HYDRODINAMIC FLOOD MODELLING OF POSHUR RIVER USING HEC-RAS AND SOURCES OF ITS UNCERTAINTY

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ABSTRACT

The hydrodynamic model approaches applied in this study are the one-dimensional (1D) model, HEC-RAS. Many cities and towns are developed on downstream side of dams. Some of them are established on the banks of river. During the monsoon period, when the dam is full at its Maximum Reservoir Level (MRL) and still the surplus floods are approaching into dam submergence, the maximum discharge is released from the dam to avoid the overtopping. This results into floods onto downstream and may cause the disaster in cities or towns settled on banks of rivers. This project aimed to analyze the behavior of possur river with the use of the hydrodynamic modeling software developed by the "hydrologic engineering center, u.s. Army corps of engineers", to simulate different water levels, flow rates corresponding to different return periods and observe the conditions of the project from the available database provided by the Bangladesh Water Development Board (BWDB).

Keywords: *Cross section, model uncertainty, steady, unsteady*

1. INTRODUCTION

HEC-RAS is an integrated system of software, designed for interactive use in a multi-tasking environment. The system is comprised of a graphical user interface (GUI). Separate analysis components, data storage and management capabilities, graphics and reporting facilities (Maidment, 1993). The HEC-RAS system contains four one dimensional river analysis components for: (1) Steady flow water surface profile computations: (2) Unsteady flow simulation: (3) movable boundary sediment transport computations: and (4) water quality analysis. A key element is that all four components use a common geometric data representation and common geometric and hydraulic computation routines (Bates, 1996). In addition to the four river analysis components, the system contains several hydraulic design features that can be invoked once the basic water surface profiles are computed. The current version of HEC-HAS supports steady and unsteady flow water surface profile calculations, sediment transport / mobile bed computations and water quality analysis. The Poshur River, which flows through the urban area, has suffered more often significant increases in water level as a result of the changes throughout its basin, in both rural and urban areas. The main changes observed in the basin are concentrated in the process of with the acceleration of urban development in recent decades, some engineering concepts regarding water control have been changing (Aronica et al., 1998). Sanitary problems reflect on the population health, constant flooding and the deterioration of a rich and diverse environment in many regions. The transformation of a rural environment in an urban area increases the sanitary problems jeopardizing future generations. In flood Modelling, awareness has grown that models may not be reliable and may be uncertain and that performances should be evaluated more critically. Models may be uncertain due to many reasons that commonly relate to the selected model structure, the required input but also the mathematical algorithms. In flood modeling, however, the governing flow equations are well known and nowadays efficient numerical solvers are available (Chow, 1964). With the advent of fast computing facilities it now is possible to solve the full set of equations rapidly and accurately that reduces uncertainty (Stephens et al., 2012). However, there remain other sources of uncertainty and in this study the objective is to evaluate effects of selected boundary conditions, of applied surface roughness values and the spatial resolution of the model domain (Bernardara et al., 2010). The hydrodynamic model approaches applied in this study are the one-dimensional (1D) model, HEC-RAS. Many cities and towns are developed on downstream side of dams. Some of them are established on the banks of river. During the monsoon period, when the dam is full at its Maximum Reservoir Level (MRL) and still the surplus floods are approaching into dam submergence, the maximum discharge is released from the dam to avoid the overtopping. This results into floods onto downstream and may cause the disaster in cities or towns settled on banks of rivers (Egorova et al., 2008). The importance of this study is to facilitate the appropriate measures for effective flood mitigation in advance; there is a need to model a flood plain. With the advent of modern technology, the use of sophisticated software in flood modelling help in getting idea of exact of flood at its submergence. This paper presents a case study of hydrodynamic flood modelling of Poshur River using HEC-RAS and analysing its uncertainty. The model facilitates to locate the flood plain and its extent for effective flood mitigation measures. The objective of this research is to (a) steady flow analysis, (b) sources of uncertainty of river modelling; (c) adjust station and elevation, (d) unsteady flow analysis.

