.5150	0.238	1.213
14183	TM14183	100.426	98.3550	0.222	1.138
14077	TM14077	100.427	98.3100	0.169	0.921
14037	TM14037	100.427	98.2920	0.170	0.926
13900	TM13900	100.421	97.7330	0.362	1.883
13700	TM13700	100.413	97.2550	0.364	1.801
13500	TM13500	100.401	96.6700	0.437	2.008
13327	TM13327	100.372	96.4230	0.459	1.235
13322	TM13322	100.371	96.4150	0.561	1.240
13316	TM13316	100.369	96.4170	0.306	1.129
13164	TM13164	100.364	96.3930	0.312	1.142
12964	TM12964	100.322	95.9480	0.368	1.726
12864	TM12864	100.299	95.8880	0.273	0.989
12764	TM12764	100.276	95.7120	0.344	1.334
12621	TM12621	100.270	95.4670	0.328	1.436
12421	TM12421	100.254	95.2570	0.332	1.182
12221	TM12221	100.224	95.0170	0.297	1.264
12021	TM12021	100.189	94.7860	0.317	1.248
11821	TM11821	100.136	94.5340	0.333	1.300
11769	TM11769	100.122	94.4700	0.355	1.325
11608	TM11608	100.083	94.2220	0.312	1.508
11601	TM11590	100.080	94.1950	0.386	1.520
11600	TM11600	100.065	94.1220	0.293	1.324

TABLE A10 CONTINUED

11500	**TM11500**	**100.055**	**93.9050**	**0.324**	**1.723**
11415	TM11415	100.054	93.8350	0.300	1.356
11408	TM11408	100.054	93.8250	0.307	1.360
11300	TM11300	100.050	93.7030	0.248	1.298
11200	TM11200	100.045	93.6360	0.196	1.140
11142	TM11142	100.042	93.6420	0.172	0.811
11124	TM11124	100.040	93.6330	0.173	0.814
11000	TM11000	100.032	93.4900	0.289	1.365
10800	TM10800	100.012	93.2880	0.339	1.167
10600	TM10600	99.9850	93.0620	0.293	1.248
10400	TM10400	99.9570	92.7050	0.370	1.664
10202	TM10202	99.9240	92.4560	0.255	1.294
10189	TM10189	99.9220	92.4380	0.257	1.303
9990	TM9990	99.9010	92.4160	0.190	0.766
9978	TM9978	99.8960	92.4100	0.193	0.767
9900	TM9900	99.8710	92.3840	0.284	0.734
9790	TM9790	99.8720	92.0830	0.374	1.666
9786	TM9786	99.8720	92.0700	0.376	1.675
9600	TM9600	99.8690	91.7340	0.374	1.292
9461	TM9461	99.8560	91.4960	0.394	1.247
9458	TM9458	99.8560	91.4910	0.398	1.256
9300	TM9300	99.8360	91.1910	0.394	1.445
9098	TM9098	99.8040	90.7550	0.503	1.590
9068	TM9068	99.8000	90.6860	0.660	1.980
9050	TM9050	99.7960	90.7740	0.357	0.710
9040	TM9040	99.7920	90.7700	0.428	0.768
8944	TM8944	99.7620	90.7440	0.207	0.655
8924	TM8924	99.7570	90.7390	0.230	0.656
8834	TM8834	99.7350	90.6150	0.257	1.293
8832	TM8832	99.7350	90.612	0.257	1.294
8676	TM8676	99.7340	89.963	0.465	2.315
8620	TM8620	99.7370	89.800	0.410	2.012
8618	TM8618	99.7370	89.7890	0.412	2.021
8604	TM8604	99.7380	89.7290	0.420	2.075
8484	TM8484	99.7400	89.5970	0.229	1.232
8480	TM8480	99.7400	89.5930	0.230	1.233
8456	TM8456	99.7410	89.5000	0.323	1.590
8366	TM8366	99.7450	89.2570	0.401	1.647
8336	TM8336	99.7450	89.1850	0.420	1.579
8328	TM8328	99.7450	89.1620	0.497	1.595
8132	TM8134	99.7470	88.6540	0.337	1.752
8124	TM8124	99.7470	88.6240	0.342	1.77
8111	TM8111	99.7470	88.6510	0.308	1.421
7966	TM7966	99.7440	88.2490	0.464	1.634
7846	TM7846	99.7390	87.8290	0.551	1.910
7843	TM7843	99.7390	87.8160	0.637	1.919
7837	TM7837	99.7390	87.8480	0.273	1.564
7834	TM7834	99.7380	87.8430	0.274	1.566
7724	TM7724	99.7370	87.8370	0.245	1.349

TABLE A10 CONTINUED

7700	TM7700	99.7330	87.5850	0.345	1.756
7640	TM7640	99.7280	87.5100	0.259	1.311
7524	TM7524	99.7190	87.1760	0.431	1.825
7324	TM7324	99.7000	86.7590	0.278	1.501
7170	TM7170	99.6800	86.4490	0.493	1.617
7122	TM7122	99.6730	86.3400	0.326	1.662
6958	TM6958	99.6480	86.0050	0.347	1.623
6957	TM6957	99.6480	86.0030	0.349	1.624
6947	TM6947	99.6460	85.9300	0.446	1.897
6942	TM6942	99.6450	85.9130	0.497	1.908
6930	TM6930	99.6430	85.9150	0.413	1.734
6910	TM6910	99.6400	85.8640	0.918	1.767
6888	TM6888	99.6350	85.8500	0.320	1.583
6886	TM6886	99.6350	85.8460	0.322	1.585
6724	TM6724	99.6170	85.6090	0.334	1.386
6641	TM6641	99.6150	85.5200	0.334	1.272
6620	TM6620	99.6130	85.4950	0.517	1.283
6524	TM6524	99.6080	85.4330	0.262	1.012
6324	TM6324	99.5880	85.2830	0.267	1.003
6166	TM6166	99.5750	85.0880	0.233	1.376
6024	TM6024	99.5640	84.8910	0.252	1.399
5924	TM5924	99.5530	84.7470	0.269	1.350
5724	TM5724	99.5220	84.4640	0.282	1.300
5524	TM5524	99.4800	84.1660	0.290	1.308
5324	TM5324	99.4280	83.8370	0.307	1.359
5124	TM5124	99.4250	83.4920	0.319	1.358
4924	TM4924	99.4070	83.1480	0.424	1.411
4871	TM4871	99.4010	83.1470	0.240	0.875
4866	TM4866	99.4010	83.1440	0.253	0.876
4724	TM4724	99.3840	82.9600	0.278	1.375
4524	TM4524	99.3600	82.7090	0.265	1.340
4324	TM4324	99.3330	82.4110	0.262	1.445
4177	TM4177	99.3060	82.2750	0.226	1.082
4138	TM4138	99.2920	82.2450	0.170	0.924
4115	TM4115	99.2870	82.2300	0.172	0.928
4097	TM4097	99.2830	82.2060	0.206	1.032
3924	TM3924	99.2380	81.9250	0.316	1.344
3684	TM3684	99.2270	81.5140	0.350	1.336
3524	TM3524	99.2130	81.3240	0.284	1.200
3324	TM3324	99.1800	81.1060	0.309	1.189
3124	TM3124	99.1300	80.9120	0.281	1.116
2924	TM2924	99.0690	80.6370	0.381	1.403
2724	TM2724	98.9900	80.4720	0.234	0.894
2524	TM2524	98.9550	80.2960	0.304	0.953
2324	TM2324	98.9210	80.0690	0.285	1.123
2124	TM2124	98.8730	79.8660	0.287	1.002
1924	TM1924	98.8010	79.6840	0.287	0.932
1840	TM1840	98.7620	79.5700	0.324	1.214
1835	TM1835	98.7590	79.5630	0.333	1.222

