

**GMR Institute of Technology**  
An Autonomous Institute Affiliated to JNTUK, Kakinada



# **SIMULATION OF FLOW OF RIVER USING HEC-RAS: A CASE STUDY OF BRAHMANI RIVER**

*A Project Report submitted in partial fulfillment of the requirement for the award of degree of*

**BACHELOR OF TECHNOLOGY**

*in*

**CIVIL ENGINEERING**

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**AUGUST 2021.**



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**CERTIFICATE**

*This is to certify that the thesis entitled **SIMULATION OF FLOW OF RIVER USING HEC-RAS: A CASE STUDY OF BRAHMANI RIVER** submitted by **Y. JANAKI RAM, S. HARI KIRAN, T. VASUDEVULU NAIDU, B. TANUJA, U. SHAIK MAHABOOB BASHA, S. NANDA KISHORE** bearing Reg. No.: **17341A01B8, 17341A0197, 17341A01A8, 18345A0117, 18345A0116, 17341A01A0** has been carried out in partial fulfillment of the requirement for the award of degree of **Bachelor of Technology in Civil Engineering** of **JNTU, KAKINADA** is a record of bonafide work carried out by him under my guidance & supervision. The results embodied in this thesis have not been submitted to any other University or Institute for the award of any degree.*

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## NOTATIONS

<b>SYMBOL</b>	<b>DESCRIPTION</b>
HECRAS	Hydrological Engineering Centre-River Analysis System
ArcGIS	Aeronautical Reconnaissance Coverage Geographic Information System
DEM	Digital Elevation Model
WSE	Water Surface Elevation
GCS	Geographic Coordinate System
PCS	Projected Coordinate System



## **ABSTRACT**

A river is also known as second mother resource of water present in the earth. Although water coming from ground and rain plays a vital role as main source of water but the role of rivers cannot be ignored. The distribution of water from main sources to sub-channels is mostly carried by rivers. In India the behaviour of water flowing through the rivers are not constant as the rainfall depends on the continuously changing climate. Especially the rivers present in Odisha shows an uneven behaviour throughout the year. The present study represents the application of HEC-RAS simulation flow of the river Brahmani. In this analysis, Digital Elevation Model (DEM) files of various locations of Brahmani river are taken from Bhuvan site and are merged together in ArcGIS to form a single raster data file which contains entire Brahmani river. This merged raster data file having projected coordinated system is taken into HEC-RAS to conduct simulation flow for a certain precipitation and flow rate data. Here the study area is taken over Rengali reservoir of Angul district which is one of the major flood prone areas in Odisha state. The modeling is prepared for a specific period of time to observe the flow behavior of Brahmani river in and around Rengali reservoir. This analysis helps to identify the profiles like velocity profile, water surface profile, water depth and inundation characteristic of water both in tabular and graphical form. From this a flood simulation can be created which shows the flow of river water across the study area during the period of floods. This study provides information to water resources engineers for constructing different hydraulic structures, water management, flood control and environmental planning.

**Keywords:** Brahmani river, Rengali reservoir, Flood modeling, DEM files, ArcGIS, HEC-RAS, Precipitation, Flow rate, Flood simulation

# CHAPTER-1

## INTRODUCTION

### GENERAL:

#### 1.1 HEC-RAS:

“HEC-RAS” (Hydrologic Engineering Center River Analysis System) is numerical program for flow river hydraulic calculations. In this program three hydraulic components for flow analysis: Steady flow; unsteady flow; and sediment transport computations. One-dimensional flow characteristics calculations is usually used containing water surface profiles, energy grade line, depth of water, velocity, wetted perimeter for steady and unsteady river flow. These calculations are necessary in the analysis of various problems. “HEC-RAS” is a computer program that models the hydraulics of water flow through natural rivers and other channels. It was developed by the US Department of Defense, Army Corps of Engineers in order to manage the rivers. Hydrological flood analysis can be carried out using the open-source software HEC-RAS established by the U.S. Army Corps of Engineers. It can be applied for steady and unsteady flow during the model development stage. The current versions of it are capable of performing water surface calculations for increasingly varied steady flow in a river reach, or an entire network of channels. The constant flow module is used for modeling subcritical, supercritical, and mixed flow regime in water surface profiles. It relies on the result of the 1D energy equations. The peak discharge is applied at each cross section to achieve the full water surface elevation. The unsteady flow component of HECRAS simulates 1D unsteady flow through an entire network of open channels, and it mostly agrees with subcritical flow regime calculations.

It is also applicable to supercritical and rapidly varied flows. The well-defined geometric information in “HEC-RAS” includes information related to cross sections, reach lengths, and stream junctions. The unsteady component can model hydraulic connections between storage areas, reaches, pumping stations, and flap gated culverts. The other functions include floodplain encroachment, channel modification, bridge scour analysis, contraction, and expansion losses. The overall aim of this study was to model the high flood level or water surface elevation of river Brahmani by using “HEC-RAS” model at

its downstream and correlate to real-time flood monitoring data for calibration and validation of the model. Further, recurrence interval of the flood event also has been estimated to predict the future flood events. The HEC-RAS model is globally used for hydraulic analysis of river reaches. The model contains a hydraulic analysis component, graphical user interface, data management, and data storage capabilities.

## **1.2 Arc-GIS:**

1. Aeronautical Reconnaissance Coverage Geographic Information System.
2. “ArcGIS” is a geographic information system (GIS) application developed and maintained by the American company Esri.
3. It is an extensive and integrated software platform technology for building operational GIS (Geographic Information System).
4. “ArcGIS” comprises four key software parts:
  - a. A geographic information model for modeling aspects of the real world.
  - b. Components for storing and managing geographic information in files and databases.
  - c. A set of out-of-the-box applications for creating, editing, manipulating, mapping, analyzing and disseminating geographic information.
  - d. Collection of web services that provide content and capabilities (data and functions) to networked software clients.
5. ArcGIS Desktop consists of several integrated applications, including “ArcMap”, “Arc Catalog”, “Arc Toolbox”, “Arc Scene”, “Arc Globe”, and “ArcGIS Pro”.
6. “Arc Catalog” is the data management application, used to browse datasets and files on one's computer, database, or other sources.
7. In addition to showing what data is available, “Arc Catalog” also allows users to preview the data on a map.
8. “Arc Catalog” also provides the ability to view and manage metadata for spatial datasets.
9. “ArcMap” is the application used to view, edit and query geospatial data, and create maps.
10. “Arc Toolbox” contains geoprocessing, data conversion, and analysis tools, along with much of the functionality in “Arc Info”.

11. “Arc Scene” is an application which allows the user to view their GIS data in 3-D and is available with the 3D Analyst License.

### **1.3 Flood:**

An overflow of a large amount of water beyond its normal limits, especially over what is normally dry land is termed as Flood. It is one of the most dangerous natural disasters. It happens when excessive water is collected in any area. It usually happens due to heavy rainfall. India is highly prone to flood. There are many regions in the country that face this natural disaster because of the overflowing of rivers. Moreover, it also happens because of the melting of snow. Another reason for floods is when the dam breaks down. If we look at the coastal areas, the hurricanes and tsunamis are held responsible for causing floods. In this essay on flood, we will see the prevention and after-effect of flood.

In monetary terms, the extent of damages caused by floods is dependent on the location, extent, depth and duration of flooding, and the velocities of flows in the flooded areas, and the vulnerability and value of the natural and constructed environments they affect. Flood protection can be achieved through various structural measures such as dykes, diversion channels, reservoirs, floodway, improving channel conveyance capacity and non-structural A flood can be defined as a massive water flow exceeding the river capacity. Consequently, the water overflows and inundates flood plains or other plains bordering with the main river. Flood striking territories cannot be separated from the watershed. Watershed is a plain area with a complex hydrology unit holding, storing, and flowing the rainwater to be drained to the lake and sea. The area should be properly managed to reduce the impacts of disaster and flood strikes

Floods impact on both individuals and communities, and have social, economic, and environmental consequences. measures such as flood forecasting and warning, mass evacuation, watershed management, insurance and etc.

#### **Effects of floods:**

1. Agricultural lands are destroyed due to crops being submerged in water.
2. They wreck houses, particularly kuccha houses in the villages.
3. They cause disruption of all transport and communication.
4. There is shortage of drinking water.

5. They harm human, animal and plant life.
6. They cause a rise in epidemics because of waterlogging. Malaria and diarrhea are common diseases during floods.

**Floods in India:**

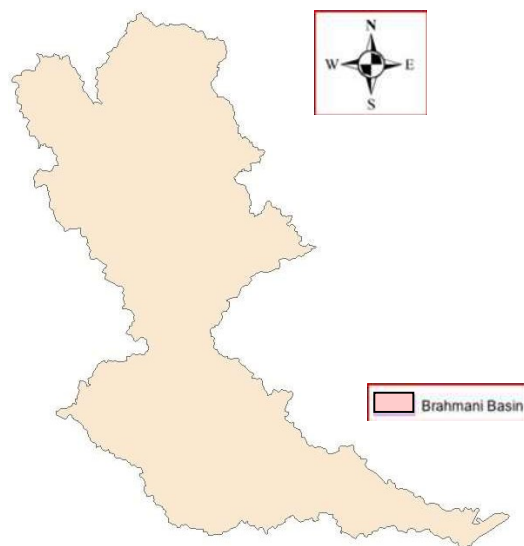
1. 2017 Mumbai Flood. 2017 Mumbai flood was the second worst regional flooding in Mumbai and can be compared with the 2005 floods.
2. 2017 Gujarat Flood.
3. 2017 West Bengal Floods.
4. 2017 Bihar Flood.
5. 2017 Northeast India Floods.
6. 2016 Brahmaputra Floods.
7. 2015 Chennai Floods.
8. 2015 Gujarat Floods.

**Major floods faced by Brahmani river:**

1. 1971 Sundergarh floods
2. 1980 Sambalpur floods
3. 1982 Phulbani floods
4. 1985 Sambalpur floods
5. 1997 Balasore floods
6. 2001 Balasore floods
7. 1999 Kendrapara floods
8. 2001 Jajpur floods
9. 2003 Cuttack floods
10. 2008 Angul floods
11. 2012 Keonjhar floods
12. 2013 Rayagada
13. 2017 Angul floods
14. 2021 Angul floods

The UN report stated that 2.3 billion people get affected and 1,57,000 people life massacred by the flood disaster globally during the period 1995–2015. The countries have rich in river resources but the lack of proper management to regulate river resulting more challenges from the flood. India is one of them that has plenty of river resources and is severely affected by floods due to intense rainfall, non-uniform geographical structure, bank erosion, improper management, etc. India is one of those countries, where availability of surface water is more in the form of rivers and the large community of people lives near the bank of the river. Around 12% geographical area in India is affected by flood and every year, 3.47 million Indians faces flood risk. Almost, all Indian rivers cross water surface elevation level/danger line especially in monsoon seasons and distress to the mass of the population. In this regard, the accurate prediction about river flood could be an effective tool for the prevention of disaster. The exact prediction of flood potential gives sufficient time to apply required preventive measures for security.

The prediction of flood potential through GIS applications could be helpful to apply preventive measures and plan mitigation strategies. HEC-RAS (Hydrologic Engineering Center, River Analysis System) software is very useful tool to give the easy prediction of possible potential of flood and used worldwide for prediction of the potential water disaster.



**Fig-1.1** Brahmani river basin

#### **1.4 Objectives of the project:**

1. To create a merged raster file using DEM files of the study area and to change its coordinate system.
2. To generate stage and flow hydrographs of the study area for the applied data.
3. To generate the geometry (2D Flow Area) of the study area using RAS MAPPER tool in HEC-RAS.
4. To conduct the Unsteady flow analysis of Brahmani river using HEC-RAS.
5. To delineate the flood simulation in the year 2021 for one day of July month.
6. To find Maximum depth, maximum velocity and maximum WSE.

## **CHAPTER-2**

### **STUDY AREA**

#### **2.1 Brahmani river:**

Brahmani is a major seasonal river in the Odisha state of eastern India. Brahmaniriver is formed by the confluence of the rivers South Koel and Sankh near the major industrial town of Rourkela at 22°15' N and 84°47' E. It flows through the districts of Sundargarh, Deogarh, Angul, Dhenkanal, Cuttack, Jajpur and Kendrapara. Together with the river Baitarani, it forms a large delta before emptying into Bay of Bengal at Dhamra.