2. METHODOLOGY

In the steady flow analysis, the river cross sectional data is applied. At first, geometrical data are applied. Then cross sectional data are input with a known elevation at a station are applied. Then stations and elevations are applied with a slope factor 0.003. The flow chart is shown in below:

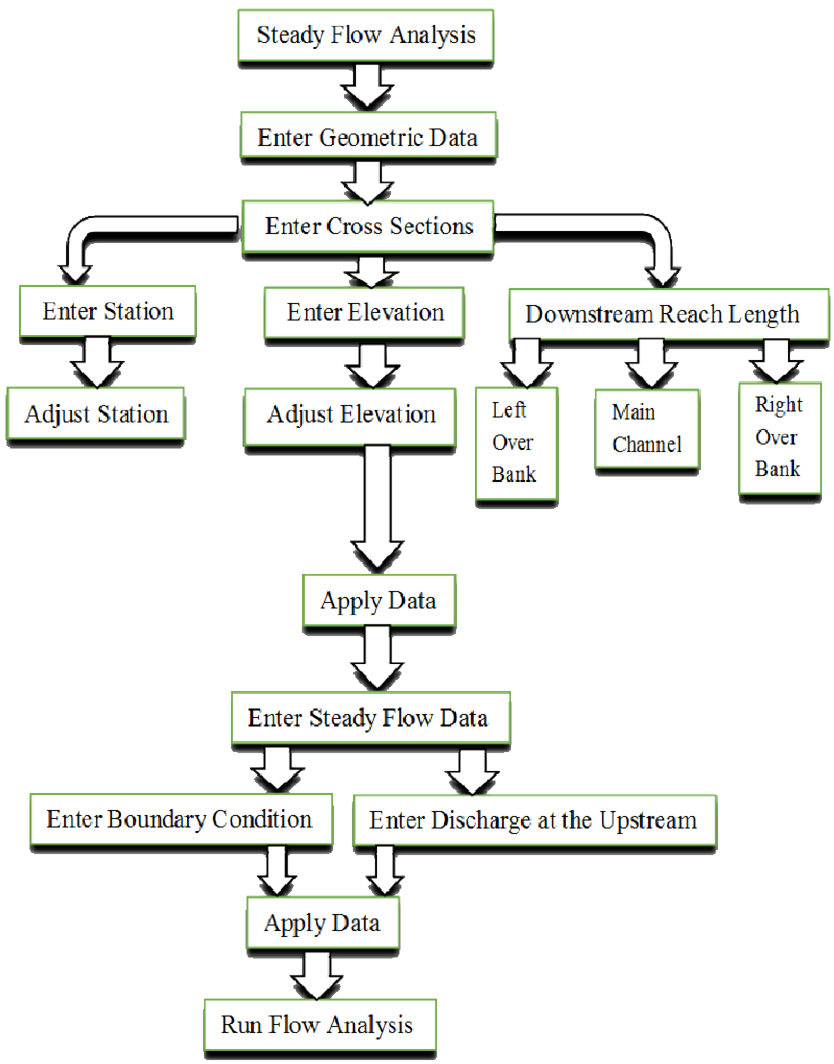

Figure 1: Steady Flow Analysis by HEC-RAS

In the Unsteady Flow Analysis, the cross sectional data with geometrical data are input. Then station and elevation are adjusted as before with the slope factor 0.003. Then downstream reach length like main channel length, left over bank, right over bank are input. After applying all those data the flow data are input with the different boundary condition. Then run all the data with unsteady flow analysis. The flow chart shown in below of unsteady flow analysis