TABLE A10 CONTINUED

1724	TM1724	98.6980	79.4750	0.377	1.173
1606	TM1606	98.6800	79.4140	0.238	0.821
1582	TM1582	98.6800	79.4030	0.256	0.830
1528	TM1528	98.6780	79.2300	0.540	1.627
1484	TM1484	98.6770	79.2430	0.290	1.090
1470	TM1470	98.6760	79.2300	0.353	1.095
1327	TM1327	98.6700	79.0610	0.350	1.299
1127	TM1127	98.6570	78.7800	0.318	1.382
922	TM922	98.6430	78.2580	0.423	2.019
916	TM916	98.6420	78.2380	0.426	2.038
728	TM728	98.6250	77.9520	0.343	1.380
516	TM516	98.6060	77.3790	0.371	1.972
511	TM511	98.6060	77.3630	0.373	1.983
480	TM480	98.6040	77.3200	0.406	1.780
400	TM328	98.5830	77.0830	0.331	1.246
390	TM128	98.5700	76.5880	0.473	1.556
380	TM78	98.5730	76.4570	0.534	1.581
370	TM5	98.5770	76.3400	0.370	1.162
360	TM0	98.5770	76.3330	0.418	1.166
350	TL30121	98.5750	75.9690	0.472	1.369
340	TL29919	98.4990	75.5630	0.584	1.452
330	TL29734	98.2790	75.4180	0.313	0.787
320	TL29544	98.1340	75.2050	0.494	1.305
310	TL29421	98.0220	75.0500	0.542	1.360
300	TL29301	97.8390	74.9580	0.571	1.272
290	TL29211	97.8100	74.7920	0.352	1.164
280	TL29185	97.8070	74.7430	0.422	1.211
270	TL29100	97.7930	74.6710	0.406	1.063
260	TL29091	97.7910	74.6630	0.401	1.086
250	TL29000	97.7760	74.5170	0.330	1.206
240	TL28910	97.7570	74.4250	0.351	1.035
230	TL28901	97.7550	74.4140	0.442	1.043
220	TL28590	97.7320	74.3290	0.273	1.000
210	TL28500	97.6530	73.9370	0.339	1.381
200	TL28490	97.6500	73.9410	0.296	1.247
190	TL28480	97.6480	73.9260	0.298	1.255
180	TL28000	97.6270	73.2450	0.348	1.264
170	TL27900	97.6240	73.1180	0.288	1.199
160	TL27896	97.6240	73.1130	0.290	1.202
150	TL27770	97.6200	72.9490	0.265	1.278
140	TL27768	97.6200	72.9470	0.266	1.279
130	TL27500	97.6020	72.4680	0.358	1.501
120	TL27020	97.5780	72.0140	0.370	1.372
110	TL27011	97.5770	72.0010	0.544	1.380
100	TL27000	97.5760	72.0060	0.357	1.225
90	TL26799	97.5460	71.7250	0.314	1.239
80	TL26794	97.5450	71.7170	0.316	1.244
70	TL26750	97.5390	71.6590	0.343	1.232
60	TL26741	97.5370	71.6450	0.347	1.246

TABLE A10 CONTINUED					
50	TL26500	97.5190	71.2930	0.663	1.503
40	TL26460	97.5230	71.2380	0.391	1.415
30	TL26459	97.5230	71.2240	0.394	1.432
20	TL26450	97.5240	71.2320	0.332	1.259
10	TL26445	97.5240	71.2260	0.333	1.264
0	TL26180	97.5400	70.6430	0.603	2.034

TABLE A11: MAXIMUM OF ALL VARIABLES CASE 4, ISIS, RUN TIME STEP 20 SEC.

Label (HEC-RAS)	Label	Flow	Stage	Froude no	Velocity
25144	TM24413	104.999	111.805	0.215	0.981
25052	TM24321	104.968	111.642	0.449	1.707
25045	TM24314	104.968	111.144	0.492	1.968
24940	TM24940	104.940	111.018	0.507	1.256
24745	TM23982	104.866	110.738	0.244	1.040
24680	TM24680	104.836	110.705	0.457	1.118
24537	TM23802	104.759	110.570	0.315	0.896
24457	TM24457	104.715	110.555	0.563	1.239
24398	TM23692	104.702	110.460	0.347	1.180
24370	TM23664	104.702	110.433	0.360	1.194
24190	TM24190	104.652	110.313	0.402	0.968
24159	TM23454	104.640	110.264	0.217	0.962
24148	TM23443	104.640	110.248	0.219	0.968
24038	TM23333	104.606	110.198	0.335	0.845
23990	TM23990	104.586	110.146	0.405	1.084
23890	TM23890	104.531	110.056	0.482	1.185
23720	TM23720	104.424	109.855	0.418	1.074
23585	TM23585	104.364	109.744	0.484	1.288
23494	TM22795	104.320	109.403	0.524	1.859
23465	TM22768	104.320	109.340	0.524	1.912
23400	TM23400	104.298	109.333	0.430	1.100
23355	TM22660	104.277	109.308	0.337	0.875
23345	TM22650	104.277	109.274	0.379	0.898
23135	TM23135	104.175	109.168	0.284	0.713
23050	TM22381	104.152	109.056	0.362	1.148
23044	TM22375	104.152	109.047	0.403	1.155
23024	TM22355	104.147	108.965	0.447	1.464
22996	TM22327	104.147	108.951	0.489	1.473
22790	TM22790	104.108	108.680	0.283	1.208
22667	TM22005	104.077	108.596	0.220	0.998
22653	TM21991	104.077	108.049	0.255	1.218
22500	TM22500	103.983	107.987	0.270	0.651
22402	TM21770	103.940	107.946	0.217	0.717
22396	TM21764	103.940	107.915	0.223	0.732
223000	TM22300	103.871	107.906	0.423	0.944
22137	TM21516	103.736	107.733	0.466	1.188
22104	TM21466	103.721	107.648	0.507	1.387
22066	TM21428	103.711	107.561	0.758	1.886

TABLE A11 CONTINUED					
21925	TM21925	103.648	107.479	0.496	1.141
21831	TM21219	103.619	107.340	0.294	1.339
21820	TM21208	103.619	106.433	0.429	1.908
21700	TM21700	103.575	106.270	0.556	1.318
21539	TM20928	103.458	106.022	0.430	1.415
21532	TM20921	103.458	105.536	0.514	1.686
21518	TM20907	103.447	105.338	0.670	2.575
21493	TM20882	103.447	105.286	0.695	2.638
21460	TM21460	103.342	105.458	0.502	1.007
21260	TM21260	102.187	105.369	0.731	1.235
21060	TM21060	101.159	105.333	0.473	0.944
20698	TM20160	100.439	104.956	0.395	1.435
20675	TM20137	100.439	104.815	0.409	1.497
20470	TM20500	100.345	104.695	0.285	0.897
20273	TM20300	100.205	104.556	0.230	1.077
20203	TM19962	100.126	104.504	0.270	1.110
20124	TM20175	100.102	104.441	0.305	1.364
20080	TM20170	100.102	104.008	0.370	1.621
20000	TM20000	99.9510	103.811	0.306	1.380
19900	TM19900	99.8510	103.710	0.291	1.344
19700	TM19700	99.6020	103.550	0.288	1.196
19500	TM19500	99.3090	103.398	0.282	1.203
19300	TM19300	98.9520	103.293	0.249	1.079
19100	TM19100	98.5230	103.201	0.236	1.052
18900	TM18900	97.9080	103.159	0.303	0.772
18700	TM18700	97.1290	103.080	0.339	1.163
18500	TM18500	96.1900	103.038	0.213	0.767
18300	TM18300	94.7440	103.015	0.347	0.873
18200	TM18200	93.8720	103.012	0.529	1.295
18100	TM18100	92.8600	103.009	0.394	0.843
17900	TM17900	91.4500	102.998	0.390	0.963
17800	TM17800	91.1540	102.952	0.314	1.027
17700	TM17700	91.0750	102.935	0.220	0.748
17600	TM17600	91.0010	102.906	0.208	0.749
17550	TM17550	90.9610	102.905	0.243	0.797
17520	TM17520	90.9390	102.872	0.230	0.918
17515	TM17515	90.9390	102.089	0.250	1.125
17400	TM17400	90.8800	101.926	0.359	1.649
17300	TM17300	90.8030	101.924	0.424	1.193
17200	TM17200	90.7100	101.862	0.342	1.118
17146	TM17146	90.6850	101.842	0.386	1.256
17138	TM17138	90.6850	101.498	0.389	1.256
17132	TM17132	90.6810	101.494	0.282	1.037
17117	TM17117	90.6810	101.277	0.287	1.050
17000	TM17000	90.6310	101.19	0.325	1.208
16800	TM16800	90.5390	101.029	0.271	1.156
16593	TM16593	90.4410	100.890	0.277	1.121
16583	TM16583	90.4410	100.500	0.286	1.192
16300	TM16300	90.3030	100.267	0.244	1.043

