

River Flood Modeling Using GIS, HEC-GeoRAS And HEC-RAS For Purna River, Navsari District, Gujarat, India

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Abstract—This research work represents a process of 1D modeling of river by ArcGIS, HEC-RAS and HEC-GeoRAS software. The methodology is applied to a research of Purna River, Navsari district, Gujarat, India. First part of the study is followed by the ArcGIS and HEC-GeoRAS software in which pre-processing to be completed which contain to develop D.E.M (digital elevation model), Geo referencing, Shape file, Mosaic, Extract by mask of Navsari District and Purna River. Then from the HEC-GeoRAS geometry stream centerline, bankline, flow path and its centerline and cross section cut lines is define. Then all GIS data exported to HEC-RAS. In Model execution work first import the GIS data then in HEC-RAS (Hydrologic Engineering Center River Analysis System) processing output of the HEC-RAS in which station/elevation of each cross section are determine and steady flow analysis, hydraulic design analysis is carried out. And after providing slope and peak discharge of particular cross section (HEC-RAS) will gives the water surface elevation height. From this work we can predict the flood by provide Embankment, Flood wall etc.

Key Words— D.E.M, TIN, GIS, RS, HEC-RAS, HEC-GeoRAS, ArcGIS

I. INTRODUCTION

A flood can be defined as any relatively high water flow that overtops the natural or artificial banks in any portion of a river or stream. When a bank is overtopped, the water spreads over the flood plain and generally becomes a hazard to society. Floods are probably the most recurring, widespread, disastrous and frequent hazard of the world. India is one of the worst flood-affected countries, being second in the world after Bangladesh and accounts for 1/5th of global death count due to floods. About 40 million hectares or nearly 1/8th of India's geographical area is flood prone. India is one of the most flood prone countries in the world.

The principal reasons for flood are prevailing natural ecological systems in the country and these are heavy rainfall with temporal and spatial variation, highly silted river systems and inadequate capacity to carry the high flood discharge, inadequate drainage to carry away the rainwater quickly to streams, rivers. Many times typhoons and cyclones also cause floods. Flash floods are caused by steep and highly erodible mountains, particularly in Himalayan ranges. The average rainfall in India is 1150 mm with significant variation across the Country. The annual rainfall along the western coast and Western Ghats, Khasi hills and over most of the Brahmaputra valley amounts to more than 2500 mm. Most of the floods occur during the monsoon period and are usually associated with tropical storms, depressions and active monsoon conditions. Due to the mentioned conditions floods occur in almost all river basins in India.

Purna River is an important west flowing river with its catchment lying in Ahwa, Valsad and Navsari districts of Gujarat and in Nasik district of Maharashtra. The Purna basin can be divided into three prominent physiographic regions, i.e. i) Eastern parts, (ii) the middle reaches and (iii) the coastal zones. An important design component of these facilities involves hydraulic analyses to determine conveyance capacity.

Computer models play a pivotal role in these analyses by aiding in the determination of water surface profiles associated with different flow conditions. Often the computed water surface elevations are manually plotted on paper maps in order to delineate floodplains. Automating this manual plotting would result in significant savings of both time and resources. Geographic information systems (GIS) offer the ideal environment for this type of work. This paper presents a GIS and HEC-RAS approach for river modeling facilities.

The approach establishes a connection between the HEC-RAS hydraulic model and ArcView GIS, allowing for improved visualization and analysis of floodplain data. It also permits GIS to function as an effective planning tool by making hydraulic data easily transferable to floodplain management, flood insurance rate determination, economic impact analysis, and flood warning system.