The Sankh has its origins near the Jharkhand-Chhattisgarh border, not far from the Netarhat Plateau. The South Koel too arises in Jharkhand, near Lohardaga, on the other side of a watershed that also gives rise to the Damodar River. Both of these sources are in the Chota Nagpur Plateau.

The physiography of the Basin is defined by four regions:

1. The northern plateau
2. The eastern ghats
3. The coastal plains
4. The central tablelands

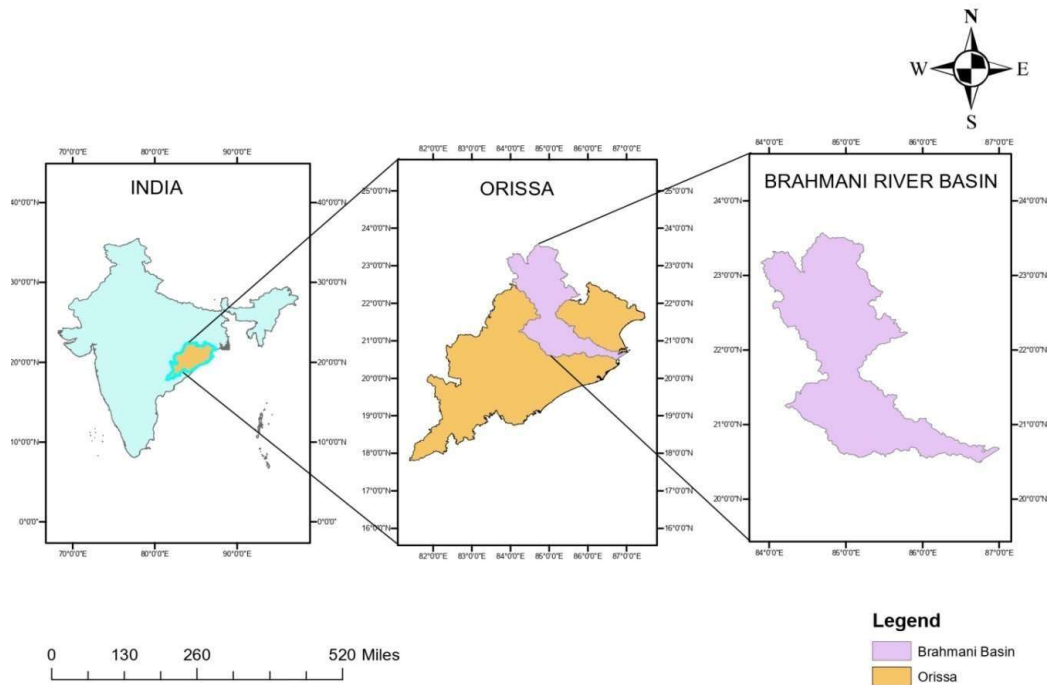
South Koel River near Jaraikela, Orissa which is one of the two tributaries of Brahmani River is 285 km long. After assuming the name of Brahmani, the river crosses the Tamra and Jharbera forests, skirting along National Highway 23. It then passes the town of Bonaigarh in Sundargarh district before being dammed at Rengali in Anugul district. A large reservoir of the same name is created as a consequence. It then flows through the towns of Talcher and Dhenkanal before splitting up into two streams. The main stream flows by the town of Jajpur Road beyond which it is crossed by National Highway 16 and the Kolkata-Chennai mainline of East Coast Railway.

At about 480 kilometres (300 mi) long, the Brahmani is the second longest river in Odisha after the Mahanadi. However, if its constituent rivers are included its length extends to about 799 kilometres (496 mi), of which 541 kilometres(336 mi) are in Odisha. It has a catchment area of about 39,033 square kilometres (15,071 sq mi) in Odisha alone. Apart from the Rengali dam mentioned



above, there also exists a barrage shortly before Talcher called Samal Barrage. The Jokadia and the Jenapur bridges are the other irrigation projects on the river. Near its mouth, the river is also crossed by the Odisha Coast Canal that takes water from it.

## 2.2 Study area:



**Fig-2.1** Thematic map of study area

Angul is a town and a municipality and the headquarters of Angul district in the state of Odisha, India. Angul is located at 21.21°N 86.11°E. Angul has an average elevation of 195 m above sea level. The total geographical area of the district is 6232 km<sup>2</sup>. From the point of view of area, it stands 11th among the 30 Districts of Odisha.

- **Weather:** 26 °C, Wind E at 8 km/h, 93% Humidity
- **Population:** 44,390 (2011)
- **Nearest city(s):** Cuttack, Sambalpur, Bhubaneswar.
- **Sex ratio:** 893 female per 1000 male

Rengali dam is a dam located in Odisha, India. It is constructed across Brahmani River in Rengali village, located 70 km from Angul in Angul district. The dam was constructed in 1985. The project was not welcomed by the local people during the conception and initial implementation of the project due to the displacement of several people and the way the government tackled the issue. The project has displaced a total of 10,700 families.

Rengali Dam is 70.5 m tall and 1040 m wide. The reservoir formed by the dam is the second largest reservoir in Odisha, with 37,840 hectares at full level and 28,000 hectares at mean level. The reservoir has a catchment area of 25,250 km<sup>2</sup>, mostly forests and wasteland. The dam is also used to generate electricity using five turbines with a capacity of 50 MW each. The dam holds 3412 million cubic meters of water at Full Reservoir Level (FRL).

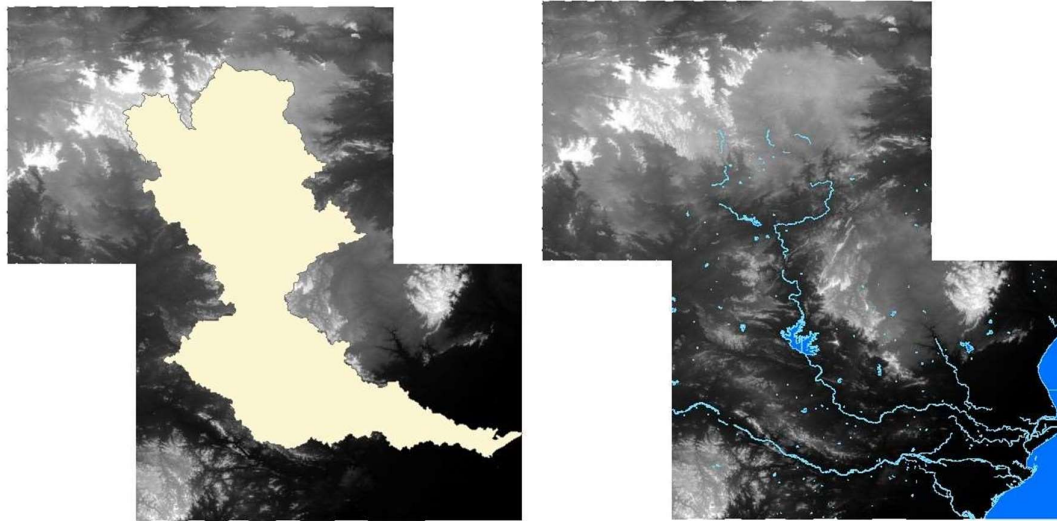
### **2.3 Flood modelling:**

Flood risk assessments are carried out to identify the source of potential flooding, the extent of flooding and the proposed mitigation and protection measures. 1D and 2D hydraulic models can be used to simulate flood events enabling us to have a better understanding of flood risk, allowing us to develop options to manage that risk. Our experienced hydrologists and engineers use hydraulic flood models and ground modeling to assess the impact of flooding on a development and the impact of the development on a watercourse. Models can also be used to assess overtopping or breach scenarios and to undertake blocked culvert analysis. The results can then be used to determine levels of flood protection, developing mitigation and alleviation options.

A good hydraulic model requires a good geometry and flow data input. However, the goodness of the simulations are also affected by model type, i.e. one dimensional (1D), two dimensional (2D) or combined (1D/2D) types. 1D model is widely used to simulate flow in the main river channel and in certain cases very effective in predicting flood extent.

### **2.4 Data collection:**

The downloaded DEM files from Bhuvan software are merged together to get the required study area.



**Fig-2.2** Brahmani river and its basin shape files over DEM files

Data requirement for the HEC-RAS is one of the most important parts of the study. Basically, HEC-RAS require some input data, which are:

1. Geometric data of river—Width, elevation, shape, length, location, geomorphic shape, Boundary condition, slope.
2. River floodplain data—Length, elevation.
3. Cross section of the river at required locations.
4. Manning's coefficient of studied river, floodplain, and other required land use pattern
5. River flow value.
6. Water discharge data.

The selection of appropriate stations and their depth profiles and cross sections area are essential for HEC-RAS modeling. After putting the values of input parameters, the major outputs are found:

1. Water surface elevations
2. Hydraulic properties i.e., energy grade line slope and elevation, flow area, velocity.
3. Visualization of stream flow shows the extent of flooding.

## **2.5 Applications:**

1. Floodplain mapping
2. Flood level assessment
3. Flood routing
4. Breach of coastal/fluvial defences
5. Overtopping of coastal/fluvial defences
6. Dam breach assessment
7. Culvert capacity assessments
8. Sewer network assessments
9. Flood prevention and protection

## CHAPTER-3

### LITERATURE REVIEW

Sl.no	Author	Year	Title of the paper	Methodology	Observation
1	RifkiRandaSyafri  MuhammadpramonoHadi	2020	HYDRODYNAMIC MODELLING OF JUWANA RIVER FLOODING USING HEC RAS 2D	HEC RAS 5.0.6 software with a 2D model.  Flood inundation model	This study aimed to examine the discharge and distribution of floods based on the return period of floods 2,5,10,25,50,100 years. HEC-RAS 5.0.6. Hydrodynamic modelling had been able to model flood inundation. Meanwhile, the capability greatly depended on the hydrological analysis and DEM resolution. The higher the DEM resolution, the better the way to represent flood that occurs in the field.
2	MadhusmitaGhadai  Deba Prakash Satapathy	2020	ANALYSIS OF HYDRODYNAMIC BEHAVIOUR OF BRAHMANI RIVER USING HEC RAS	Importing data from Bhuvan website. Creating new project and merging the terrain files.  Land use and land cover Plotting Geometrical data.  Editing Manning's N (or) K values.	HEC RAS model is a very useful model for computation of real time hydrodynamic behaviour of rivers. In this study it is found that the flow characteristic and velocity profile changing with changing the season and cross section.
3	Muhammad KashfyZainalfikry,	2020	HEC-RAS One-Dimensional	HEC-RAS 5.0 to simulate 1D	This paper involves one-dimensional flood

	Aminuddin Ab Ghani  Nor Azazi Zakaria and Ngai Weng Chan		Hydrodynamic Modelling for Recent Major Flood Events in Pahang River	hydrodynamic of a large scale river	modelling consisting of three main phases beginning with hydrological modelling, hydraulic modelling and eventually flood level and flood inundation analysis.  The model developed to analyse and predict water levels along the river reach, which the total length of the reach is almost 450 km.
4	Zainab Ali Omran  Nariman Yahya Othman  Zahra Abd Saleh	2019	STEADY FLOW ANALYSIS FOR SHATT AL- HILLA USING HEC-RAS PROGRAM	HEC RAS	In this paper, to perform flow parameters, the steady flow component was used of the Shatt Al Hilla to analyze this hydraulic system, geometric data, schematic of river, length of the reach, coefficient of Manning, contraction coefficient and expansion coefficient.  High probability of embankments erosion and may cause natural series of frequently shifting bends.
5	Sumit B. Patel, Darshan J. Mehta, Sanjay M. Yadav	2018	ONE DIMENSIONAL HYDRODYNAMIC FLOOD MODELING FOR AMBICA RIVER, SOUTH GUJARAT	Hydraulic modelling using HEC-RAS	The hydrodynamic flood modelling for the Ambica River in present study was performed using the HEC-RAS for one dimensional steady flow analysis The model was run for one dimensional steady flow water surface profile computations for

					river.  The energy equation, using the standard step method, solved the steady flow, while Manning's equation and contraction and expansion coefficients determined head losses.
6	Ismail Mondal JatisankarBandyopadhyay	2016	ESTIMATION OF HYDRODYNAMIC PATTERN CHANGE OF ICHAMATI RIVER USING HECRAS MODEL, WEST BENGAL INDIA.	Hydrodynamic modelling-HEC RAS  Remote sensing Hydraulic simulation Nonlinear unsteady flow	Flow depth, velocity, shear stress and wave celerity can be determined from flood hydraulics by the model. In all cases shear stress increases with the increasing rate of shear stress is heigher with the depth ratio in comparable to width ratio. Low magnitude of boundary shear stress is resulted in the outer bend as compared to the inner bend of a compound meandering channel.
7	Vieux BoukhalyTraore, MamadouBop, Moustapha Faye, Giovani Malomar, El HadjOumarGueye	2015	Using of Hec-ras Model for Hydraulic Analysis of a River with Agricultural Vocation: A Case Study of the Kayanga River Basin, Senegal	Arcgis software  Hec-ras model to compute the flow characteristics to analyze the hydraulic behavior.	This paper focusses on using Hec-ras model to compute the flow characteristics to analyze the hydraulic behavior. Hec-ras model was used to calculate the main flow characteristics along the study reach. This has allowed locating the high, low and constant flow characteristics areas. Certain parameters such as total surface area, volume decrease from upstream to downstream.