TABLE A11 CONTINUED

16250	TM16250	90.2920	100.228	0.245	1.068
16248	TM16248	90.2920	100.069	0.248	1.119
16000	TM16000	90.2250	99.8950	0.265	0.970
15900	TM15900	90.1930	99.8050	0.294	1.075
15850	TM15850	90.1780	99.7480	0.289	1.154
15780	TM15780	90.1490	99.7150	0.260	1.003
15775	TM15775	90.1490	99.3510	0.298	1.150
15700	TM15700	90.1060	99.2690	0.328	1.126
15400	TM15400	89.9130	99.0390	0.256	0.923
15100	TM15100	89.7930	98.7380	0.427	1.410
14509	TM14509	89.7640	98.6210	0.364	1.316
14501	TM14501	89.7640	98.6210	0.368	1.289
14383	TM14383	89.7230	98.5260	0.221	1.095
14183	TM14183	89.6550	98.4020	0.206	1.012
14077	TM14077	89.6260	98.3690	0.155	0.810
14037	TM14037	89.6260	98.1660	0.161	0.863
13900	TM13900	89.6040	97.7080	0.348	1.699
13700	TM13700	89.5820	97.3530	0.348	1.563
13500	TM13500	89.5420	97.0100	0.377	1.660
13327	TM13327	89.4680	96.9040	0.368	1.086
13322	TM13322	89.4680	96.3020	0.677	1.221
13316	TM13316	89.4630	96.3050	0.308	1.096
13164	TM13164	89.4630	96.2380	0.310	1.117
12964	TM12964	89.3760	95.8630	0.351	1.618
12864	TM12864	89.3240	95.8120	0.274	0.930
12764	TM12764	89.2560	95.6700	0.343	1.295
12621	TM12621	89.1840	95.4820	0.320	1.366
12421	TM12421	89.0410	95.3310	0.327	1.165
12221	TM12221	88.8510	95.1730	0.294	1.176
12021	TM12021	88.6060	95.0390	0.279	1.178
11821	TM11821	88.3100	94.9100	0.317	1.232
11769	TM11769	88.2300	94.8800	0.331	1.257
11608	TM11608	88.0300	94.7520	0.385	1.276
11601	TM11590	88.0300	94.6300	0.386	1.284
11600	TM11600	87.9580	94.5950	0.292	1.118
11500	TM11500	87.8640	94.4890	0.295	1.428
11415	TM11415	87.8820	94.4610	0.302	1.117
11408	TM11408	87.8820	94.1100	0.304	1.179
11300	TM11300	87.9270	94.0460	0.231	1.115
11200	TM11200	87.9690	94.0100	0.190	0.964
11142	TM11142	87.9940	94.01600	0.168	0.692
11124	TM11124	87.9940	93.7570	0.170	0.739
11000	TM11000	88.0430	93.6680	0.265	1.259
10800	TM10800	88.1570	93.5530	0.327	1.107
10600	TM10600	88.2840	93.4310	0.289	1.138
10400	TM10400	88.4010	93.2650	0.320	1.462
10202	TM10202	88.5390	93.1640	0.247	1.110
10189	TM10189	88.5390	92.9990	0.252	1.125
9990	TM9990	88.7900	92.9930	0.194	0.665

TABLE A11 CONTINUED

9978	TM9978	88.7900	92.9850	0.196	0.668
9900	TM9900	89.8820	92.9750	0.290	0.735
9790	TM9790	91.1930	92.8730	0.309	1.433
9786	TM9786	91.1930	92.6300	0.310	1.433
9600	TM9600	92.5910	92.5290	0.388	1.196
9461	TM9461	93.9660	92.5250	0.394	1.234
9458	TM9458	93.9660	92.5050	0.394	1.237
9300	TM9300	94.9990	92.5040	0.398	1.349
9098	TM9098	95.9530	92.5100	0.665	1.885
9068	TM9068	95.9530	92.4930	0.665	1.885
9050	TM9050	96.0290	92.4970	0.360	0.741
9040	TM9040	96.0290	92.4550	0.361	0.743
8944	TM8944	95.8520	92.4580	0.158	0.482
8924	TM8924	95.8520	92.5150	0.230	0.500
8834	**TM8834**	**95.2240**	**92.4960**	**0.273**	**1.465**
8832	TM8832	95.2240	91.0160	0.381	1.972
8676	TM8676	94.4820	90.7820	0.371	1.793
8620	TM8620	94.1330	90.7350	0.378	1.556
8618	TM8618	94.1330	90.7350	0.378	1.558
8604	TM8604	94.0380	90.7190	0.366	1.573
8484	TM8484	92.9890	90.6820	0.183	0.878
8480	TM8480	92.9890	89.9880	0.194	1.018
8456	TM8456	92.7930	89.9370	0.304	1.276
8366	TM8366	91.9230	89.8420	0.408	1.357
8336	TM8336	91.5780	89.8120	0.444	1.212
8328	TM8328	91.5780	88.9920	0.498	1.593
8132	TM8134	91.3300	88.4760	0.345	1.744
8124	TM8124	91.3300	88.4760	0.345	1.744
8111	TM8111	91.3290	88.4960	0.321	1.437
7966	TM7966	91.2800	88.0790	0.467	1.681
7846	TM7846	91.2090	87.6560	0.634	1.922
7843	TM7843	91.2090	87.6340	0.634	1.939
7837	TM7837	91.2010	87.6650	0.282	1.527
7834	TM7834	91.2010	87.6650	0.282	1.528
7724	TM7724	91.1820	87.6570	0.248	1.328
7700	TM7700	91.1140	87.4200	0.353	1.732
7640	TM7640	91.0440	87.3480	0.274	1.297
7524	TM7524	90.8680	87.0190	0.431	1.828
7324	TM7324	90.5890	86.6050	0.290	1.455
7170	TM7170	90.5450	86.3090	0.502	1.570
7122	TM7122	90.5260	86.2060	0.331	1.614
6958	TM6958	90.4290	85.8910	0.371	1.570
6957	TM6957	90.4290	85.8790	0.371	1.578
6947	TM6947	90.4210	85.8130	0.577	1.843
6942	TM6942	90.4210	85.7930	0.615	1.859
6930	TM6930	90.4120	85.7930	0.629	1.687
6910	TM6910	90.4120	85.7150	0.929	1.744
6888	TM6888	90.3920	85.6990	0.328	1.556
6886	TM6886	90.3920	85.6660	0.341	1.578