II. STUDY AREA

The river Purna rises in the Saputara hills of the Western Ghats near the village Chinchinchi in Maharashtra. The length of the river from its source to outflow in the Arabian Sea is about 180 km. The important tributaries of the Purna River are Dhodarnala, Bardanala, Nagihparnala, Girna River, Zankari River and Dumas khadi. The catchment area of the Purna basin is 2431 Km² of the basin lies between 72°45' to 74°00' East longitude and 20°41' to 21°05' North latitude. Navsari district is situated in the southern part of Gujarat State. It is one of the most important districts in Gujarat State bifurcated from Valsad district. It lies between Latitude 20°32' & 21°05' North and Longitude 72°42' & 73°30' East and falls in Survey of India Toposheet Nos 46C,

46D, 46G& 46H. It is bounded by Surat district in the north, Dangs district in the east, Valsad district in the South and Arabian sea in the west. Navsari district has a geographical area of about 2210.97 Km²

As per below **Fig.1** indicate the Navsari District, Gujarat, India and **Fig.2** indicate the Basin map of Purna River (source:www.cwc.nic.in).

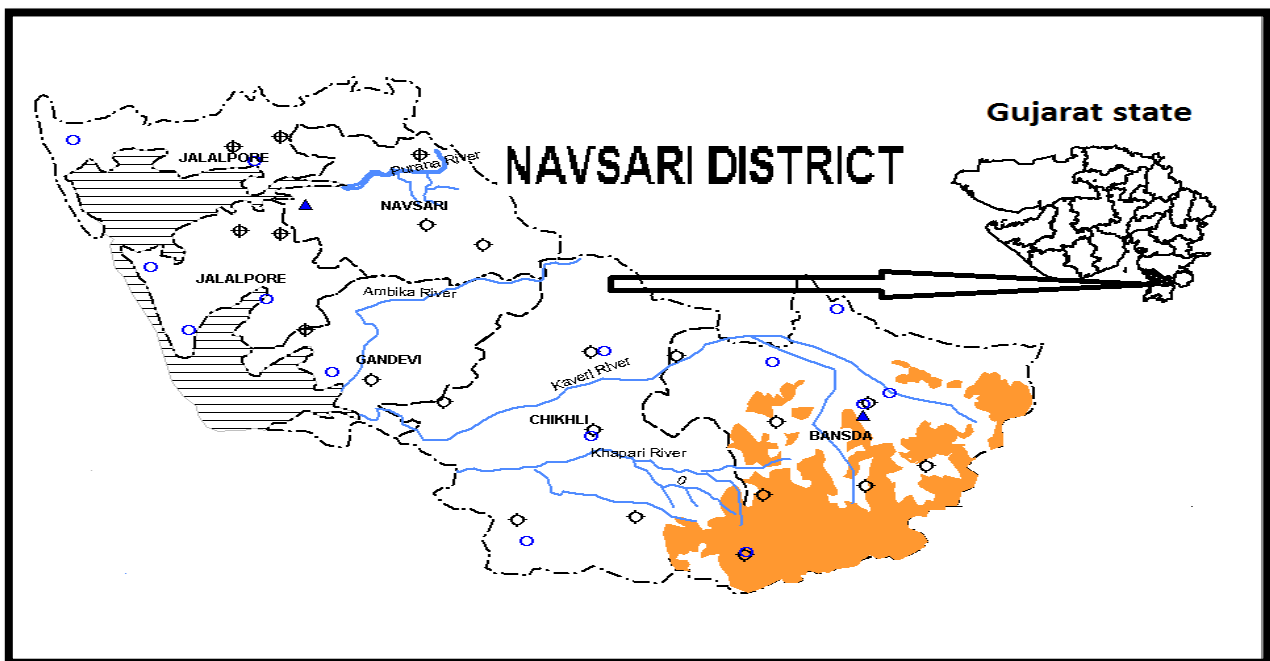


Figure 1: Navsari district, Gujarat, India



Figure 2: Basin map of Purna River (source: www.cwc.nic.in)

III. DATA COLLECTION

- I. Image of the area under study.
- II. DEM or TIN Model.
- III. High resolution Google-earth image will be downloaded through internet.
- IV. For the research Geo-coded Indian Remote Sensing (IRS) satellite image will be used from Bhuvan(Indian geo-platform of ISRO).

V. The water level, river discharge, Cross sections data details from 1990 up to present. For different stations will be collected from Central Water Commission (C.W.C)Surat, and Irrigation Department (Navsari).