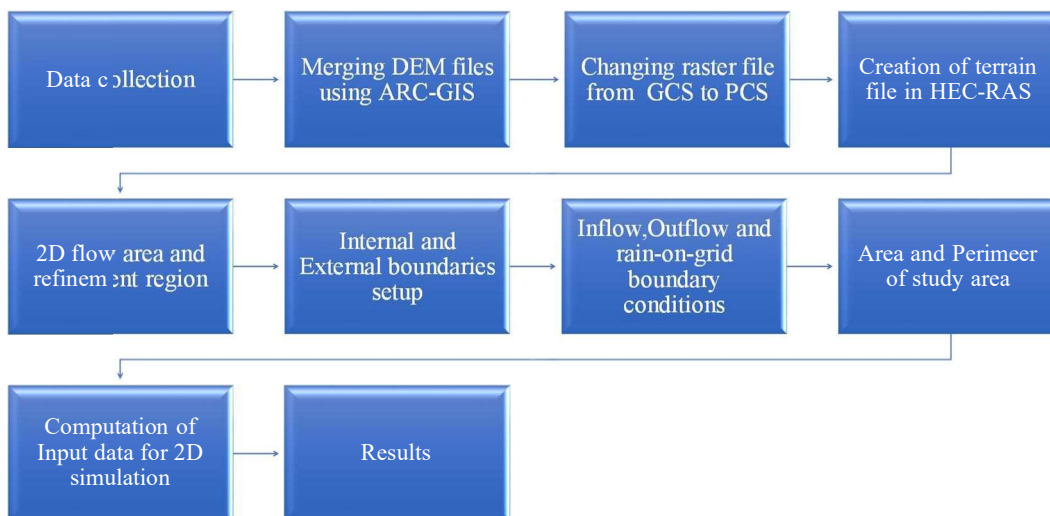
8	P.V.Timbadiya P.L.Patel P.D.Porey	2014	HEC RAS BASED HYDRODYNAMIC MODEL IN PREDICTION OF STAGES OF LOWER TAPI RIVER	Hydrodynamic model Flood and stage hydrograph, HECRAS Stimulation of stages using HEC RAS	Hydrodynamic model of the lower Tapi river from ukai dam to surat city. The reasearch analyzed that an attempt has been made to stimulate the different past floods using HEC RAS hydrodynamic model for the Tapi river taking flood hydrograph at ukai dam and stage hydrograph at Surat city. The mentioned hydrographic model could be useful in computation of flood situation in Tapi basin including the Surat city.
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# CHAPTER-4

## METHODOLOGY

### 4.1 Flow Chart:



**Fig-4.1** Flowchart

### 4.2 Downloading DEM files from Bhuvan site and CWC:

1. Open “Bhuvan” site and go to “Open Data Archive”. Create a new account and fill all the necessary credentials or log in with username and password if there is already an account.



**Fig-4.2** Bhuvan site

2. Select “Satellite/sensor” in the category and select”Rresourcesat-1/resourcesat-2 LISS-3” in subcategory.
3. Go to “Tiles” in select area option and press “Start”. The tiles can be selected using the co-ordinates displayed on the right bottom side of the screen.

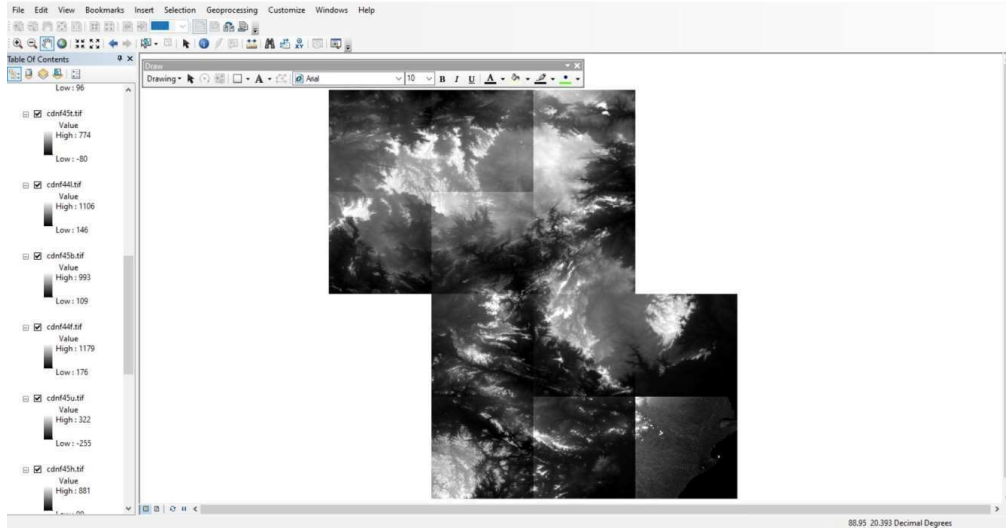


**Fig-4.3** Open data archive

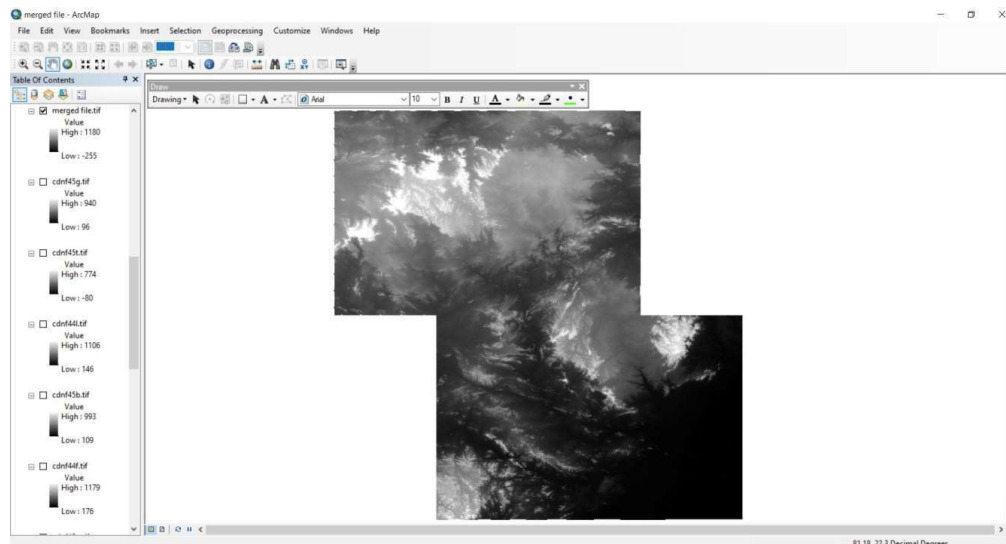
4. Select the tiles of Indian locations displayed on the right side of the screen that you want to download. Then press “Stop” and “download” the selected tiles.
5. Extract the downloaded files into the desired location before using them in the project.

#### **4.3 Merging of DEM files using HEC-RAS:**

1. Open ARC-GIS software and change its co-ordinate system to WGS-1984.
2. Click on add data and open selected raster files that are downloaded from bhuvan website.
3. Now the individual raster files appear in ARC GIS. Open add tool box(new dialogue box appears) and then click on data management tools.



**Fig-4.4** Before merging of individual DEM files



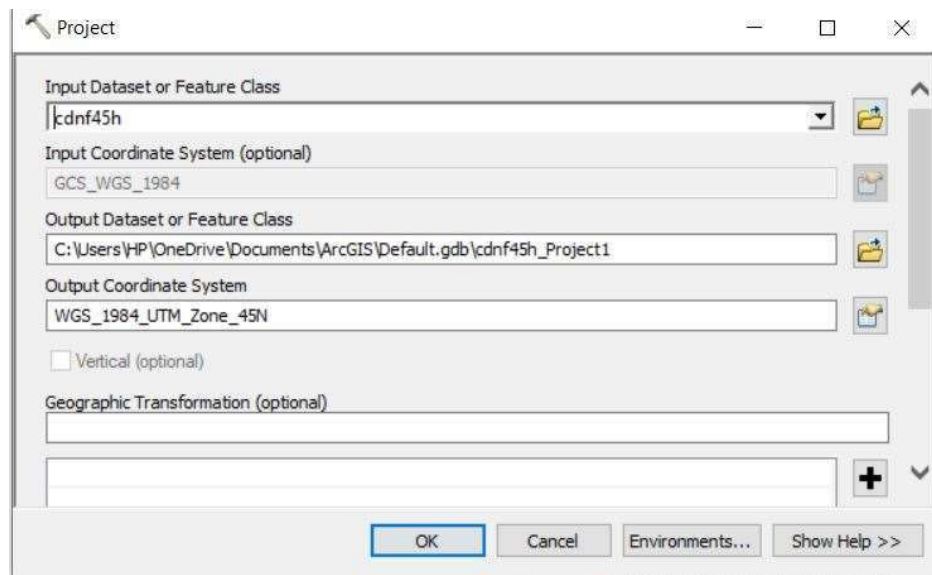
**Fig-4.5** After merging of individual DEM files

4. Click on raster to select raster data sheet. Click on mosaic to new raster(new dialogue box appears).
5. Select input raster files that are needed to be merged. Select the output location of merged mosaic file.
6. Give a specific name to the new merged mosaic file. Also change its pixel type and cell size (if needed) and then click OK.

7. Change its spatial reference system if necessary and then assign number of bands.
8. Now the raster files are merged and converted into single raster sheet so that it would be easy to perform further details in HEC-RAS.

#### 4.4 Changing raster file from GCS to PCS:

1. First open “ArcGIS” software and create a new file. Add the merged file to which the projected co-ordinate system is to be applied.
2. Right click on the added data layer on the left side of the screen and go to properties to check in which co-ordinate system the file is added.
3. If it shows GCS\_WGS\_1984 that means the file is in geographic co-ordinates.
4. So, it should be changed to plane coordinates that means projected co-ordinates.
5. Go to “Arc toolbox” and then go to “Data management tool”.
6. Click on projection and transformation option in that raster is there go to project raster click on that.



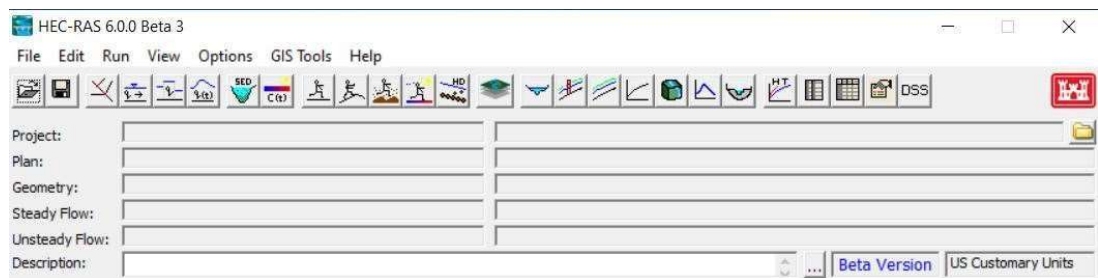
**Fig-4.6** Applying Projections and Transformations to the merged file

7. A file box opens in that input raster is there we should add the file and then go to output raster save the file as projected.
8. Go to output coordinate system and go to projected coordinate system. In that go to WGS 1984 and then go to UTM.

9. Select Northern hemisphere and in there select WGS 1984 UTM ZONE 45N and click OK.
10. The file projected will be shown in right bottom of the system. Right click on the layer and go to properties to confirm that the file is in projected coordinate system.