TABLE A11 CONTINUED

6724	TM6724	90.1810	85.4280	0.329	1.417
6641	TM6641	90.0390	85.3400	0.471	1.272
6620	TM6620	90.0390	85.3020	0.517	1.293
6524	TM6524	89.9460	85.2360	0.262	1.043
6324	TM6324	89.8060	85.0830	0.267	1.008
6166	TM6166	89.7130	84.8980	0.228	1.316
6024	TM6024	89.6420	84.7070	0.250	1.348
5924	TM5924	89.6090	84.5630	0.269	1.323
5724	TM5724	89.5730	84.2800	0.276	1.288
5524	TM5524	89.5140	83.9850	0.274	1.291
5324	TM5324	89.4320	83.6580	0.287	1.345
5124	TM5124	89.3200	83.3140	0.302	1.351
4924	TM4924	89.2860	82.9660	0.424	1.410
4871	TM4871	89.2740	82.9680	0.250	0.836
4866	TM4866	89.2740	82.9640	0.253	0.838
4724	TM4724	89.2450	82.7910	0.243	1.315
4524	TM4524	89.2060	82.5560	0.230	1.273
4324	TM4324	89.1570	82.2840	0.253	1.355
4177	TM4177	89.1010	82.1580	0.215	1.024
4138	TM4138	89.0700	82.1310	0.163	0.862
4115	TM4115	89.0700	82.0560	0.170	0.885
4097	TM4097	89.0610	82.0330	0.204	0.991
3924	TM3924	89.0240	81.7540	0.315	1.320
3684	TM3684	88.9840	81.3500	0.346	1.291
3524	TM3524	88.9410	81.1630	0.277	1.168
3324	TM3324	88.8520	80.9450	0.307	1.182
3124	TM3124	88.7180	80.7520	0.276	1.100
2924	TM2924	88.5880	80.4890	0.372	1.373
2724	TM2724	88.4910	80.3350	0.232	0.863
2524	TM2524	88.3540	80.1690	0.302	0.900
2324	TM2324	88.1840	79.9580	0.279	1.081
2124	TM2124	88.0460	79.7760	0.285	0.957
1924	TM1924	87.9220	79.6180	0.285	0.916
1840	TM1840	87.8510	79.5200	0.328	1.163
1835	TM1835	87.8510	79.5180	0.333	1.163
1724	TM1724	87.7420	79.4440	0.377	1.146
1606	TM1606	87.6650	79.3940	0.251	0.793
1582	TM1582	87.6650	79.3150	0.256	0.802
1528	TM1528	87.6570	79.1700	0.533	1.505
1484	TM1484	87.6540	79.1790	0.301	0.995
1470	TM1470	87.6540	79.0950	0.353	1.024
1327	TM1327	87.6330	78.9410	0.343	1.274
1127	TM1127	87.5970	78.6980	0.305	1.304
922	TM922	87.5610	78.3040	0.372	1.772
916	TM916	87.5610	78.0710	0.396	1.932
728	TM728	87.5350	77.7950	0.337	1.341
516	TM516	87.5040	77.3070	0.343	1.821
511	TM511	87.5040	77.2810	0.347	1.836
480	TM480	87.5010	77.2420	0.388	1.671

TABLE A11 CONTINUED

400	TM328	87.4690	77.0460	0.325	1.176
390	TM128	87.4130	76.7150	0.456	1.430
380	TM78	87.3950	76.6500	0.494	1.441
370	TM5	87.3690	76.5860	0.301	1.010
360	TM0	87.3690	76.2130	0.418	1.101
350	TL30121	87.2910	75.8570	0.460	1.339
340	TL29919	87.0900	75.4420	0.569	1.404
330	TL29734	86.7040	75.3130	0.310	0.776
320	TL29544	86.4930	75.1000	0.473	1.269
310	TL29421	86.4020	74.9360	0.513	1.317
300	TL29301	86.2310	74.8410	0.611	1.290
290	TL29211	86.2020	74.6840	0.425	1.136
280	TL29185	86.2020	74.6350	0.427	1.162
270	TL29100	86.1940	74.5650	0.392	1.054
260	TL29091	86.1940	74.5050	0.395	1.070
250	TL29000	86.1810	74.3630	0.320	1.164
240	TL28910	86.1670	74.2720	0.413	0.999
230	TL28901	86.1670	74.2410	0.442	1.019
220	TL28590	86.1500	74.1550	0.271	0.976
210	TL28500	86.0870	73.7830	0.318	1.316
200	TL28490	86.0860	73.7880	0.286	1.179
190	TL28480	86.0860	73.7510	0.297	1.199
180	TL28000	86.0350	73.1070	0.340	1.197
170	TL27900	86.0360	72.9890	0.277	1.124
160	TL27896	86.0360	72.9600	0.283	1.141
150	TL27770	86.0350	72.8100	0.254	1.193
140	TL27768	86.0350	72.7850	0.258	1.206
130	TL27500	86.0230	72.3350	0.350	1.419
120	TL27020	86.0020	71.9310	0.487	1.254
110	TL27011	86.0020	71.9050	0.546	1.268
100	TL27000	86.0000	71.9080	0.344	1.150
90	TL26799	85.9700	71.6690	0.290	1.124
80	TL26794	85.9700	71.6380	0.295	1.142
70	TL26750	85.9630	71.5890	0.319	1.162
60	TL26741	85.9630	71.5330	0.332	1.204
50	TL26500	85.9230	71.2230	0.666	1.424
40	TL26460	85.9250	71.1760	0.357	1.328
30	TL26459	85.9250	71.1120	0.378	1.368
20	TL26450	85.9250	71.1210	0.322	1.209
10	TL26445	85.9250	71.0720	0.332	1.257
0	TL26180	85.9470	70.5330	0.599	2.035

TABLE A12: MAXIMUM OF ALL VARIABLES, ISIS, DECREASING THE ROUGHNESS VALUES

Label (HEC-RAS)	Label	Flow	Stage	Froude no	Velocity
25144	TM24413	104.999	110.739	0.383	1.537
25045	TM24314	104.991	110.332	0.651	2.888
24940	TM24940	104.982	110.162	1.035	2.887

TABLE A12 CONTINUED

24745	TM23982	104.964	109.91	0.528	1.682
24680	TM24680	104.956	109.832	0.983	2.607
24537	TM23802	104.932	109.726	0.623	1.576
24457	TM24457	104.905	109.735	1.256	3.463
24398	TM23692	104.896	109.537	0.788	1.984
24370	TM23664	104.895	109.503	0.87	2.343
24190	TM24190	104.863	109.427	0.896	2.861
24159	TM23454	104.856	109.431	0.436	1.419
24148	TM23443	104.855	109.426	0.436	1.423
24038	TM23333	104.841	109.42	0.963	2.32
23990	TM23990	104.842	109.237	1.004	2.647
23890	TM23890	104.849	109.084	1.261	2.813
23720	TM23720	104.852	108.807	0.998	2.539
23585	TM23585	104.851	108.534	1.166	2.977
23494	TM22795	104.853	108.285	1.097	3.585
23465	TM22768	104.853	108.186	1.212	3.905
23400	TM23400	104.854	107.987	1.117	2.49
23355	TM22660	104.853	107.955	0.862	2.177
23345	TM22650	104.852	107.939	0.877	2.21
23135	TM23135	104.832	107.838	0.733	1.765
23050	TM22381	104.828	107.666	0.969	2.683
23044	TM22375	104.828	107.651	0.992	2.717
23024	TM22355	104.828	107.604	1.119	3.033
22996	TM22327	104.828	107.527	1.281	3.344
22790	TM22790	104.825	107.015	0.837	2.843
22667	TM22005	104.82	106.932	0.642	2.048
22653	TM21991	104.819	106.91	0.754	2.074
22500	TM22500	104.821	106.916	0.751	1.826
22402	TM21770	104.826	106.836	0.446	1.482
22396	TM21764	104.826	106.831	0.449	1.488
223000	TM22300	104.816	106.866	1.131	2.518
22137	TM21516	104.734	106.615	1.132	3.054
22104	TM21466	104.733	106.458	1.21	3.465
22066	TM21428	104.739	106.298	1.612	4.275
21925	TM21925	104.766	105.793	1.367	2.89
21831	TM21219	104.752	105.653	0.802	2.927
21820	TM21208	104.774	105.616	0.829	2.997
21700	TM21700	104.634	105.345	1.31	3.061
21539	TM20928	104.617	105.041	0.764	2.399
21532	TM20921	104.622	105.021	0.935	2.452
21518	TM20907	104.625	104.86	1.236	3.144
21493	TM20882	104.619	104.785	1.625	3.878
21460	TM21460	104.6	104.703	1.222	2.488
21260	TM21260	104.481	104.409	1.635	2.97
21060	TM21060	104.275	104.286	1.128	2.242
20698	TM20160	104.149	103.246	0.916	3.025
20675	TM20137	104.149	103.144	1.082	3.206
20470	TM20500	104.153	102.994	1.184	2.187
20273	TM20300	104.154	102.741	0.521	2.369