IV. METHODOLOGY

Using GIS for hydrologic, hydraulic modeling usually involves following steps.

- I. Pre-processing of Data (ARC-GIS & HEC-GeoRAS)
- II. Model Execution (HEC-RAS)

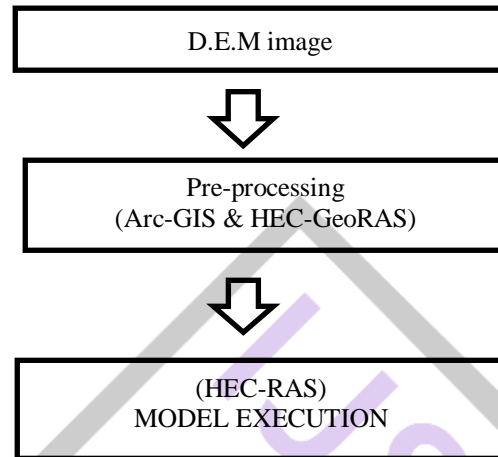


Figure 3: Conceptual Diagram of Methodology in HEC-RAS

Arc-GIS software

- I. ArcGIS is a geographical information systems (GIS) for working with maps and geographic information.
- II. It is used for creating and using maps, compiling geographic data, analyzing mapped information, sharing and discovering geographic information, using maps and geographic information in a range of applications, and managing geographic information in a database.

HEC-GeoRAS

- I. HECGEO-RAS is a set of procedures, tools, and utilities for processing geospatial data in ARC-GIS using a graphical interface.
- II. The interface allows the preparation of geometric data for import into HEC-RAS and processes simulation results exported from HEC-RAS.

HEC-RAS (Hydrologic Engineering Center River Analysis System)

- I. HEC-RAS is known program that model the hydraulics of water flow through natural rivers and other channels.
- II. HEC-RAS is a computer program for modeling water flowing through systems of open channels and computing water surface profiles.
- III. HEC-RAS finds particular commercial application in floodplain management.

Pre-processing (Arc-GIS & HEC-GeoRAS)

For the pre-processing of the data, software HEC-GeoRAS and ArcGIS is used. HEC-GeoRAS is an extension used with Arc GIS. It is specially designed to process geospatial data for use with the Hydrological Engineering Center River Analysis System (HEC-RAS). It allows the creation of a HEC-RAS import file containing geometric attribute data from an existing digital elevation model (DEM) and complimentary data sets. The results exported from HEC-RAS will be further processed in the GIS environment. By means of HEC-GeoRAS an import file have been created describing the geometry of the discharging watersheds into the floodway.

Following steps are covered by Arc GIS software.