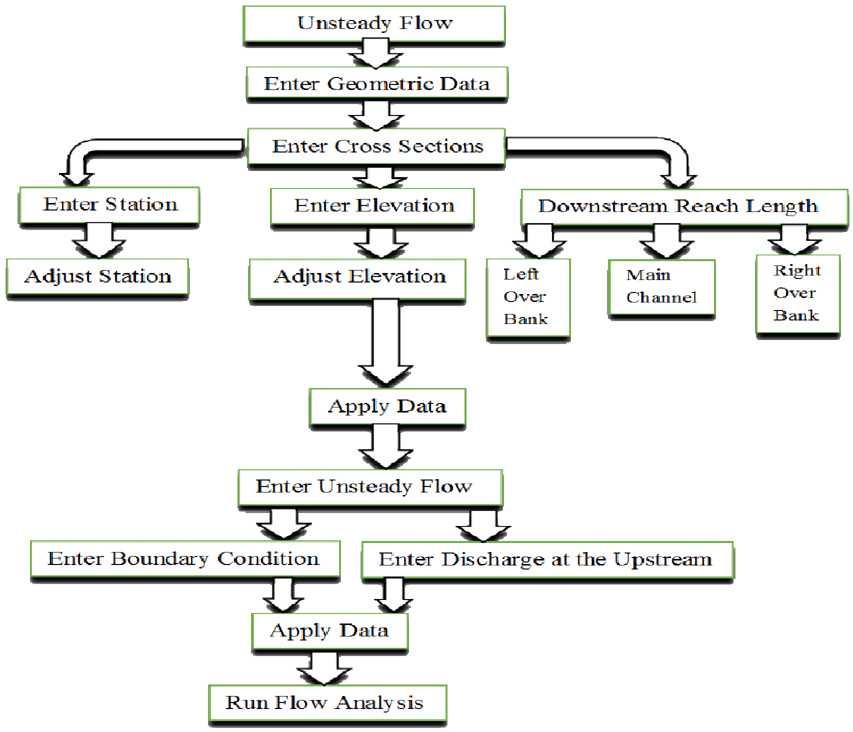

Figure 2: Unsteady Flow Analysis

A flow in which the velocity of the fluid at a particular fixed point changes with time is called unsteady flow. The devastating flood occurrence and its impact on the people have been of great concern to man.

Flood studies are the important first step towards understanding and managing flood behavior, whether for a large rural catchment, a highly developed urban area or for individual property and infrastructure developments. Flood studies provide information about flood behavior and risk, quantify the impact from proposed developments, and inform floodplain planning and water quality studies. Flood hydraulic modelling introduce the basic concepts of flood risk management and the latest tools and techniques available in managing flood risk. Specific contents are:

- Application domains of Hydro informatics: floods and urban systems environment.
- Climate change and its impacts on hydrology
- Introduction to 1D,2D modelling
- Nature and characteristics of floods
- Modelling flood propagation- flood routing
- Hydraulic methods for flood routing/ modeling in rivers

2.1 Study Area

Poshur River located at Mongla Port in Khulna Division with coordinates 22029’20’’N 89035’43’’E. Mongla is the main sea port in the Bagerhat District of South-Western Bangladesh.