TABLE A12 CONTINUED					
20203	TM19962	104.152	102.647	0.524	2.382
20124	TM20175	104.152	102.389	0.784	3.332
20080	TM20170	104.152	102.37	0.851	3.365
20000	TM20000	104.151	102.25	0.642	2.688
19900	TM19900	104.148	102.096	0.723	2.772
19700	TM19700	104.138	101.881	0.656	2.579
19500	TM19500	104.125	101.695	0.597	2.426
19300	TM19300	104.109	101.594	0.526	2.113
19100	TM19100	104.089	101.489	0.476	1.963
18900	TM18900	104.055	101.492	0.697	1.888
18700	TM18700	104.016	100.933	0.725	2.84
18500	TM18500	104.003	101.057	0.485	1.633
18300	TM18300	103.978	100.758	0.718	2.442
18200	TM18200	103.953	100.89	1.539	3.094
18100	TM18100	103.908	100.848	0.964	2.087
17900	TM17900	103.831	100.682	1.029	2.373
17800	TM17800	103.809	100.558	0.794	2.612
17700	TM17700	103.792	100.655	0.529	1.866
17600	TM17600	103.782	100.608	0.466	1.764
17550	TM17550	103.784	100.524	0.592	2.041
17520	TM17520	103.785	100.43	0.592	2.305
17515	TM17515	103.785	100.424	0.599	2.325
17400	TM17400	103.789	100.049	0.861	3.616
17300	TM17300	103.792	100.114	1.051	2.983
17200	TM17200	103.793	99.894	0.9	2.815
17146	TM17146	103.794	99.782	0.919	3.006
17138	TM17138	103.794	99.751	0.926	3.094
17132	TM17132	103.794	99.807	0.673	2.314
17117	TM17117	103.794	99.787	0.684	2.342
17000	TM17000	103.793	99.473	0.76	2.9
16800	TM16800	103.792	99.315	0.686	2.608
16593	TM16593	103.788	99.035	0.732	2.674
16583	TM16583	103.787	99.008	0.756	2.74
16300	TM16300	103.775	98.781	0.591	2.293
16250	TM16250	103.773	98.725	0.627	2.322
16248	TM16248	103.773	98.722	0.64	2.327
16000	TM16000	103.754	98.49	0.642	2.327
15900	TM15900	103.746	98.211	0.75	2.85
15850	TM15850	103.743	98.083	0.79	3.041
15780	TM15780	103.738	98.059	0.666	2.663
15775	TM15775	103.737	98.07	0.645	2.601
15700	TM15700	103.731	97.911	0.776	2.771
15400	TM15400	103.692	97.772	0.586	2.079
15100	TM15100	103.692	97.135	1.048	3.574
14509	TM14509	103.693	96.943	0.956	3.17
14501	TM14501	103.693	96.919	1.065	3.194
14383	TM14383	103.693	96.936	0.529	2.392
14183	TM14183	103.689	96.809	0.466	2.173
14077	TM14077	103.686	96.851	0.339	1.631

TABLE A12 CONTINUED					
14037	TM14037	103.685	96.834	0.342	1.644
13900	TM13900	103.681	96.3	0.849	3.524
13700	TM13700	103.682	95.868	0.85	3.451
13500	TM13500	103.681	95.411	0.89	3.691
13327	TM13327	103.679	95.081	1.264	2.704
13322	TM13322	103.679	95.062	1.584	2.737
13316	TM13316	103.679	95.15	0.697	2.409
13164	TM13164	103.678	95.11	0.727	2.508
12964	TM12964	103.672	94.583	0.976	3.196
12864	TM12864	103.667	94.742	0.605	1.936
12764	TM12764	103.662	94.306	0.673	2.904
12621	TM12621	103.656	94.031	0.789	2.989
12421	TM12421	103.645	93.851	0.64	2.635
12221	TM12221	103.628	93.623	0.695	2.591
12021	TM12021	103.609	93.383	0.642	2.566
11821	TM11821	103.615	93.045	0.738	2.761
11769	TM11769	103.616	92.906	0.819	2.939
11608	TM11608	103.619	92.696	0.803	2.823
11601	TM11590	103.619	92.645	1.065	2.901
11600	TM11600	103.62	92.695	0.712	2.37
11500	TM11500	103.619	92.254	0.895	3.316
11415	TM11415	103.618	92.383	0.726	2.614
11408	TM11408	103.618	92.371	0.754	2.646
11300	TM11300	103.615	92.307	0.59	2.287
11200	TM11200	103.612	92.354	0.437	1.805
11142	TM11142	103.611	92.413	0.409	1.35
11124	TM11124	103.61	92.404	0.415	1.355
11000	TM11000	103.607	92.163	0.471	2.321
10800	TM10800	103.597	91.954	0.8	2.727
10600	TM10600	103.583	91.767	0.644	2.458
10400	TM10400	103.572	91.413	0.649	2.931
10202	TM10202	103.56	91.438	0.628	2.088
10189	TM10189	103.559	91.425	0.808	2.102
9990	TM9990	103.55	91.53	0.447	1.188
9978	TM9978	103.548	91.526	0.451	1.191
9900	TM9900	103.529	91.517	0.608	1.587
9790	TM9790	103.512	90.991	0.671	2.912
9786	TM9786	103.511	90.977	0.678	2.932
9600	TM9600	103.511	90.649	0.945	2.865
9461	TM9461	103.516	90.335	1.005	2.94
9458	TM9458	103.516	90.327	1.016	2.957
9300	TM9300	103.519	89.982	0.935	3.179
9098	TM9098	103.52	89.481	1.101	3.461
9068	TM9068	103.52	89.39	1.356	3.828
9050	TM9050	103.52	89.524	0.983	1.635
9040	TM9040	103.52	89.519	1.069	1.857
8944	TM8944	103.519	89.521	0.565	1.102
8924	TM8924	103.52	89.517	0.738	1.264
8834	TM8834	103.52	89.23	0.553	2.402

TABLE A12 CONTINUED					
8832	TM8832	103.52	89.228	0.554	2.405
8676	TM8676	103.52	88.802	0.865	3.915
8620	TM8620	103.52	88.669	1.273	3.594
8618	TM8618	103.52	88.66	1.522	3.612
8604	TM8604	103.52	88.624	1.011	3.601
8484	TM8484	103.52	88.572	0.412	1.897
8480	TM8480	103.52	88.57	0.413	1.899
8456	TM8456	103.52	88.299	0.771	2.953
8366	TM8366	103.519	88.044	0.982	3.343
8336	TM8336	103.518	87.949	1.122	3.036
8328	TM8328	103.518	87.913	1.705	3.116
8132	TM8134	103.516	87.483	0.661	2.966
8124	TM8124	103.516	87.45	0.675	3.014
8111	TM8111	103.515	87.496	0.754	2.766
7966	TM7966	103.513	86.988	1.183	3.682
7846	TM7846	103.511	86.407	1.51	4.1
7843	TM7843	103.511	86.39	2.04	4.152
7837	TM7837	103.511	86.521	0.59	2.667
7834	TM7834	103.511	86.516	0.592	2.674
7724	TM7724	103.511	86.593	0.491	2.253
7700	TM7700	103.509	86.254	0.81	3.322
7640	TM7640	103.507	86.288	0.581	2.402
7524	TM7524	103.504	86.012	1.058	3.541
7324	TM7324	103.497	85.61	0.61	2.53
7170	TM7170	103.492	85.229	1.277	2.962
7122	TM7122	103.49	85.079	0.818	3.161
6958	TM6958	103.483	84.619	0.916	3.334
6957	TM6957	103.483	84.616	0.92	3.341
6947	TM6947	103.482	84.58	1.142	3.862
6942	TM6942	103.482	84.56	1.221	3.919
6930	TM6930	103.481	84.514	1.097	3.592
6910	TM6910	103.481	84.438	2.27	3.797
6888	TM6888	103.48	84.382	0.8	3.281
6886	TM6886	103.48	84.374	0.804	3.295
6724	TM6724	103.475	84.046	0.72	3.285
6641	TM6641	103.47	84.115	0.857	2.605
6620	TM6620	103.468	84.036	1.295	2.756
6524	TM6524	103.455	84.076	0.615	2.097
6324	TM6324	103.462	83.917	1.015	2.082
6166	TM6166	103.467	83.751	0.464	2.246
6024	TM6024	103.47	83.54	0.58	2.477
5924	TM5924	103.472	83.413	0.562	2.441
5724	TM5724	103.474	83.162	0.548	2.404
5524	TM5524	103.476	82.887	0.561	2.445
5324	TM5324	103.477	82.565	0.602	2.557
5124	TM5124	103.477	82.206	0.632	2.648
4924	TM4924	103.474	81.709	1.083	3.046
4871	TM4871	103.473	81.92	0.659	1.472
4866	TM4866	103.473	81.918	0.788	1.474