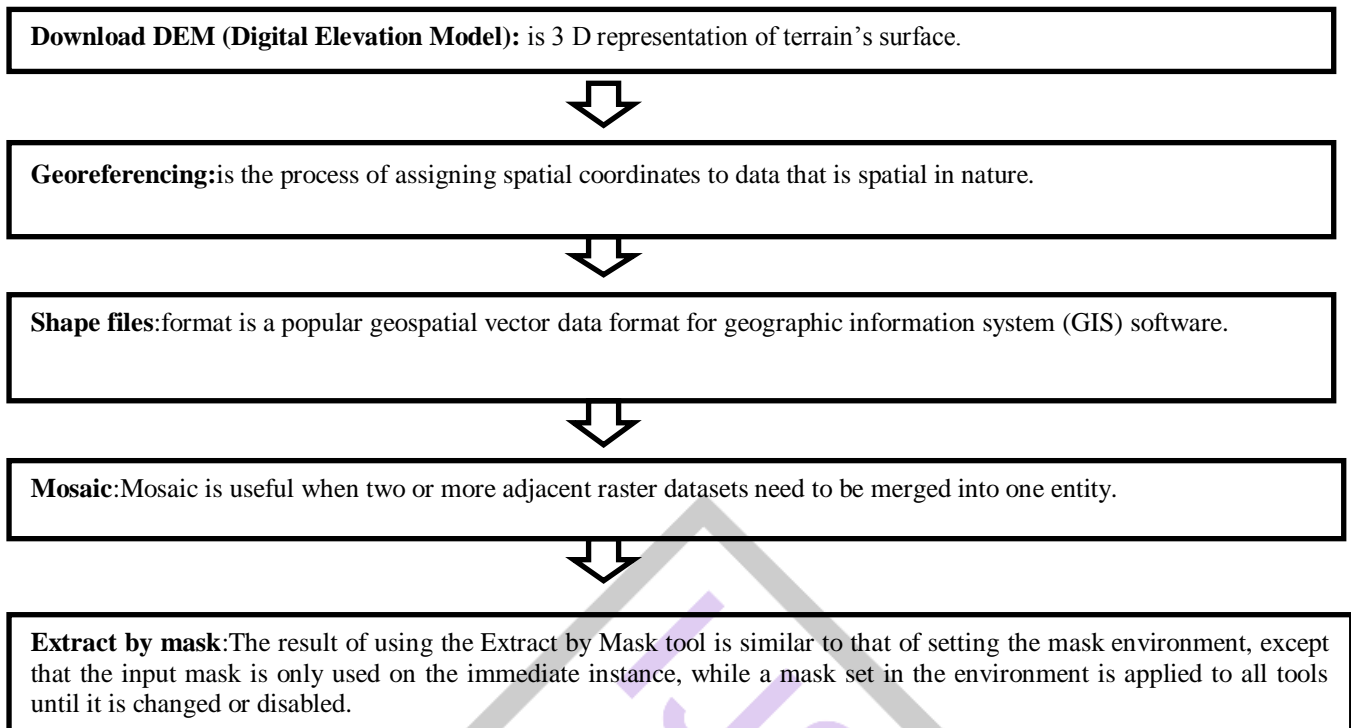


Figure 4: Conceptual Diagram of Pre-processing Methodology

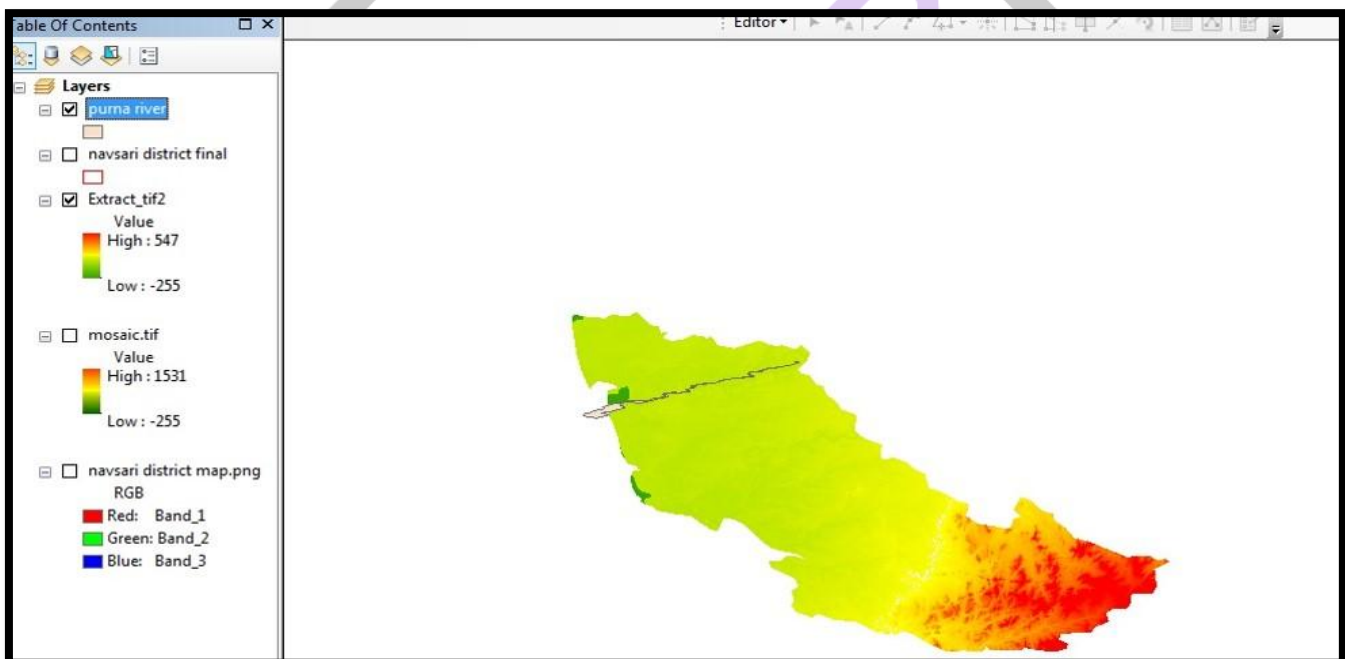


Figure 5: Final image in ArcGIS of Navsari district and PurnaRiver

HEC-RAS- MODEL EXECUTION

In this phase, the geometric data created is imported in the HEC-RAS. Then From geometric data menu import GIS data base file. Then add cross section details which contain station, elevation, right over bank, left over bank and channel length. Manning's constant, left bank, right bank.

Then from steady flow analysis menu ,apply boundary condition and peak discharge parameters then save steady flow analysis file, now from hydraulic design function apply peak discharge and slope then after applying geometry its gives directly the water surface elevation height.

Fig.6below indicate the HEC-RAS import file from ArcGIS environment, there are 10 cross sections are provided for the simulation of model.in this model execution work first of all from geometric menu select the cross section option then from that

cross section option enter all the values of cross section like station, elevation, left over bank, right over bank, manning's constant, leftbank, rightbank, expansion and contraction coefficient. Then finally apply the geometry.

So that HECRAS will give the cross section plot on right side of geometric data menu. Now repeat the same procedure for the cross section from 1 to 10.

Graph which will results from applying geometry data clearly indicate the flooding of left bank and right bank as per the geometric data.