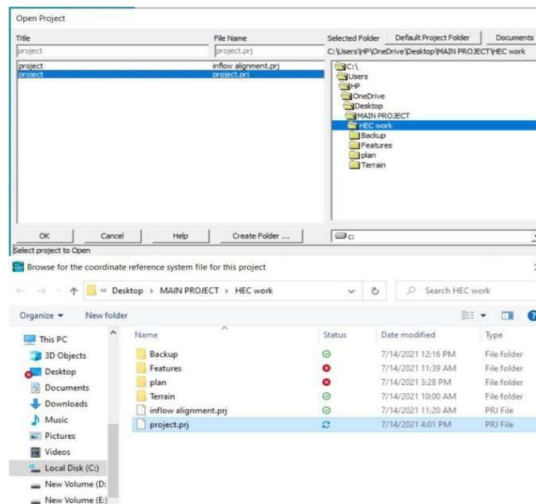
#### 4.5 Creation of terrain file in HEC-RAS :

1. Open HEC RAS 6.0 and create a new file and give a name to it. Default units are set in SI units.



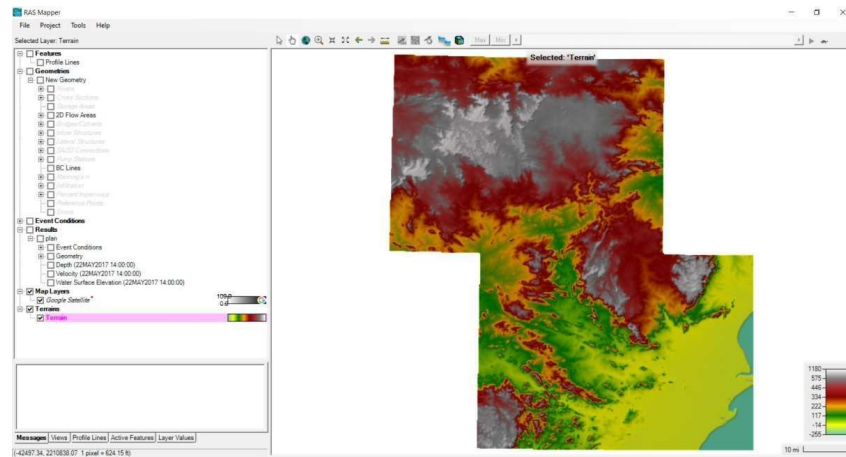
**Fig-4.7** HEC RAS home page

2. Set projection before creating a new RAS mapper file.



**Fig-4.8** Creating a new project in HEC RAS

3. Open RAS mapper and select the merged DEM file that is saved in ArcGIS.
4. Check by adding map and change transparency to see whether the ArcGIS file is set in correct position or not.

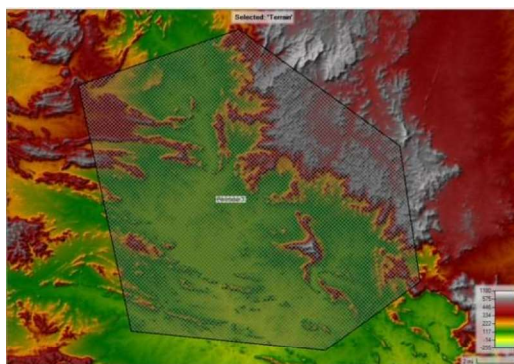


**Fig-4.9** Terrain in RAS mapper

5. Add Google satellite view by creating a new web imagery layer.
6. Save the file by naming it.

#### 4.6 2D flow area and refinement region:

1. Go to Geometry and right click on it to add new Geometry (new window appears).
2. Now start editing 2D flow area by defining the perimeter. Select the area needed to be assessed for perimeter and save it by giving it a name. Give the grid size and now it's been defined but not been enforced.
3. Right click on the perimeter region to edit its properties and generate the computational points.



**Fig-4.10** Perimeter



**Fig-4.11** Break line



**Fig-4.12** Refinement region



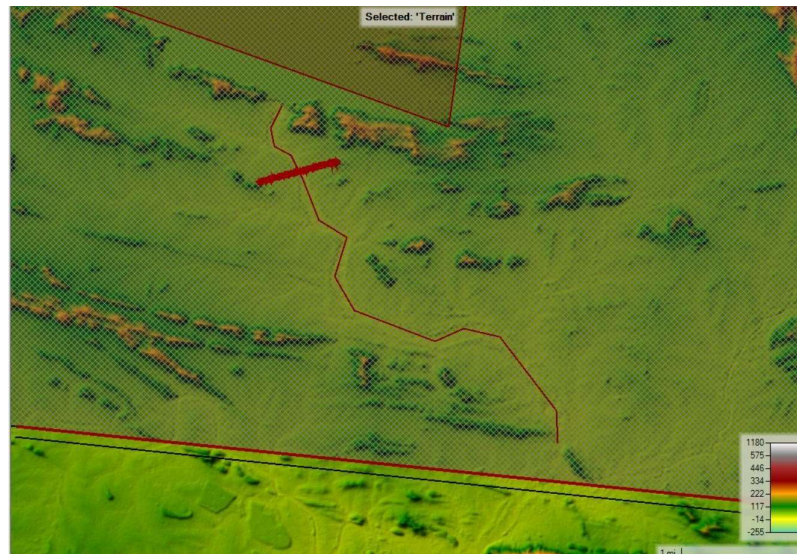
**Fig-4.13** Computational points

4. Now a grid like structure appears on the screen which means the perimeter of the selected area has been created. Save the edits of perimeter region after stop editing.
5. Now edit its break lines by right clicking on it and start editing. This break line indicates the flow of river from upstream to downstream. Assign its properties.
6. Go to perimeter properties and generate computation points again. Thus, the break line is enforced into the perimeter. Stop editing and save the edits.
7. Next, a polygon is to defined which indicates the reservoir in the selected area for the refined region.
8. Draw a polygon of required areas and shape which can be used for future construction of dam next to it.
9. Edit its properties. Give cell spacing. Go to perimeter properties and generate computation points. Stop editing and save the edits.
10. Edit new geometry to add a new computation point which splits the cell that has more than 8 sides.
11. Edit the geometry again by clicking on force mesh re-computation (avoid generate computation points so that it does not affect the already existed polygon area).
12. Close it and save it to set up internal and external boundary conditions.

#### **4.7 Internal and external boundaries setup:**

1. Add BC (Boundary Conditions) line and draw outside the perimeter and set 2D area type as catchment and connection type as external.

2. Add profile line inside the perimeter and save it with a file name. Export it into the folder where the geometry data is being saved.
3. Stop edits and save edits so that two lines are formed, one inside and other outside the perimeter.
4. Open attributes table of the break lines set previously. Add the exported profile line and give near spacing and far spacing.
5. Generate computational points for this process and stop edits and save edits.
6. Open attributes table of the BC lines. Add the profile line from the break lines to it.
7. Set 2D area type as inflow alignment and connection type as internal. Stop and save edits.
8. The catchment line acts as external boundary for the perimeter and inflow alignment line acts as internal boundary for the perimeter.



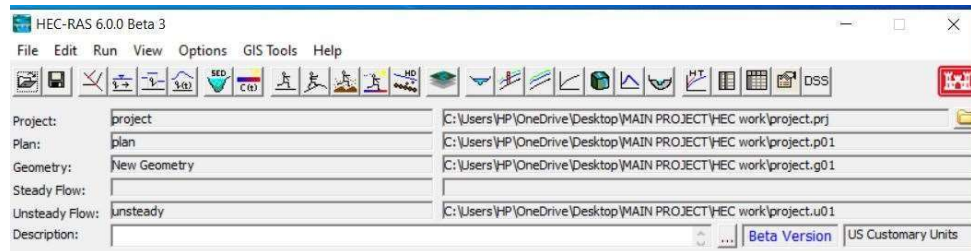
**Fig-4.14** Internal and external boundary setup

#### **4.8 Inflow, outflow and rain-on-grid boundary conditions:**

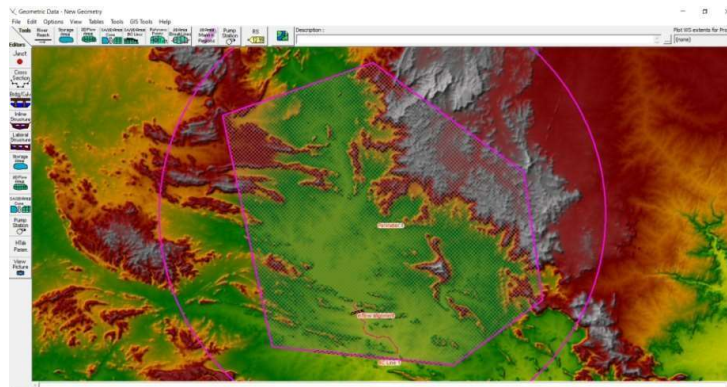
1. Open unsteady flow data in RAS mapper → open geometry → cross the channel at required places → double click (a new window appears i.e., measure line) → click on cut profile from terrain and plot (graph appears).
2. Measure distance of bottom points in the graph (check  $dy/dc$  which represents slope).
3. Again cross the channel at different place and follow the same process (it gives accurate results). → Exit geometric viewer. → Enter boundary conditions in unsteady flow data.



4. Click on normal depth where a downstream boundary window appears and give friction slope as 0.01, Click OK.
5. For inflow at the top click on flow hydrograph (new window appears and give a zero flow) → give its slope to 1.5 percent for 1 hour duration → click on add 2D flow area → select all → click OK.



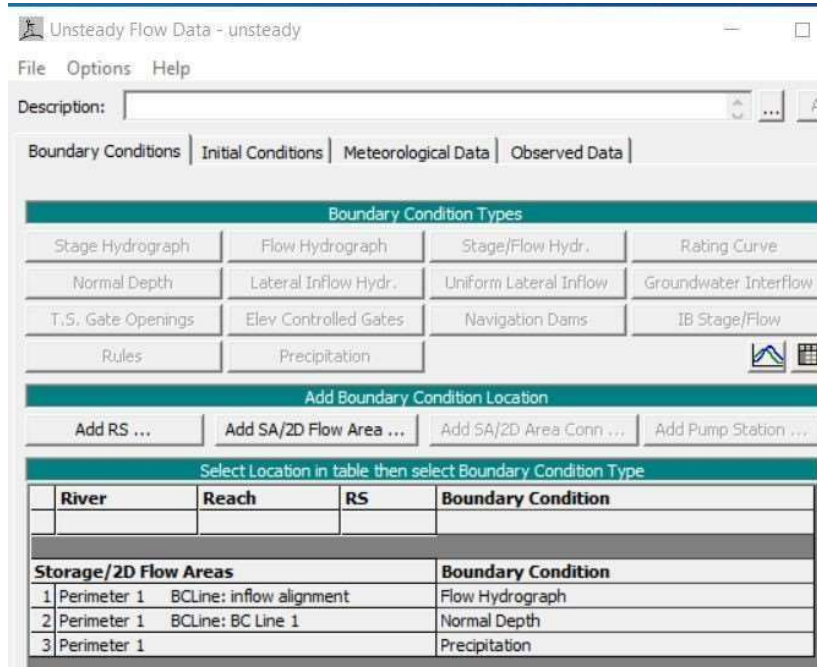
**Fig-4.15** Saving geometry data



**Fig-4.16** Geometry data of set perimeter

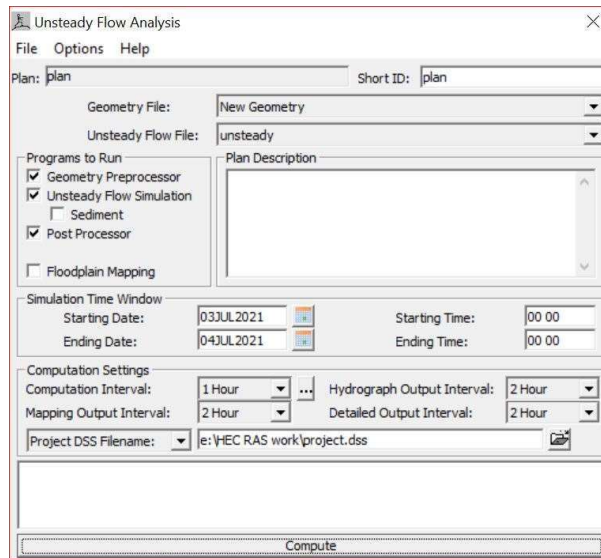
6. Click on precipitation in unsteady flow data (precipitation hydrograph window appears) → give rainfall data that is taken from internet and developed in a spreadsheet → change the data time interval to 12 hours and paste the copied intensities of rainfall data from spread sheet.
7. Click on plot data (precipitation hydrograph appears with time intervals) → click ok → save unsteady flow data → close it.
8. Open unsteady flow analysis → give access to geometry pre-processor, unsteady low simulation, post processor → give simulation time window details for 1 month.
9. Change computational settings (computation interval-12 hours and remaining to 1 month each) → save this with new name. → Click on compute (if error occurs re-do it and eliminate errors).