TABLE A12 CONTINUED

4724	TM4724	103.466	81.613	0.567	2.453
4524	TM4524	103.459	81.455	0.51	2.25
4324	TM4324	103.45	81.187	0.569	2.468
4177	TM4177	103.443	81.216	0.474	1.714
4138	TM4138	103.438	81.234	0.334	1.43
4115	TM4115	103.436	81.224	0.344	1.437
4097	TM4097	103.434	81.172	0.423	1.689
3924	TM3924	103.425	80.738	0.697	2.609
3684	TM3684	103.406	80.287	0.875	2.664
3524	TM3524	103.406	80.129	0.649	2.431
3324	TM3324	103.411	79.902	0.628	2.475
3124	TM3124	103.416	79.798	0.576	2.125
2924	TM2924	103.416	79.35	0.679	2.945
2724	TM2724	103.411	79.455	0.507	1.682
2524	TM2524	103.403	79.243	0.751	2.029
2324	TM2324	103.392	78.948	0.663	2.281
2124	TM2124	103.377	78.819	0.684	1.952
1924	TM1924	103.359	78.654	0.596	1.894
1840	TM1840	103.351	78.318	0.799	2.744
1835	TM1835	103.35	78.297	0.827	2.786
1724	TM1724	103.334	78.218	0.828	2.818
1606	TM1606	103.303	78.284	0.554	1.658
1582	TM1582	103.296	78.27	0.633	1.686
1528	TM1528	103.3	77.891	1.183	3.368
1484	TM1484	103.303	78.051	0.798	1.824
1470	TM1470	103.304	78.042	0.95	1.887
1327	TM1327	103.312	77.633	0.683	2.987
1127	TM1127	103.319	77.499	0.539	2.565
922	TM922	103.323	76.874	0.738	3.562
916	TM916	103.323	76.846	0.751	3.604
728	TM728	103.325	76.71	0.763	2.968
516	TM516	103.327	76.381	0.635	3.001
511	TM511	103.327	76.369	0.64	3.016
480	TM480	103.327	76.314	0.892	3.199
400	TM328	103.328	76.073	0.704	2.504
390	TM128	103.326	75.659	0.976	3.408
380	TM78	103.326	75.515	1.085	3.454
370	TM5	103.324	75.341	0.926	2.341
360	TM0	103.324	75.326	1.092	2.398
350	TL30121	103.316	74.943	0.98	3.2
340	TL29919	103.307	74.54	0.961	2.917
330	TL29734	103.293	74.661	0.389	1.598
320	TL29544	103.281	74.331	0.693	2.477
310	TL29421	103.275	74.176	0.567	2.576
300	TL29301	103.264	74.006	1.207	3.211
290	TL29211	103.256	73.842	0.858	2.483
280	TL29185	103.253	73.756	1.065	2.66
270	TL29100	103.245	73.577	1.007	2.623
260	TL29091	103.244	73.559	1.018	2.679

TABLE A12 CONTINUED					
250	TL29000	103.237	73.388	0.787	2.764
240	TL28910	103.241	73.34	0.9	2.325
230	TL28901	103.242	73.314	1.118	2.387
220	TL28590	103.246	73.3	0.863	1.987
210	TL28500	103.257	72.844	0.785	2.787
200	TL28490	103.257	72.932	0.687	2.324
190	TL28480	103.258	72.915	0.697	2.357
180	TL28000	103.267	72.074	0.771	2.988
170	TL27900	103.268	72.061	0.676	2.366
160	TL27896	103.267	72.052	0.682	2.383
150	TL27770	103.266	71.957	0.573	2.215
140	TL27768	103.266	71.954	0.574	2.218
130	TL27500	103.265	71.38	0.838	3.048
120	TL27020	103.26	71.116	1.116	2.281
110	TL27011	103.26	71.104	2.361	2.894
100	TL27000	103.26	71.068	0.72	2.396
90	TL26799	103.252	70.973	0.542	2.038
80	TL26794	103.251	70.967	0.544	2.046
70	TL26750	103.25	70.925	0.584	2.125
60	TL26741	103.249	70.915	0.588	2.139
50	TL26500	103.24	70.798	1.79	3.161
40	TL26460	103.238	70.806	0.539	2.041
30	TL26459	103.238	70.801	0.547	2.055
20	TL26450	103.238	70.834	0.422	1.727
10	TL26445	103.238	70.831	0.423	1.73
0	TL26180	103.226	70.679	0.597	2.035

TABLE A13: STAGE-DISCHARGE VALUES AT CROSS-SECTION 25144, CASE 1

UNSTEADY CASE 1		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev.(m) above datum
1.000	9.00000	108.715
1.250	11.5000	108.911
1.500	14.0000	109.074
1.750	17.2500	109.254
2.000	20.5000	109.419
2.250	25.2500	109.621
2.500	30.0000	109.815
2.750	35.0000	109.980
3.000	40.0000	110.126
3.250	45.5000	110.257
3.500	51.0000	110.374
3.750	57.0000	110.494
4.000	63.0000	110.606
4.250	69.0000	110.706
4.500	75.0000	110.799
4.750	81.5000	110.886
5.000	88.0000	110.972
5.250	92.7500	111.038
5.500	97.5000	111.102
5.750	99.2500	111.132
6.000	101.000	111.158
6.250	102.250	111.176
6.500	103.492	111.193
6.750	103.997	111.202
7.000	104.497	111.209
7.250	104.748	111.213
7.500	104.998	111.216
7.750	104.752	111.214
8.000	104.502	111.211
8.250	104.003	111.206
8.500	103.503	111.199
8.750	102.258	111.185
9.000	101.008	111.169
9.250	98.0200	111.134
9.500	95.0200	111.094
9.750	90.0330	111.031
10.00	85.0330	110.964
10.25	74.0730	110.825
10.50	63.0680	110.670
10.75	53.5000	110.500
11.00	44.0000	110.301
11.25	37.5000	110.150
11.50	31.0430	109.984
11.75	26.7780	109.841
12.00	22.5280	109.687
12.25	19.2710	109.533
12.50	16.0210	109.363
12.75	13.7650	109.207

TABLE A13 CONTINUED		
13.00	11.5150	109.051
13.25	9.51300	108.900
13.50	7.51300	108.739
13.75	5.76200	108.561
14.00	4.01100	108.348
14.25	4	108.27

TABLE A14: STAGE-DISCHARGE VALUES AT CROSS-SECTION 25045, CASE 1

UNSTEADY CASE 1		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.648
1.250	11.2380	108.834
1.500	13.7510	108.990
1.750	16.9620	109.158
2.000	20.2200	109.315
2.250	24.8480	109.509
2.500	29.6410	109.694
2.750	34.6780	109.846
3.000	39.7040	109.976
3.250	45.2360	110.091
3.500	50.7370	110.190
3.750	56.7130	110.289
4.000	62.7340	110.381
4.250	68.7640	110.460
4.500	74.7750	110.530
4.750	81.3000	110.586
5.000	87.7920	110.641
5.250	92.5860	110.687
5.500	97.3340	110.731
5.750	99.1770	110.757
6.000	100.934	110.776
6.250	102.203	110.791
6.500	103.444	110.804
6.750	103.974	110.811
7.000	104.477	110.817
7.250	104.737	110.820
7.500	104.988	110.823
7.750	104.759	110.823
8.000	104.510	110.821
8.250	104.021	110.818
8.500	103.521	110.813
8.750	102.301	110.804
9.000	101.054	110.793
9.250	98.1260	110.771
9.500	95.1340	110.745
9.750	90.2160	110.704
10.00	85.2170	110.658
10.25	74.4580	110.570
10.50	63.5540	110.460

TABLE A14 CONTINUED		
10.75	53.9490	110.323
11.00	44.4400	110.155
11.25	37.8240	110.022
11.50	31.4620	109.879
11.75	27.0900	109.748
12.00	22.8920	109.606
12.25	19.6130	109.458
12.50	16.3660	109.292
12.75	14.0490	109.140
13.00	11.7950	108.989
13.25	9.77200	108.844
13.50	7.79900	108.688
13.75	5.99800	108.509
14.00	4.26800	108.305
14.25	4.03800	108.219
14.50	4.00800	108.203
14.75	4.00200	108.199
15.00	4.00000	108.199