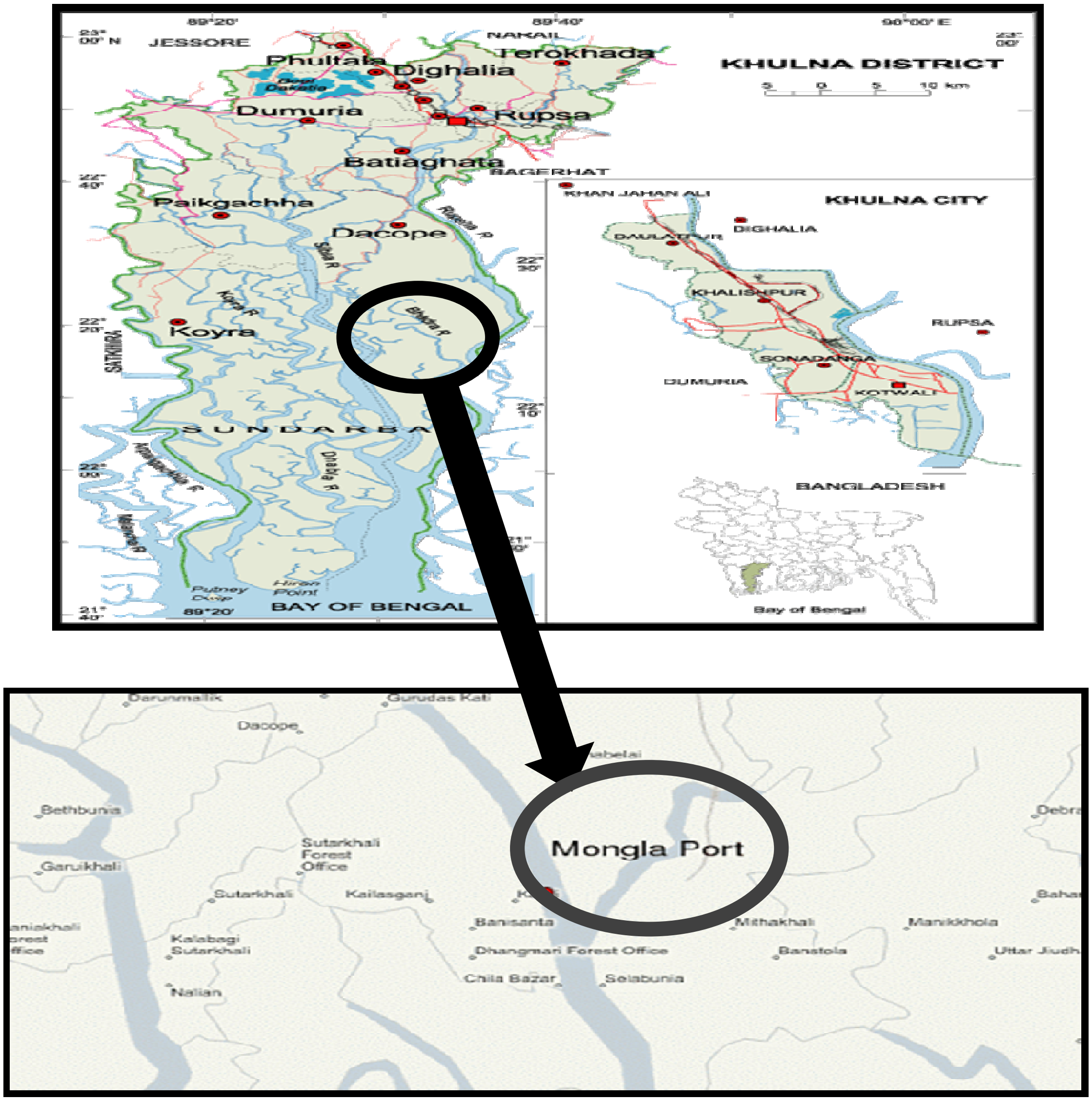

Figure 3: Location of the study Area

2.2 Cross Sectional Data

The cross sectional data are input for the analysis of steady and unsteady flow.