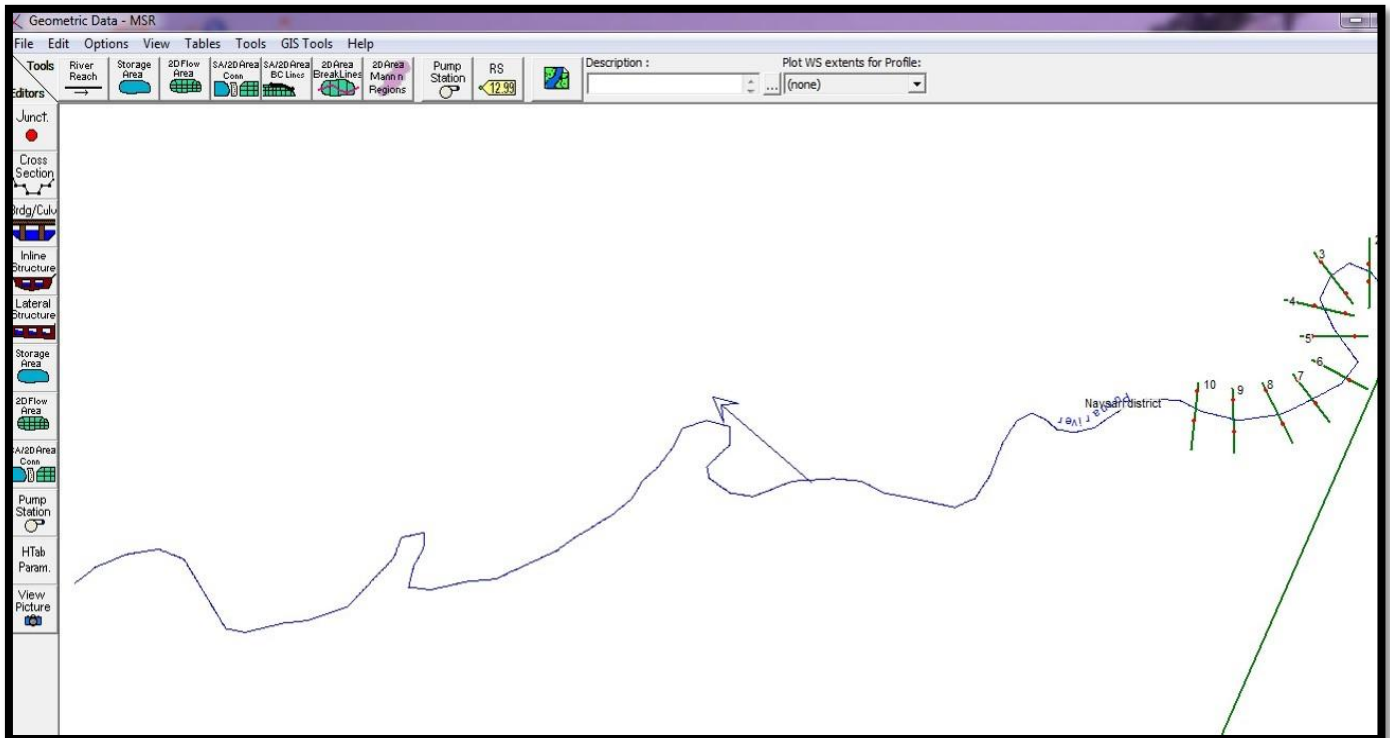


Figure 6: Imported GIS data base file of Purna River in HECRAS

Result and discussion

In HECRAS software after running hydraulic analysis of particular cross section by applying slope and peak discharge of river then after applying geometry, HECRAS will give the water surface elevation height. Below **Fig.7** and **Fig.8** of cross section 1 and cross section 4 indicates that the water is not ovetop the left bank and right bank of cross section 1 after applying peak discharge of 8836 m³/sec, but in cross section 4, water is ovetop from left bank but at right bank water is not ovetop.so there is chances of flooding is more in cross section 4.