- Close computations output and go to RAS mapper. →turn on results to watch the animations of run-off depths.



**Fig-4.17** Giving unsteady flow data

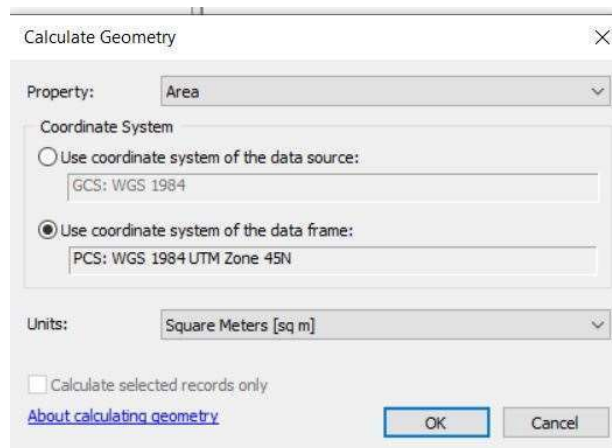
- Click on profile lines, right click on saved file→plot time series→ flow (precipitation hydrograph appears).
- Click on table→ select hydrograph values, copy and paste these into unsteady flow fileunsteady flow data→flow hydrograph→paste in flow column and change the data time interval to 1 minute). →Click on plot data to check the hydrograph → ok.
- Delete the precipitation by taking out the storage area in options. →Close unsteady flow data→go to unsteady flow analysis and re-run this plan by clicking on compute. →Close it.
- Open RAS Mapper → check depths in results(shows only run-off in the channel itself excluding rainfall), → turn on profile line we can see the flow going both sides in animation.



**Fig-4.18** Unsteady flow analysis

#### 4.9 Area and perimeter of study area:

1. Open “ArcGIS” and add basin shape file to the layers. Right click on the added layer and open attributes table.



**Fig-4.19** Calculating area and perimeter

2. Go to table options and select “add field” and give name. Select output type as double and scale as 3 and set precision up to 15 to get accurate results.
3. Now the field is added to the attributes table. Right click on it and click on “calculate geometry”.

- Select property type as “area” and units as sq m. Make sure the “added file” is in projected co-ordinate system. If not set it to PCS from GCS.
- Click “OK” and it shows the area covered by the basin. Similarly same process is adapted for perimeter but the units are set to m.

Also X and Y co-ordinates of centroid of the basin can be calculated if required using the same process with “m” as units.

#### 4.10 Computation of Input data for 2D simulation:

- The input data for the simulation of the selected area is set in unsteady flow data.
- Three different data are given namely flow hydrograph, normal depth and precipitation.
- Check all parameters of the geometry set previously so that no error occurs during computation of the set input data.

Normal Depth Downstream Boundary

Fig-4.20 Normal depth

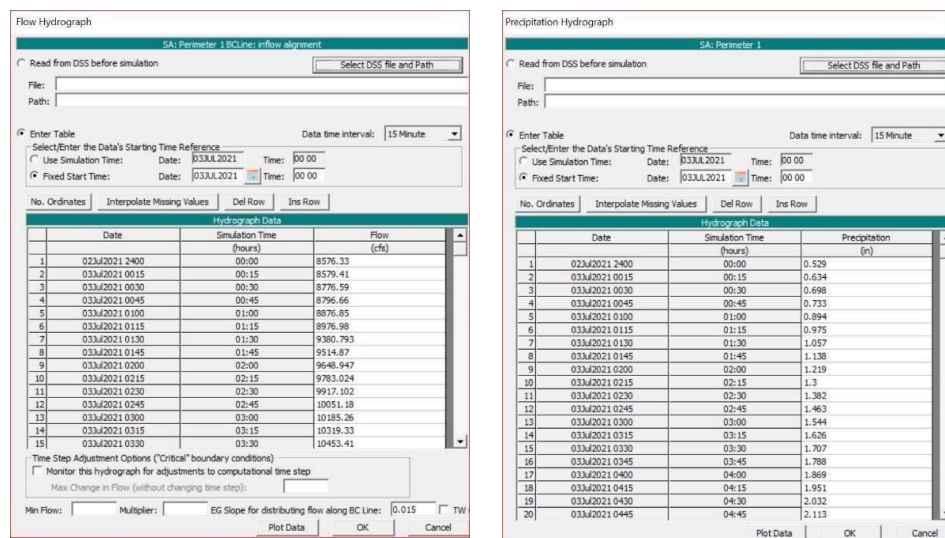


Fig-4.21 Flow and Precipitation data

## CHAPTER-5

### RESULTS AND DISCUSSIONS

#### 5.1 Obtaining area and perimeter:

1. All these results are précised up to 3 decimal points.
2. The area and perimeter of the taken study area covers the entire Rengali reservoir.
3. The area and perimeter also covers a dam named Rengali dam at the downstream of reservoir.

FID	Shape *	Id	perimeter	area	length X	length Y
0	Polygon	0	1739488.29	38566946576.492	297679.835	2427952.766

**Fig-5.1** Area and Perimeter

4. The perimeter of the study area is found to be 1739488.29 m or approximately 1739.50 km.
5. The area of the study area is found to be 38566946576.492 m<sup>2</sup> or approximately 38566.95 km<sup>2</sup>.
6. The X-co ordinate length of the study area is found to be 297679.835 m or approximately 297.68 km.
7. The Y-co ordinate length of the study area is found to be 2427952.766 m or approximately 2427.95 km.
8. These parameters give an overall view of the study area that undergoes simulation.

#### 5.2 Flow hydrograph:

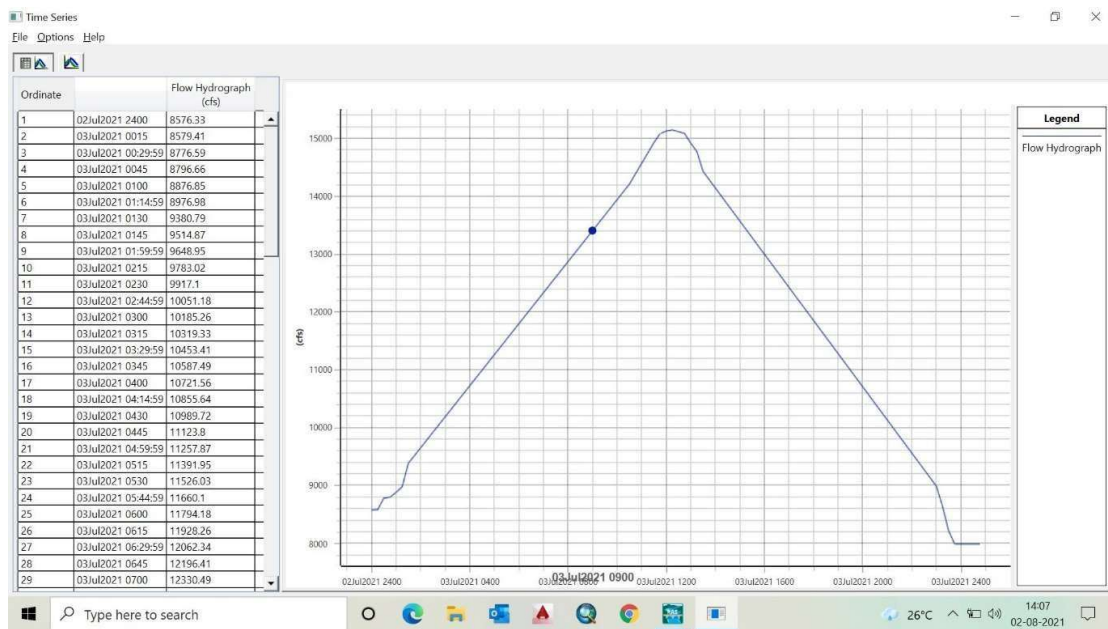
**Table-5.1** Time series data of flow

SI. No.	Date & Time	Rate of flow (cfs)	SI. No.	Date & Time	Rate of flow (cfs)
1	02Jul2021 2400	8576.33	51	03Jul2021 12:29:59	15116.09
2	03Jul2021	8579.41	52	03Jul2021	15086.05

	0015			1245	
3	03Jul2021 00:29:59	8776.59	53	03Jul2021 1300	14916.42
4	03Jul2021 0045	8796.66	54	03Jul2021 13:14:59	14773.2
5	03Jul2021 0100	8876.85	55	03Jul2021 1330	14429.97
6	03Jul2021 01:14:59	8976.98	56	03Jul2021 1345	14286.74
7	03Jul2021 0130	9380.79	57	03Jul2021 13:59:59	14143.51
8	03Jul2021 0145	9514.87	58	03Jul2021 1415	14000.28
9	03Jul2021 01:59:59	9648.95	59	03Jul2021 1430	13857.05
10	03Jul2021 0215	9783.02	60	03Jul2021 14:44:59	13713.82
11	03Jul2021 0230	9917.1	61	03Jul2021 1500	13570.6
12	03Jul2021 02:44:59	10051.18	62	03Jul2021 1515	13427.37
13	03Jul2021 0300	10185.26	63	03Jul2021 15:29:59	13284.14
14	03Jul2021 0315	10319.33	64	03Jul2021 1545	13140.91
15	03Jul2021 03:29:59	10453.41	65	03Jul2021 1600	12997.68
16	03Jul2021 0345	10587.49	66	03Jul2021 16:14:59	12854.45
17	03Jul2021 0400	10721.56	67	03Jul2021 1630	12711.22
18	03Jul2021 04:14:59	10855.64	68	03Jul2021 1645	12568
19	03Jul2021 0430	10989.72	69	03Jul2021 16:59:59	12424.77
20	03Jul2021 0445	11123.8	70	03Jul2021 1715	12281.54
21	03Jul2021 04:59:59	11257.87	71	03Jul2021 1730	12138.31
22	03Jul2021 0515	11391.95	72	03Jul2021 17:44:59	11995.08
23	03Jul2021 0530	11526.03	73	03Jul2021 1800	11851.85
24	03Jul2021	11660.1	74	03Jul2021	11708.62

	05:44:59			1815	
25	03Jul2021 0600	11794.18	75	03Jul2021 18:29:59	11565.4
26	03Jul2021 0615	11928.26	76	03Jul2021 1845	11422.17
27	03Jul2021 06:29:59	12062.34	77	03Jul2021 1900	11278.94
28	03Jul2021 0645	12196.41	78	03Jul2021 19:14:59	11135.71
29	03Jul2021 0700	12330.49	79	03Jul2021 1930	10992.48
30	03Jul2021 07:14:59	12464.57	80	03Jul2021 1945	10849.25
31	03Jul2021 0730	12598.64	81	03Jul2021 19:59:59	10706.02
32	03Jul2021 0745	12732.72	82	03Jul2021 2015	10562.79
33	03Jul2021 07:59:59	12866.8	83	03Jul2021 2030	10419.57
34	03Jul2021 0815	13000.88	84	03Jul2021 20:44:59	10276.34
35	03Jul2021 0830	13134.95	85	03Jul2021 2100	10133.11
36	03Jul2021 08:44:59	13269.03	86	03Jul2021 2115	9989.88
37	03Jul2021 0900	13403.11	87	03Jul2021 21:29:59	9846.65
38	03Jul2021 0915	13537.18	88	03Jul2021 2145	9703.42
39	03Jul2021 09:29:59	13671.26	89	03Jul2021 2200	9560.19
40	03Jul2021 0945	13805.34	90	03Jul2021 22:14:59	9416.97
41	03Jul2021 1000	13939.42	91	03Jul2021 2230	9273.74
42	03Jul2021 10:14:59	14073.49	92	03Jul2021 2245	9130.51
43	03Jul2021 1030	14207.57	93	03Jul2021 22:59:59	8987.28
44	03Jul2021 1045	14387.32	94	03Jul2021 2315	8644.05
45	03Jul2021 10:59:59	14567.07	95	03Jul2021 2330	8214.5
46	03Jul2021	14746.82	96	03Jul2021	7984.94

	1115			23:44:59	
47	03Jul2021 1130	14926.57	97	03Jul2021 2400	7984.78
48	03Jul2021 11:44:59	15081.32	98	04Jul2021 0015	7984.62
49	03Jul2021 1200	15126.27	99	04Jul2021 00:29:59	7984.55
50	03Jul2021 1215	15146.11	100	04Jul2021 0045	7984.24



**Fig-5.2** Flow hydrograph

1. The graph gradually increased from the starting time July 3, 2021 12 : 00 AM to July 4, 2021 12 : 45 AM with a constant slope.
2. This indicates that the rate of flow increased gradually as the precipitation occurred over the 24-hour time period.