TABLE A15: STAGE-DISCHARGE VALUES AT CROSS-SECTION 24940, CASE 1

UNSTEADY CASE 1		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.559
1.250	11.0490	108.719
1.500	13.5720	108.862
1.750	16.7550	109.010
2.000	20.0050	109.155
2.250	24.5420	109.333
2.500	29.3150	109.508
2.750	34.3590	109.655
3.000	39.3990	109.783
3.250	44.9590	109.897
3.500	50.4700	109.992
3.750	56.4400	110.084
4.00	62.4010	110.177
4.250	68.4230	110.269
4.500	74.3880	110.357
4.750	80.9630	110.436
5.00	87.4450	110.512
5.250	92.3120	110.576
5.500	97.0610	110.635
5.750	99.0450	110.671
6.000	100.820	110.697
6.250	102.123	110.716
6.500	103.367	110.732
6.750	103.933	110.742
7.000	104.442	110.749
7.250	104.716	110.754
7.500	104.969	110.757
7.750	104.767	110.757

TABLE A15 CONTINUED		
8.000	104.522	110.755
8.250	104.047	110.751
8.500	103.551	110.746
8.750	102.369	110.735
9.000	101.127	110.722
9.250	98.2870	110.695
9.500	95.3150	110.662
9.750	90.5050	110.612
10.00	85.5220	110.554
10.25	75.0810	110.448
10.50	64.2770	110.312
10.75	54.5100	110.159
11.00	44.8980	110.002
11.25	38.1660	109.876
11.50	31.8850	109.743
11.75	27.4010	109.617
12.00	23.1930	109.485
12.25	19.8800	109.344
12.5	16.6360	109.188
12.75	14.2660	109.039
13.00	12.0010	108.895
13.25	9.96200	108.759
13.50	8.00800	108.612
13.75	6.21700	108.440
14.00	4.49200	108.247
14.25	4.07700	108.155
14.50	4.01600	108.137
14.75	4.00300	108.133
15.00	4.00100	108.133
15.25	4.00000	108.132

TABLE A16: STAGE-DISCHARGE VALUES AT CROSS-SECTION 24745, CASE 1

UNSTEADY CASE 1		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.440
1.250	10.6120	108.551
1.500	13.1080	108.685
1.750	16.1460	108.836
2.000	19.3200	108.991
2.250	23.5710	109.179
2.500	28.3070	109.360
2.750	33.4150	109.502
3.000	38.5660	109.620
3.250	44.1820	109.720
3.500	49.7430	109.805
3.750	55.7440	109.884
4.000	61.5600	109.958
4.250	67.5360	110.036
4.500	73.4310	110.109
4.750	80.0570	110.179

TABLE A16 CONTINUED		
5.000	86.5210	110.250
5.250	91.5720	110.312
5.500	96.3450	110.369
5.750	98.6760	110.407
6.00	100.516	110.434
6.250	101.910	110.453
6.500	103.171	110.468
6.750	103.823	110.479
7.000	104.351	110.486
7.250	104.658	110.491
7.500	104.922	110.494
7.750	104.781	110.495
8.000	104.550	110.494
8.250	104.111	110.490
8.500	103.622	110.486
8.750	102.530	110.477
9.000	101.309	110.465
9.250	98.6790	110.444
9.500	95.7730	110.415
9.750	91.2290	110.372
10.00	86.3060	110.319
10.25	76.6320	110.232
10.50	65.9360	110.117
10.75	55.9000	109.990
11.00	46.0770	109.859
11.25	39.1290	109.746
11.50	32.9970	109.628
11.75	28.3040	109.511
12.00	24.1270	109.387
12.25	20.7220	109.244
12.50	17.5170	109.082
12.75	14.9700	108.924
13.00	12.6010	108.770
13.25	10.4490	108.632
13.50	8.47600	108.491
13.75	6.67300	108.317
14.00	4.87400	108.133
14.25	4.15500	108.039
14.50	4.03200	108.019
14.75	4.00700	108.015
15.00	4.00200	108.014
15.25	4.00000	108.014

TABLE A17: STAGE DISCHARGE VALUES AT CROSS-SECTION 24680, CASE 1

UNSTEADY CASE 1		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.334
1.250	10.4630	108.430
1.500	12.9490	108.555
1.750	15.9300	108.693

TABLE A17 CONTINUED		
2.000	19.0800	108.835
2.250	23.2210	109.008
2.500	27.8810	109.193
2.750	32.9390	109.364
3.000	38.1770	109.501
3.250	43.7660	109.608
3.500	49.2940	109.708
3.750	55.3330	109.800
4.000	61.1470	109.885
4.250	67.1410	109.971
4.500	73.0640	110.049
4.750	79.6870	110.125
5.000	86.1430	110.201
5.250	91.2650	110.268
5.500	96.0510	110.328
5.750	98.5160	110.370
6.000	100.388	110.398
6.250	101.820	110.419
6.500	103.088	110.435
6.750	103.777	110.446
7.000	104.311	110.454
7.250	104.634	110.459
7.500	104.903	110.463
7.750	104.785	110.464
8.000	104.561	110.463
8.250	104.136	110.459
8.500	103.650	110.455
8.750	102.592	110.446
9.000	101.382	110.433
9.250	98.8310	110.411
9.500	95.9550	110.380
9.750	91.5140	110.336
10.00	86.6200	110.281
10.25	77.2350	110.191
10.50	66.6210	110.071
10.75	56.5660	109.937
11.00	46.7610	109.798
11.25	39.7090	109.673
11.5	33.5200	109.550
11.75	28.7520	109.425
12.00	24.5980	109.289
12.25	21.0790	109.135
12.50	17.8350	108.975
12.75	15.2310	108.822
13.00	12.8180	108.674
13.25	10.6190	108.542
14.00	8.63800	108.401
14.25	6.84000	108.224
14.50	5.00800	108.039
14.75	4.19100	107.932
15.00	4.04000	107.904

TABLE A17 CONTINUED		
15.25	4.00900	107.897
15.50	4.00200	107.896
15.75	4.00100	107.895
16.00	4.00000	107.895

TABLE A18: STAGE-DISCHARGE VALUES AT CROSS-SECTION 25144, CASE 3

UNSTEADY CASE 3		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.874
1.250	11.4950	109.068
1.500	13.9950	109.240
1.750	17.2430	109.426
2.000	20.4930	109.605
2.250	25.2400	109.819
2.500	29.9900	110.008
2.750	34.9890	110.179
3.00	39.9890	110.319
3.250	45.4880	110.457
3.500	50.9880	110.584
3.750	56.9870	110.705
4.000	62.9870	110.818
4.250	68.9870	110.916
4.500	74.9870	111.013
4.750	81.4860	111.115
5.000	87.9860	111.215
5.250	92.7400	111.292
5.500	97.4900	111.363
5.750	99.2460	111.398
6.000	100.996	111.427
6.250	102.247	111.448
6.500	103.497	111.466
6.750	103.999	111.475
7.000	104.499	111.482
7.250	104.749	111.486
7.500	104.999	111.490
7.750	104.751	111.488
8.000	104.501	111.485
8.250	104.001	111.480
8.500	103.501	111.474
8.750	102.253	111.460
9.000	101.003	111.444
9.250	98.0070	111.407
9.500	95.0070	111.365
9.750	90.0110	111.298
10.00	85.0110	111.226
10.25	74.0240	111.076
10.50	63.0240	110.897
10.75	53.5210	110.728

TABLE A18 CONTINUED

11.00	44.0210	110.540
11.25	37.5140	110.365
11.50	31.0140	110.189
11.75	26.7590	110.051
12.00	22.5090	109.897
12.25	19.2570	109.754
12.50	16.0070	109.595
12.75	13.7550	109.440
13.00	11.5050	109.280
13.25	9.50400	109.110
13.50	7.50400	108.930
13.75	5.75400	108.750
14.00	4.00400	108.537
14.25	4.00000	108.425