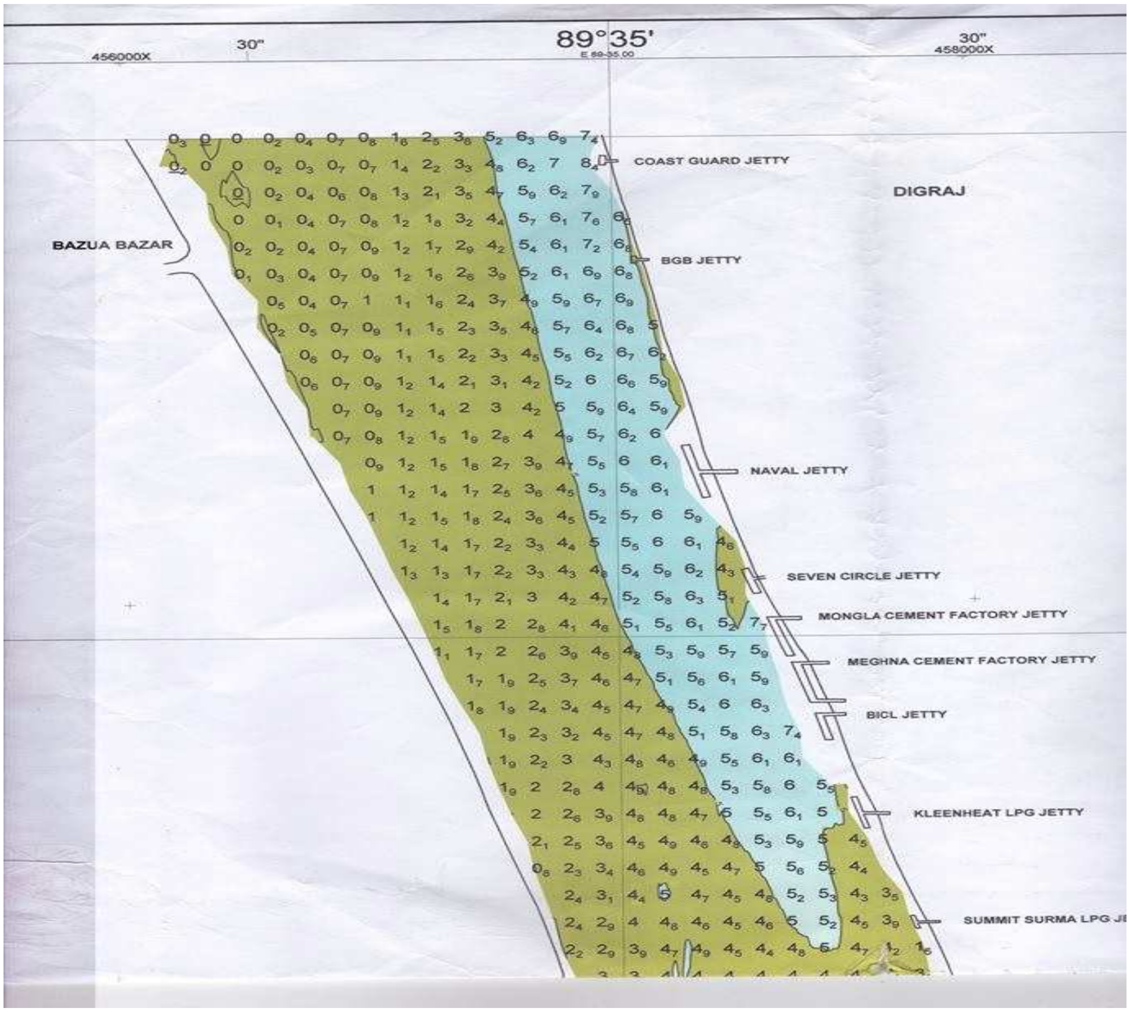

Figure 4: Cross sectional data of Poshur River

After entering the geometric data, then any kind of steady flow data can be entered. Flow data are entered from upstream to downstream for each reach. At least one flow value must be entered for each reach in the river system. The flow data can be changed at any cross section within a reach. Boundary conditions are necessary to establish the starting water surface at the ends of the river system (upstream and downstream). Water surface is necessary in order for the program to begin the calculation. In a subcritical flow regime is going to be calculated, boundary conditions are only necessary at the upstream ends of the river system. If a mixed flow regime calculation is going to be made, then boundary conditions must be entered at all of the river system.

3. RESULTS AND DISCUSSIONS

Cross Section data represents the geometric boundary of the stream. Cross sections are located at relatively short intervals along the stream to characterize the flow carrying capacity of the stream and its adjacent floodplain. Cross sections are required at representative locations throughout the stream and its locations where changes occur in discharge, slope, shape, roughness, at locations where levees begin and end, and at hydraulic structures (bridges, culverts, inline weirs/spillways, and lateral weirs/spillways).

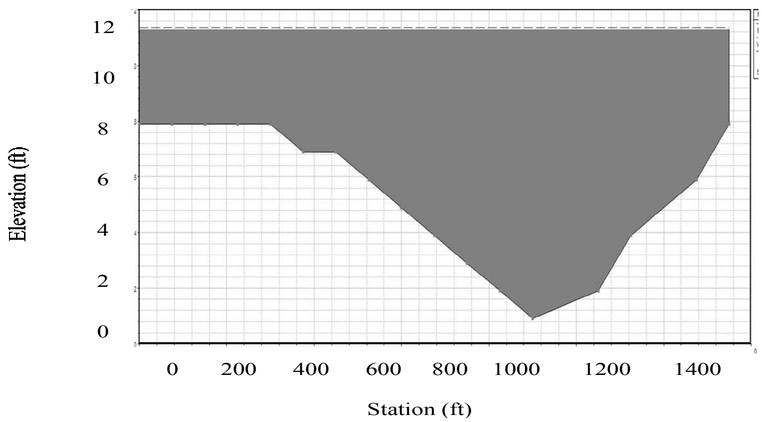

Figure 5: Cross sectional profile at river station 28

In the 31 river stations, every river stations has its cross sectional profile. The above figure represents the cross sectional profile at river station 28 that is plotted against station vs elevation from the given cross sectional data. And after adjusting the station and elevation and fulfill the boundary condition such water profile obtained.

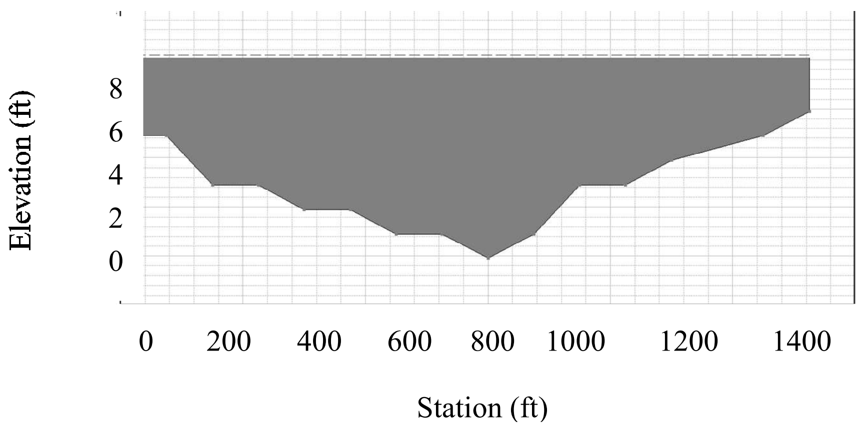

Figure 6: Cross sectional profile at river station 11

This is the cross section at river station 11 after adjusting its station and elevation. The water profile obtained from the cross sectional data at a constant elevation.