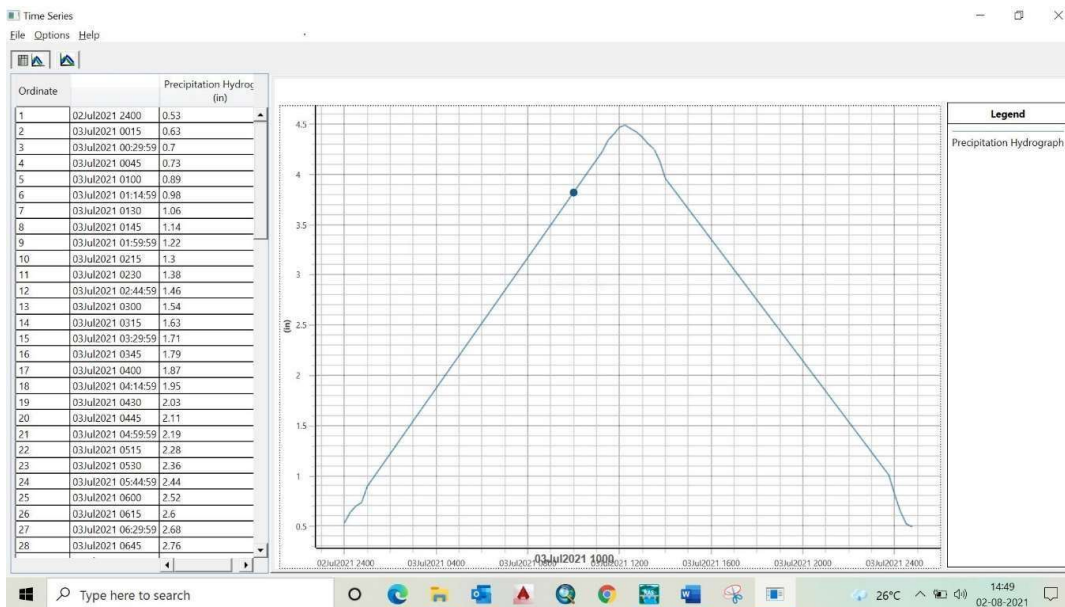
### 5.3 Precipitation hydrograph:

**Table-5.2** Time series data of precipitation

SI. No.	Date & Time	Precipitation (in)	SI. No.	Date & Time	Precipitation (in)
1	02Jul2021 2400	0.53	51	03Jul2021 12:29:59	4.45
2	03Jul2021 0015	0.63	52	03Jul2021 1245	4.42
3	03Jul2021 00:29:59	0.7	53	03Jul2021 1300	4.37
4	03Jul2021 0045	0.73	54	03Jul2021 13:14:59	4.3
5	03Jul2021 0100	0.89	55	03Jul2021 1330	4.25
6	03Jul2021 01:14:59	0.98	56	03Jul2021 1345	4.14
7	03Jul2021 0130	1.06	57	03Jul2021 13:59:59	3.96
8	03Jul2021 0145	1.14	58	03Jul2021 1415	3.88
9	03Jul2021 01:59:59	1.22	59	03Jul2021 1430	3.81
10	03Jul2021 0215	1.3	60	03Jul2021 14:44:59	3.73
11	03Jul2021 0230	1.38	61	03Jul2021 1500	3.66
12	03Jul2021 02:44:59	1.46	62	03Jul2021 1515	3.58
13	03Jul2021 0300	1.54	63	03Jul2021 15:29:59	3.5
14	03Jul2021 0315	1.63	64	03Jul2021 1545	3.43
15	03Jul2021 03:29:59	1.71	65	03Jul2021 1600	3.35
16	03Jul2021 0345	1.79	66	03Jul2021 16:14:59	3.28
17	03Jul2021 0400	1.87	67	03Jul2021 1630	3.2
18	03Jul2021 04:14:59	1.95	68	03Jul2021 1645	3.12
19	03Jul2021 0430	2.03	69	03Jul2021 16:59:59	3.05

20	03Jul2021 0445	2.11	70	03Jul2021 1715	2.97
21	03Jul2021 04:59:59	2.19	71	03Jul2021 1730	2.9
22	03Jul2021 0515	2.28	72	03Jul2021 17:44:59	2.82
23	03Jul2021 0530	2.36	73	03Jul2021 1800	2.75
24	03Jul2021 05:44:59	2.44	74	03Jul2021 1815	2.67
25	03Jul2021 0600	2.52	75	03Jul2021 18:29:59	2.6
26	03Jul2021 0615	2.6	76	03Jul2021 1845	2.52
27	03Jul2021 06:29:59	2.68	77	03Jul2021 1900	2.44
28	03Jul2021 0645	2.76	78	03Jul2021 19:14:59	2.37
29	03Jul2021 0700	2.84	79	03Jul2021 1930	2.29
30	03Jul2021 07:14:59	2.93	80	03Jul2021 1945	2.22
31	03Jul2021 0730	3.01	81	03Jul2021 19:59:59	2.14
32	03Jul2021 0745	3.09	82	03Jul2021 2015	2.06
33	03Jul2021 07:59:59	3.17	83	03Jul2021 2030	1.99
34	03Jul2021 0815	3.25	84	03Jul2021 20:44:59	1.91
35	03Jul2021 0830	3.33	85	03Jul2021 2100	1.84
36	03Jul2021 08:44:59	3.41	86	03Jul2021 2115	1.76
37	03Jul2021 0900	3.5	87	03Jul2021 21:29:59	1.69
38	03Jul2021 0915	3.58	88	03Jul2021 2145	1.61
39	03Jul2021 09:29:59	3.66	89	03Jul2021 2200	1.54
40	03Jul2021 0945	3.74	90	03Jul2021 22:14:59	1.46
41	03Jul2021 1000	3.82	91	03Jul2021 2230	1.38

42	03Jul2021 10:14:59	3.9	92	03Jul2021 2245	1.31
43	03Jul2021 1030	3.98	93	03Jul2021 22:59:59	1.23
44	03Jul2021 1045	4.06	94	03Jul2021 2315	1.16
45	03Jul2021 10:59:59	4.14	95	03Jul2021 2330	1.08
46	03Jul2021 1115	4.23	96	03Jul2021 23:44:59	1
47	03Jul2021 1130	4.34	97	03Jul2021 2400	0.81
48	03Jul2021 11:44:59	4.4	98	04Jul2021 0015	0.65
49	03Jul2021 1200	4.47	99	04Jul2021 00:29:59	0.52
50	03Jul2021 1215	4.49	100	04Jul2021 0045	0.49



**Fig-5.3** Precipitation hydrograph

1. The graph suddenly increased from July 3, 2021 12 : 00 AM to July 3, 2021 12 : 15 AM and then increased gradually up to July 4, 2021 12 : 45 AM with a constant slope.
2. The sudden increase in rainfall also increased the rate of river flow.

## 5.4 Depth of flow:

1. The depth of flow of Brahamni river increased drastically as the water flows from upstream to downstream.
2. The areas Denali to Suleipal are at major risk of floods while the areas of Singhasal to Barkote are at moderate risk.
3. The light blue region indicates low depth while the dark blue region indicates high depth.

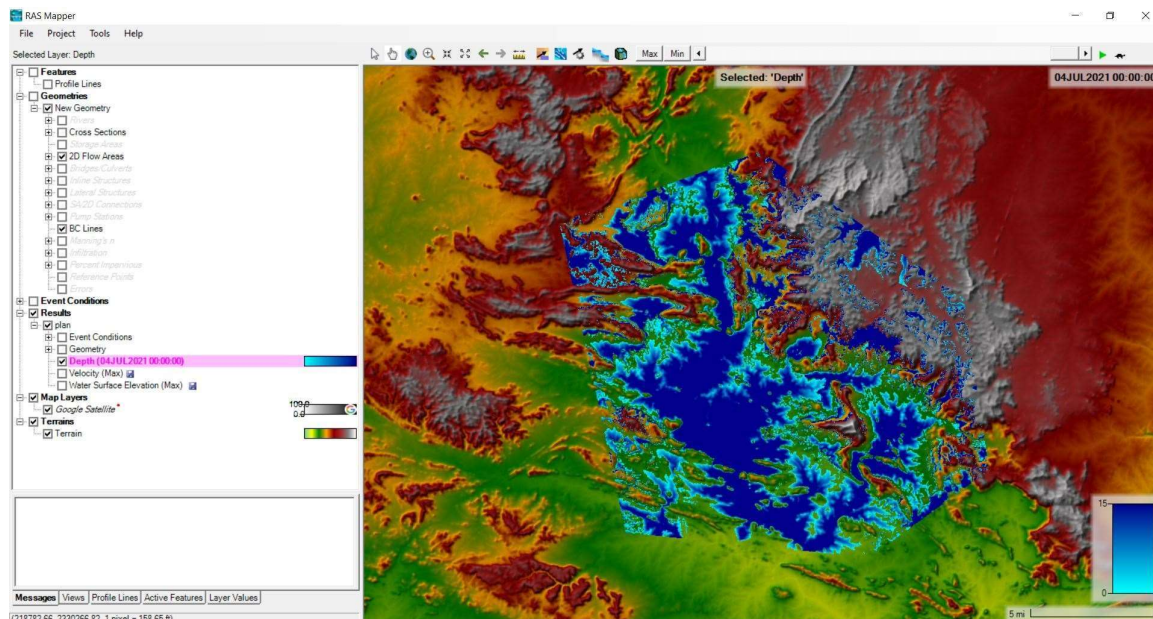
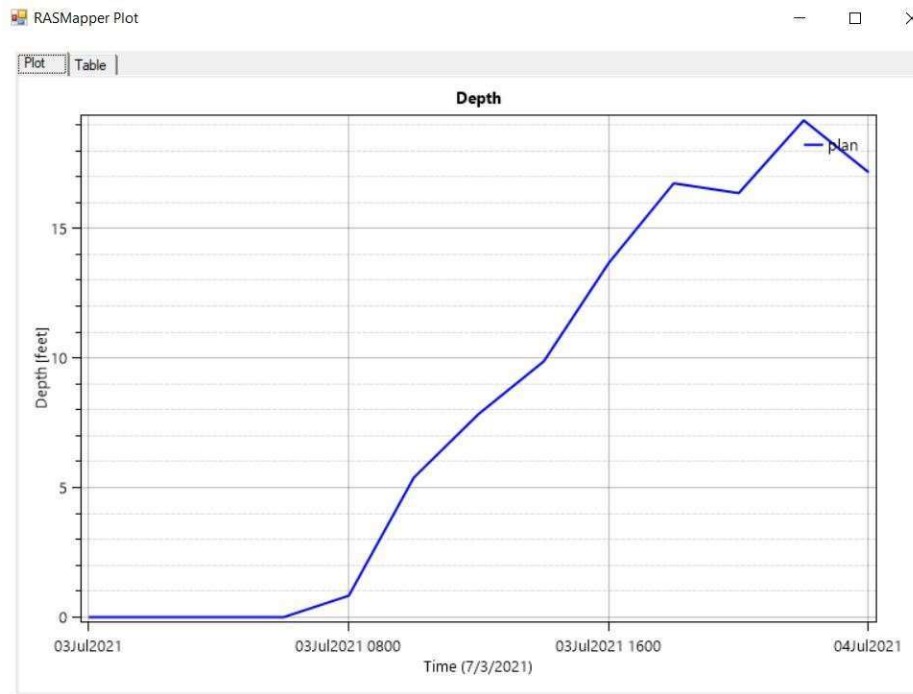