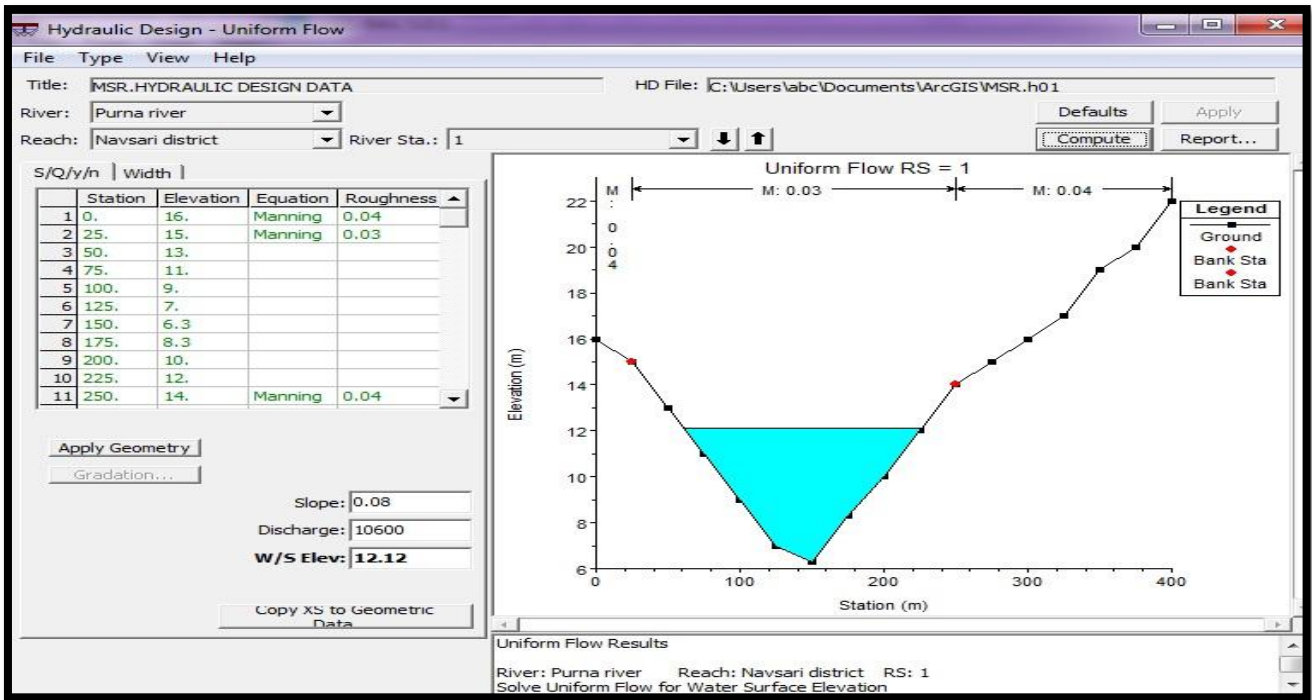


Figure 7: Hydraulic analysis of cross section 1

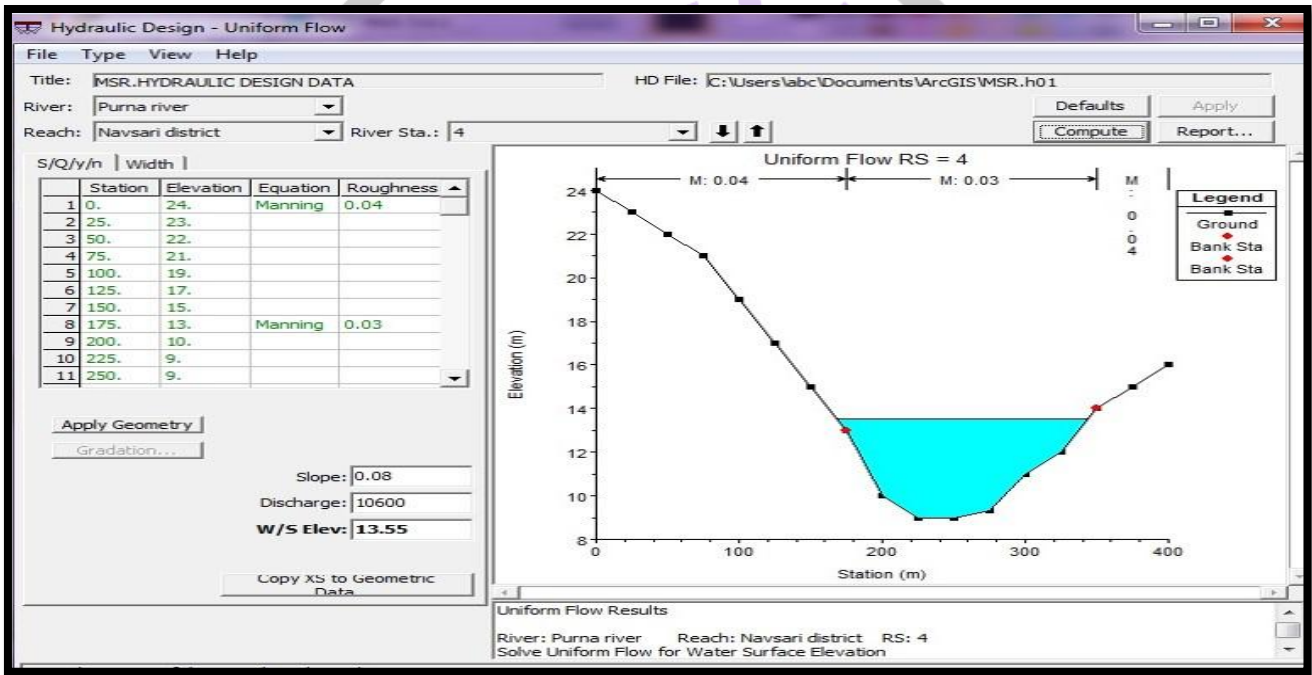


Figure 8: Hydraulic analysis of cross section 4

From below Fig.9 graph we can see that in the year of 2002 the discharge carrying capacity is 8836 m³/sec. so that consider this discharge as a peak discharge and input the value of 8836 m³/sec in HEC-RAS model simulation work. so that prediction of flooding may be easily identify.