The stage and flow hydrograph are also obtained in the the river station 28 that are given below,

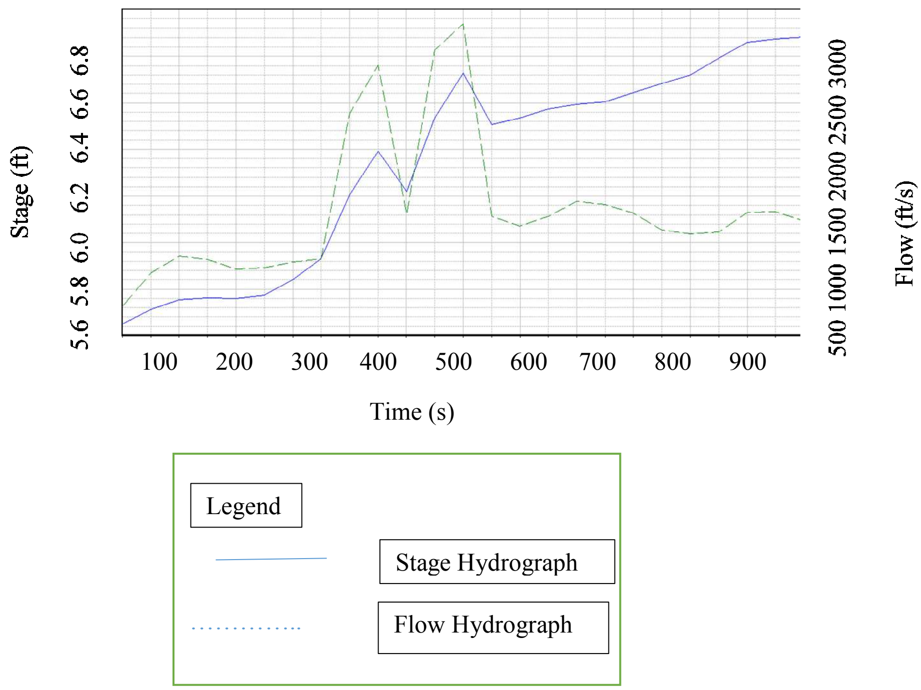

Figure 7: Stage and flow Hydrograph

In the stage and flow hydrograph, stage expressed as solid line and flow expressed as dotted line. It is observed that at time 400-500s the flow is much greater than stage hydrograph.

Table 1: The cross sectional output of 10 years profile at River Station 31

Serial No	Element	Left Over Bank	Channel	Right Over Bank
1	Reach Length	75	4500	75
2	Flow Area	2649.95	6024.95	369.44
3	Area	2649.95	6024.95	369.44
4	Average Velocity	1.18	2.06	1.34

In the cross sectional output at 10 years profile at river station 31 the flow area, average velocity, area in the main channel are greater than left and right over bank. Here flow area, area, average velocity in main channel is greater than left and right over bank.

3.1 Sources of Uncertainty

When Cross Sectional data are input, Station and Elevation data are need to be adjusted. Those values are adjusted by a slope factor .0003 at the downstream section of the river reach. The factor is not actually defined or not even mentioned. This is the sources of uncertainty

4. CONCLUSIONS

The great importance of 1D model is to rely in accurate geometric representation of the river drainage system. 1D model approaches, it is shown that model sensitivity to downstream boundary conditions is observed at distance 4500ft. By this research, it can be calculated that a 1D model is found to be more sensitive to changes in the channel roughness value than for changes in the floodplain roughness values. A common misunderstanding exists that a 100-year flood is likely to occur only once in a 100-year period. In fact, there is approximately a 63.4% chance of one or more 100-year floods occurring in any 100-year period. The HEC-RAS provides the flood profile for the worst flood intensity. This profile will facilitate to adopt appropriate flood disaster mitigation measures. The flood profiles for different flood intensities with different return periods can be plotted at any given cross section of river. Also, such flood profile can be plotted for entire length of river reach. Flood modelling using HEC-RAS is effective tool for hydraulic study, handling of disaster management measures. The maximum flows obtained from the hydrological study for the different return periods, were applied to the hydrodynamic modelling software. It was then possible to analyse the height of water level along the Poshur River and its tributary, for different flow conditions.

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