Fig-5.4 Depth of flow



**Fig-5.5** Time series graph of Depth

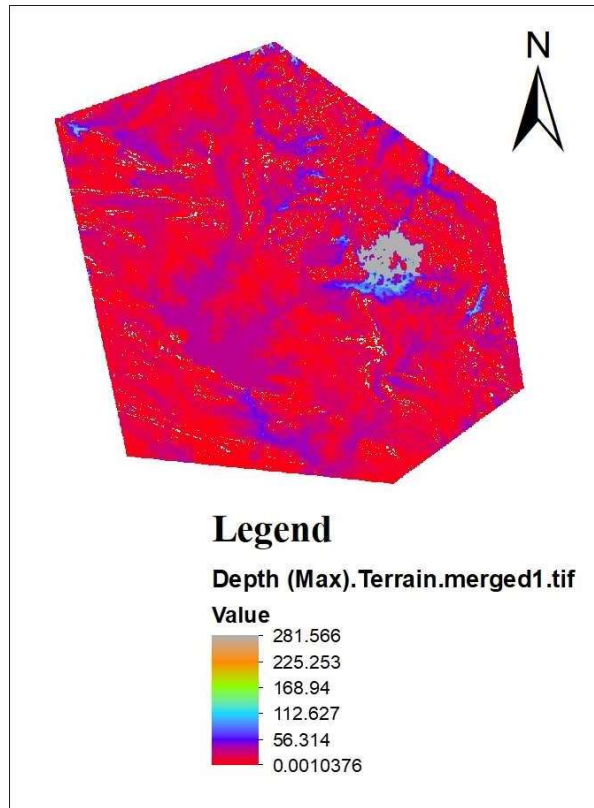
**Table-5.3** Time series data of Depth

SI. No.	Date & Time	Depth (ft)
1	03Jul2021 00:00:00	0.000
2	03Jul2021 02:00:00	1.078
3	03Jul2021 04:00:00	3.916
4	03Jul2021 06:00:00	10.422
5	03Jul2021 08:00:00	15.711
6	03Jul2021 10:00:00	20.675
7	03Jul2021 12:00:00	23.251
8	03Jul2021 14:00:00	25.159
9	03Jul2021 16:00:00	29.141
10	03Jul2021 18:00:00	32.162

11	03Jul2021 20:00:00	31.837
12	03Jul2021 22:00:00	34.613
13	04Jul2021 00:00:00	32.594

### 5.5 Maximum depth:

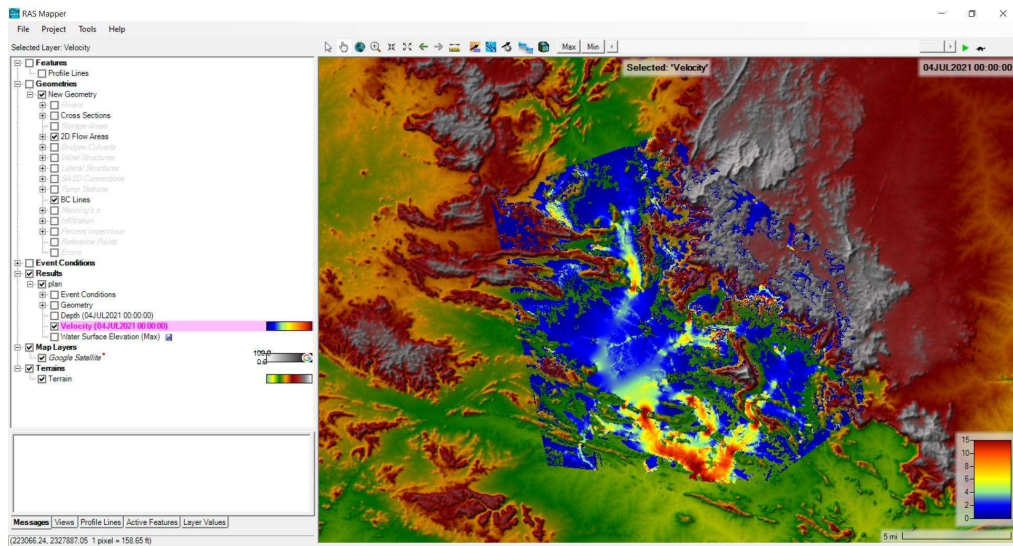
1. After the dam is created in HEC RAS, now it is exported to ArcGIS and saved into jpeg file.
2. Go to results in geometric view and right click on depth→edit map parameters(new window appears) give maximum unsteady profile, click raster based on terrain in map output mode→ click on save map
3. Go to tools→manage results maps→ click on depth→ click on compute /update stored maps→ close the tab.
4. Now again right click on depth in results→ click on compute/update stored map(now the file is saved, we need to check its path so that we can open this file in ARC GIS software)
5. Now open ARC GIS software→ click on add data →open the saved file from earlier (the data we created in HEC RAS appears in ARC GIS)
6. Now we can change its properties like colour, depth intervals etc., in ARC GIS software as we required
7. Now go to lay out view and give legend and north arrow (as the required file is completed, now we can save this file into jpeg format using ARC GIS software.
8. Go to file → export map→ select the specified path (check file type as jpeg format) and save it.
9. Now this file can be used to show the details of HEC RAS work where ever we want.



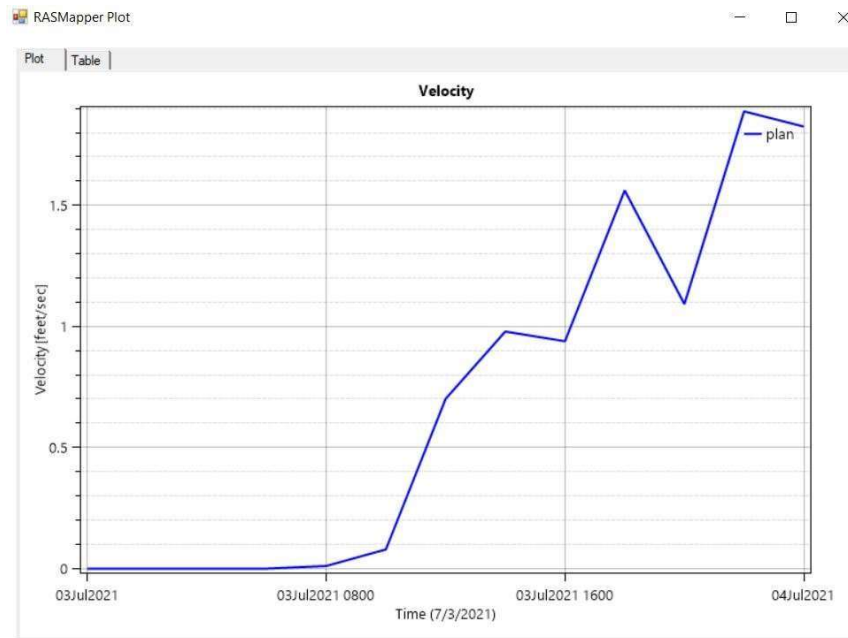
**Fig-5.6** Maximum depth

**5.6 Velocity of flow:**

1. The velocity of flow is at safe level at reservoir but dangerously increased after passing through Rengali dam at downstream.
2. This may be due to sudden variation in flow from reservoir to dam.
3. Jajpur and Kendrapara may experience severe damage since they are situated at downstream.
4. The blue region indicates low velocity while the red region indicates high velocity.



**Fig-5.7** Velocity of flow



**Fig-5.8** Time series graph of Velocity



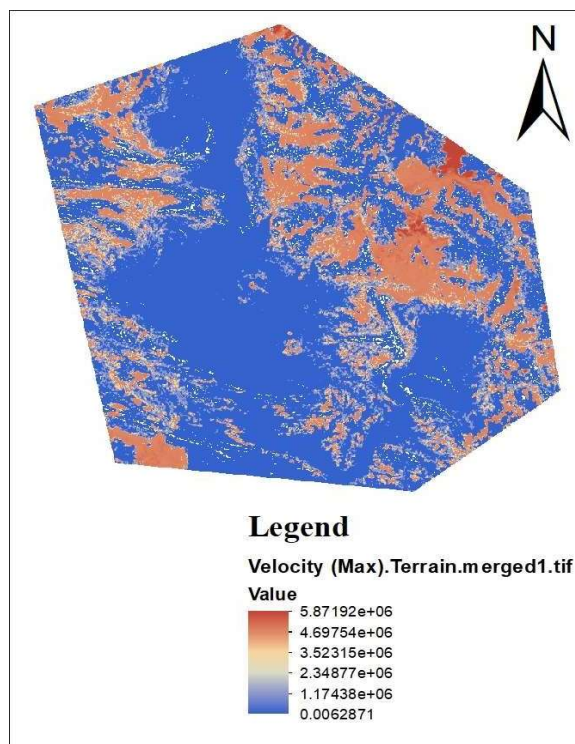
**Table-5.4** Time series data of Velocity

SI. No.	Date & Time	Velocity (ft/sec)
1	03Jul2021 00:00:00	0.000
2	03Jul2021 02:00:00	0.000
3	03Jul2021 04:00:00	0.000
4	03Jul2021 06:00:00	0.354
5	03Jul2021 08:00:00	0.617
6	03Jul2021 10:00:00	0.578
7	03Jul2021 12:00:00	0.592
8	03Jul2021 14:00:00	1.188
9	03Jul2021 16:00:00	1.235
10	03Jul2021 18:00:00	0.917
11	03Jul2021 20:00:00	2.818
12	03Jul2021 22:00:00	1.318
13	04Jul2021 00:00:00	2.336

**5.7 Maximum velocity:** After the simulation is created in HEC RAS, now it is exported to ArcGIS and saved into jpeg file.

1. Go to results in geometric view and right click on velocity of flow→edit map parameters (new window appears) give maximum unsteady profile, click raster based on terrain in map output mode→ click on save map
2. Go to tools→manage results maps→ click on velocity of flow→ click on compute /update stored maps→ close the tab.
3. Now again right click on velocity of flow in results→ click on compute/update stored map(now the file is saved, we need to check its path so that we can open this file in ARC GIS software)
4. Now open ARC GIS software→ click on add data →open the saved file from earlier (the data we created in HEC RAS appears in ARC GIS)

5. Now we can change its properties like colour, velocity of flow intervals etc., in ARC GIS software as we required
6. Now go to lay out view and give legend and north arrow (as the required file is completed, now we can save this file into jpeg format using ARC GIS software.
7. Go to file → export map→ select the specified path (check file type as jpeg format) and save it.
8. Now this file can be used to show the details of HEC RAS work where ever we want.

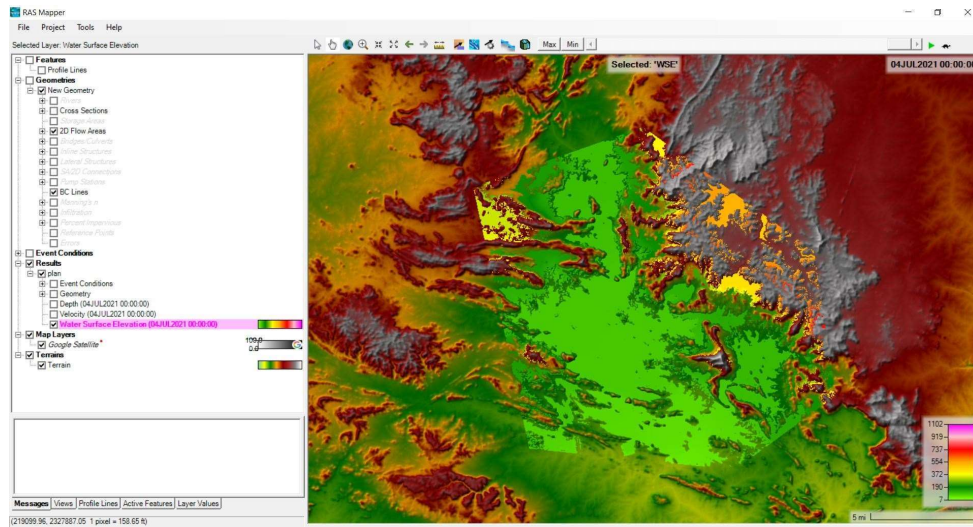


**Fig-5.9** Maximum velocity\

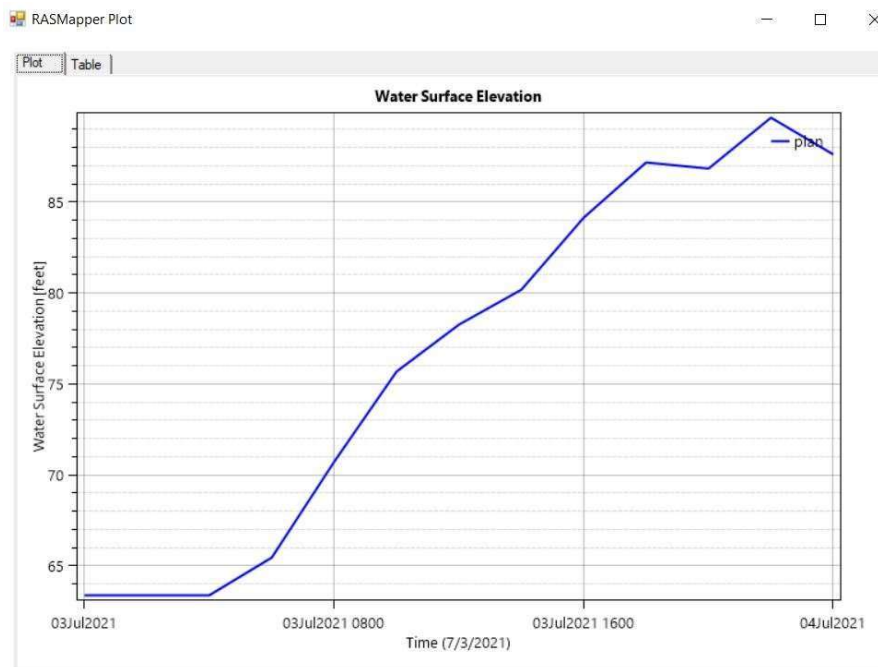
### **5.8 Water Surface Elevation (WSE):**

1. The elevation of water surface is considerably at safe level even though receiving high rainfall.
2. But the areas from Saruali to Pallahara are at heavy risk zone as the elevation is above par safe level.