TABLE A19: STAGE-DISCHARGE VALUES AT CROSS-SECTION 25045, CASE 3

UNSTEADY CASE 3		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.804
1.250	11.1930	108.989
1.500	13.6960	109.151
1.750	16.8850	109.326
2.000	20.1200	109.502
2.250	24.7900	109.705
2.500	29.5880	109.881
2.750	34.6270	110.037
3.000	39.6660	110.164
3.250	45.1250	110.284
3.500	50.6480	110.394
3.750	56.6540	110.495
4.000	62.7110	110.586
4.250	68.7160	110.659
4.500	74.7090	110.732
4.750	81.1810	110.811
5.000	87.6740	110.892
5.250	92.4930	110.959
5.500	97.2470	111.020
5.75	99.1330	111.056
6.000	100.895	111.082
6.250	102.175	111.102
6.500	103.429	111.119
6.750	103.969	111.129
7.000	104.472	111.135
7.250	104.736	111.139
7.500	104.987	111.143
7.750	104.758	111.142
8.000	104.510	111.140
8.250	104.022	111.136
8.500	103.524	111.132
8.750	102.305	111.122

TABLE A19 CONTINUED		
9.000	101.064	111.108
9.250	98.1470	111.080
9.500	95.1550	111.046
9.750	90.2460	110.995
10.00	85.2500	110.936
10.25	74.5250	110.823
10.50	63.5560	110.684
10.75	53.9920	110.550
11.00	44.6030	110.393
11.25	37.9750	110.236
11.50	31.4390	110.081
11.75	27.0820	109.956
12.00	22.8700	109.815
12.25	19.5780	109.681
12.50	16.3620	109.531
12.75	14.0650	109.378
13.00	11.8330	109.221
13.25	9.81400	109.058
13.50	7.82400	108.883
13.75	6.06200	108.708
14.00	4.30400	108.497
14.25	4.0800	108.376
14.50	4.02600	108.335
14.75	4.00800	108.322
15.00	4.00300	108.318
15.25	4.00100	108.316
15.50	4.00000	108.316

TABLE A20: STAGE-DISCHARGE VALUES AT CROSS-SECTION 24940, CASE 3

UNSTEADY CASE 3		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.705
1.250	10.9790	108.862
1.500	13.4800	109.008
1.750	16.6100	109.167
2.000	19.8300	109.334
2.250	24.3620	109.522
2.500	29.1770	109.692
2.750	34.2260	109.843
3.000	39.3190	109.967
3.250	44.7650	110.080
3.500	50.2300	110.184
3.750	56.1710	110.288
4.000	62.2420	110.391
4.250	68.2710	110.477
4.500	74.2550	110.560
4.750	80.6870	110.648
5.000	87.1570	110.739
5.250	92.0920	110.813
5.500	96.8530	110.879

TABLE A20 CONTINUED		
5.750	98.9350	110.920
6.000	100.728	110.949
6.250	102.052	110.970
6.500	103.316	110.988
6.750	103.917	110.999
7.000	104.427	111.007
7.250	104.710	111.012
7.500	104.964	111.016
7.750	104.768	111.016
8.000	104.525	111.014
8.250	104.053	111.010
8.500	103.559	111.005
8.750	102.383	110.995
9.000	101.161	110.981
9.250	98.3570	110.954
9.500	95.3790	110.919
9.750	90.6040	110.868
10.00	85.6220	110.809
10.25	75.2940	110.697
10.50	64.4170	110.551
10.75	54.7780	110.405
11.00	45.3910	110.242
11.25	38.4670	110.087
11.50	31.8870	109.946
11.75	27.4320	109.826
12.00	23.2370	109.696
12.25	19.8950	109.569
12.50	16.6630	109.430
12.75	14.3120	109.281
13.00	12.0870	109.130
13.25	10.0490	108.972
13.50	8.06100	108.808
13.75	6.29200	108.640
14.00	4.58100	108.438
14.25	4.16100	108.308
14.50	4.05200	108.263
14.75	4.01800	108.248
15.00	4.00600	108.243
15.25	4.00200	108.241
15.50	4.00100	108.241
15.75	4.00000	108.240

TABLE A21: STAGE DISCHARGE VALUES AT CROSS-SECTION 24745, CASE 3

UNSTEADY CASE 3		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.577
1.250	10.4620	108.671
1.500	12.8620	108.812
1.750	15.7710	108.972
2.000	18.9140	109.145

TABLE A21 CONTINUED

2.250	23.1080	109.330
2.500	27.9780	109.492
2.750	33.0950	109.632
3.000	38.3760	109.745
3.250	43.8590	109.844
3.500	49.2150	109.929
3.750	54.9840	110.019
4.000	60.9890	110.110
4.250	67.1560	110.194
4.500	73.1200	110.274
4.750	79.4800	110.358
5.000	85.9260	110.444
5.250	91.1510	110.518
5.500	95.9690	110.583
5.750	98.4620	110.630
6.000	100.353	110.660
6.250	101.777	110.682
6.500	103.076	110.701
6.750	103.789	110.713
7.000	104.327	110.722
7.250	104.645	110.728
7.500	104.914	110.733
7.750	104.780	110.734
8.000	104.551	110.733
8.250	104.120	110.729
8.500	103.630	110.725
8.750	102.549	110.715
9.000	101.353	110.703
9.250	98.7760	110.681
9.500	95.8510	110.651
9.750	91.3520	110.608
10.00	86.4400	110.555
10.25	77.0050	110.463
10.50	66.4440	110.333
10.75	56.7150	110.194
11.00	47.2660	110.054
11.25	39.7450	109.919
11.5	33.0440	109.798
11.75	28.4240	109.686
12.00	24.2480	109.571
12.25	20.8330	109.453
12.50	17.6030	109.321
12.75	15.1130	109.171
13.00	12.9020	109.015
13.25	10.7830	108.853
13.50	8.69100	108.688
13.75	6.83600	108.527
14.00	5.15900	108.330
14.25	4.33000	108.180
14.50	4.10900	108.129
14.75	4.03600	108.112

TABLE A21 CONTINUED		
15.00	4.01200	108.106
15.25	4.00400	108.104
15.50	4.00100	108.103
15.75	4.00100	108.103
16.00	4.00000	108.103

TABLE A22: STAGE DISCHARGE VALUES AT CROSS-SECTION 24680, CASE 3

UNSTEADY CASE 3		
Time (hrs.)	Discharge (m^3s^{-1})	Water S. Elev. (m) above datum
1.000	9.00000	108.473
1.250	10.2920	108.555
1.500	12.6460	108.686
1.750	15.4810	108.833
2.000	18.5820	108.998
2.250	22.6310	109.182
2.500	27.3960	109.365
2.750	32.5680	109.520
3.000	37.8460	109.640
3.250	43.3280	109.751
3.500	48.7250	109.847
3.750	54.4500	109.945
4.000	60.4640	110.042
4.250	66.6940	110.130
4.500	72.6540	110.215
4.750	78.9890	110.303
5.000	85.4240	110.392
5.250	90.7520	110.471
5.500	95.6020	110.540
5.750	98.2550	110.590
6.000	100.193	110.622
6.250	101.662	110.646
6.500	102.975	110.665
6.750	103.730	110.679
7.000	104.280	110.688
7.250	104.615	110.694
7.500	104.888	110.699
7.750	104.783	110.700
8.000	104.562	110.699
8.250	104.145	110.696
8.500	103.662	110.691
8.750	102.614	110.682
9.000	101.430	110.669
9.250	98.9360	110.647
9.500	96.0360	110.616
9.750	91.6410	110.572
10.00	86.7630	110.517
10.25	77.6630	110.424
10.50	67.2460	110.292
10.75	57.5020	110.150

TABLE A22 CONTINUED

11.00	48.0960	110.006
11.25	40.4690	109.866
11.50	33.7130	109.739
11.75	28.9620	109.620
12.00	24.7230	109.503
12.25	21.2890	109.378
12.50	18.0750	109.239
12.75	15.4330	109.085
13.00	13.1920	108.931
13.25	11.0570	108.772
13.50	8.91000	108.614
13.75	7.02900	108.455
14.00	5.36900	108.254
14.25	4.40100	108.092
14.50	4.13400	108.032
14.75	4.04500	108.010
15.00	4.01500	108.002
15.25	4.00600	107.999
15.50	4.00200	107.998
15.75	4.00000	107.998