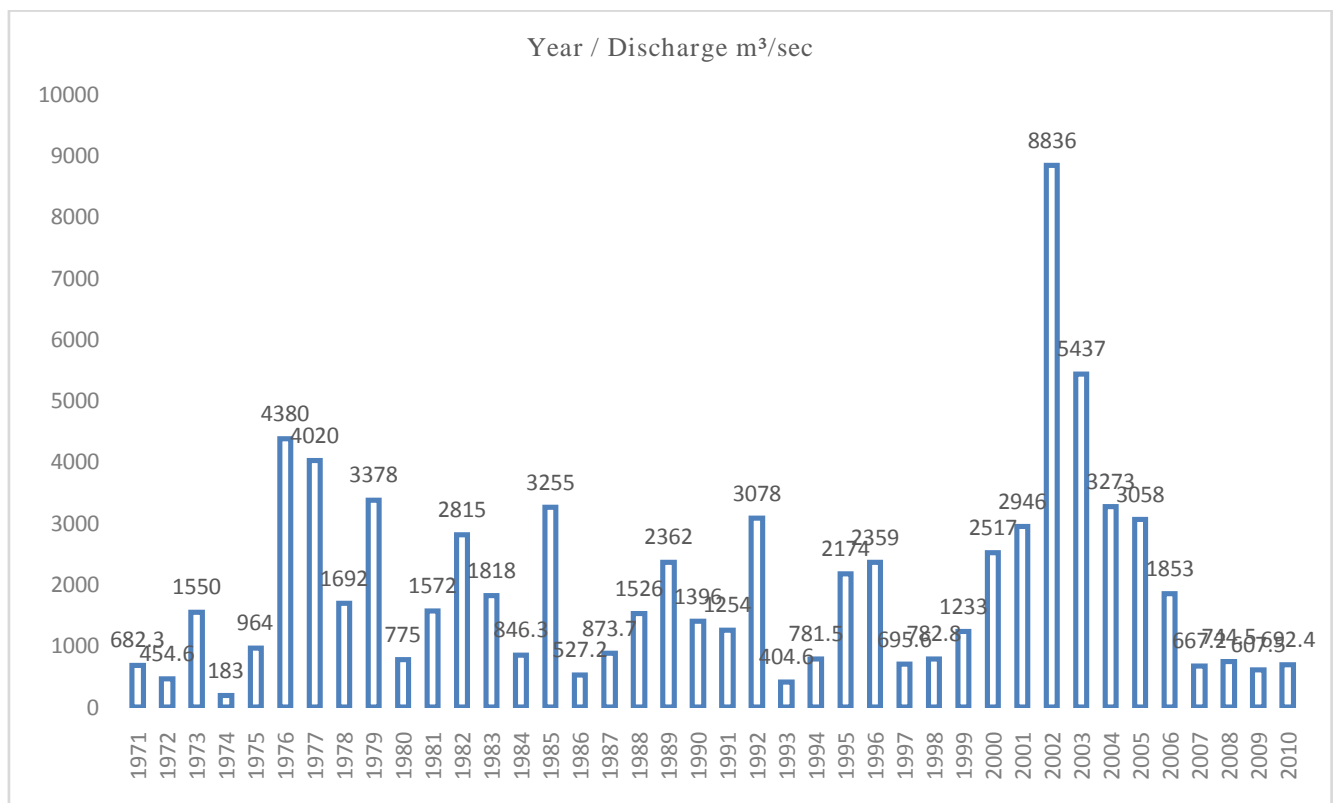


Figure 9: Year wise peak discharge capacity graph

Conclusion

The research study demonstrates the utility of ArcGIS and HECRAS combined used to quantification of flooding at different cross section and predict the chances of flooding at particular cross section. And it will give the water surface elevation height after applying peak discharge so future scope lies to create embankment near river and preparing floodplain mapping of river an also to develop flood risk map for navsari district under varying scenarios.

V. ACKNOWLEDGMENT

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