3. The green region indicates low WSE while the yellow region indicates high WSE.



**Fig-5.10** Water Surface Elevation



**Fig-5.11** Time series graph of Water Surface Elevation

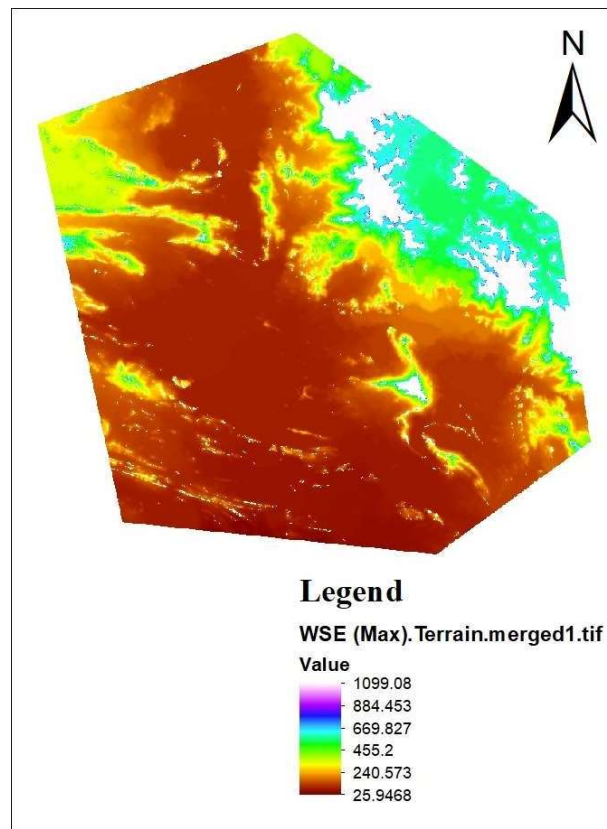
**Table-5.5** Time series data of WSE

SI. No.	Date & Time	WSE (ft)
1	03Jul2021 00:00:00	62.938
2	03Jul2021 02:00:00	62.938
3	03Jul2021 04:00:00	64.041
4	03Jul2021 06:00:00	66.931
5	03Jul2021 08:00:00	69.172
6	03Jul2021 10:00:00	72.930
7	03Jul2021 12:00:00	75.900
8	03Jul2021 14:00:00	76.474
9	03Jul2021 16:00:00	83.199
10	03Jul2021 18:00:00	85.642
11	03Jul2021 20:00:00	86.321
12	03Jul2021 22:00:00	88.169
13	04Jul2021 00:00:00	86.258

**5.9 Maximum WSE:** After the dam is created in HEC RAS, now it is exported to arc gis and saved into jpeg file.

1. Go to results in geometric view and right click on WSE→edit map parameters (new window appears) give maximum unsteady profile, click raster based on terrain in map output mode→ click on save map
2. Go to tools→manage results maps→ click on WSE→ click on compute /update stored maps→ close the tab.
3. Now again right click on WSEin results→ click on compute/update stored map(now the file is saved, we need to check its path so that we can open this file in ARC GIS software)
4. Now open ARC GIS software→ click on add data →open the saved file from earlier (the data we created in HEC RAS appears in ARC GIS)
5. Now we can change its properties like colour, velocity of flow intervals etc., in ARC GIS software as we required

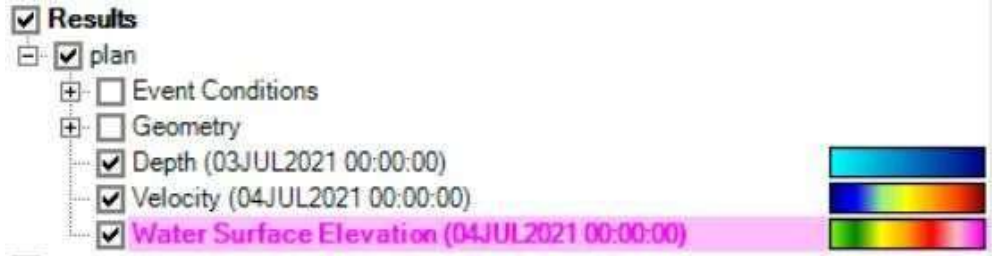
6. Now go to lay out view and give legend and north arrow (as the required file is completed, now we can save this file into jpeg format using ARC GIS software).
7. Go to file → export map→ select the specified path (check file type as jpeg format) and save it.
8. Now this file can be used to show the details of HEC RAS work where ever we want.



**Fig-5.12** Maximum Water Surface Elevation

### **5.10 Simulation of flood:**

1. After the computation is successful, the flood simulation can be run in results.
2. The simulation can be selected on the results where it appears in pink colour with a tick mark.



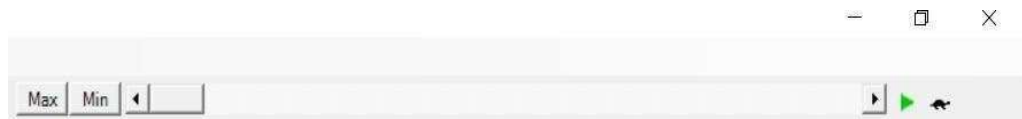
**Fig-5.13** Selection of results

3. The speed of the simulation can be slowed down or delayed up to 0.9 seconds.



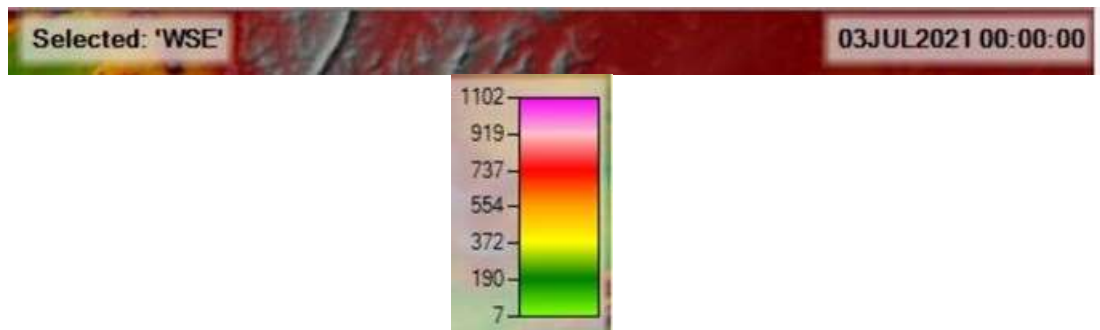
**Fig-5.14** Animation delay

4. The minimum and maximum simulation of the respective results can also be viewed.



**Fig-5.15** Maximum and Minimum simulation

5. The details including selected parameter of the result and time of simulation is shown at the top while the scale of the running simulation is shown at right bottom.



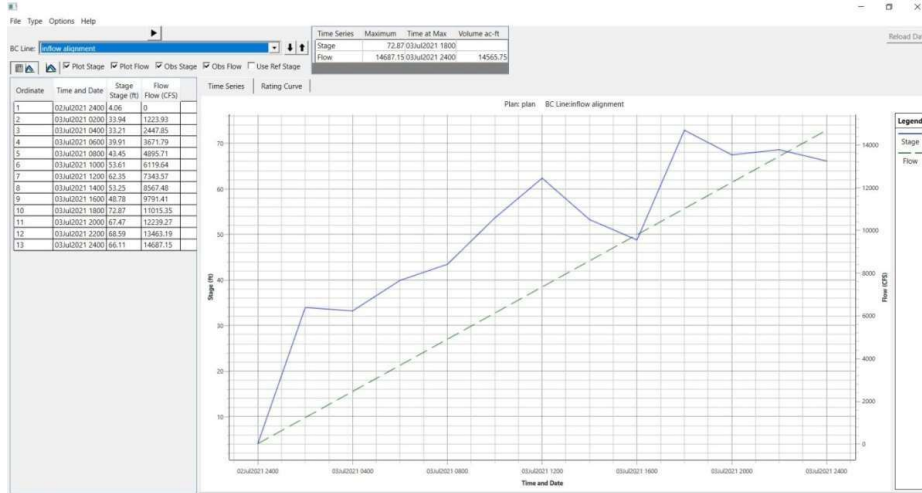
**Fig-5.16** Details and Scale

### 5.11 Stage and flow hydrographs:

1. When the stage is plotted against time, the graph is a Stage hydrograph. It can be used as either upstream or downstream boundary condition.
2. When flow rate or discharge is shown against time, the graph is a flow hydrograph.
3. The flow of the river water inside the inflow alignment where the refinement region is taken is plotted. Also, the flow of the river in the set boundary conditions is plotted.

**Table-5.6** Time series data for stage and flow for inflow alignment

SI. NO.	Date & Time	Stage (ft)	Flow (cfs)
1	02Jul2021 2400	4.06	0
2	03Jul2021 0200	33.94	1223.93
3	03Jul2021 0400	33.21	2447.85
4	03Jul2021 0600	39.91	3671.79
5	03Jul2021 0800	43.45	4895.71
6	03Jul2021 1000	53.61	6119.64
7	03Jul2021 1200	62.35	7343.57
8	03Jul2021 1400	53.25	8567.48
9	03Jul2021 1600	48.78	9791.41
10	03Jul2021 1800	72.87	11015.35
11	03Jul2021 2000	67.47	12239.27
12	03Jul2021 2200	68.59	13463.19
13	03Jul2021 2400	66.11	14687.15

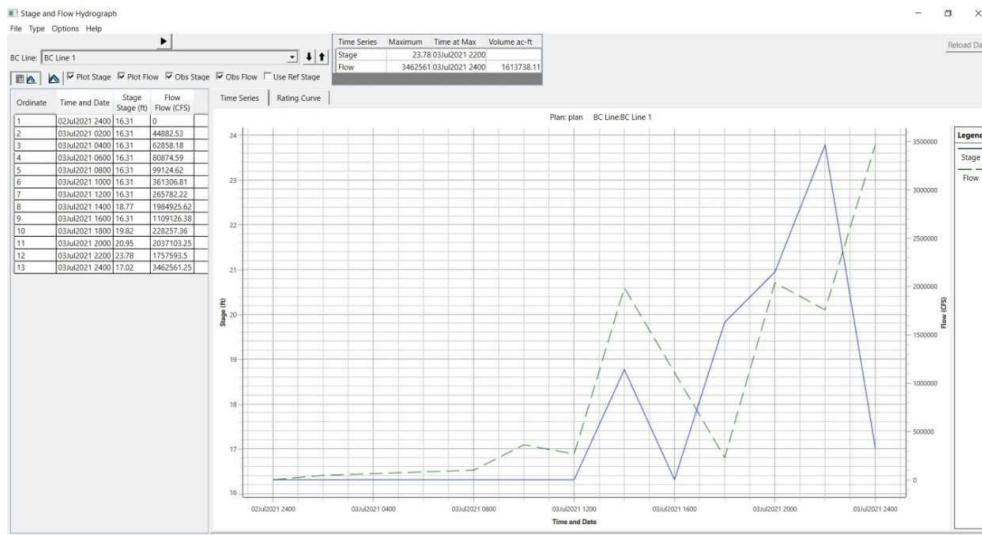


**Fig-5.17** Stage and flow hydrograph of inflow alignment

**Table-5.7** Time series data for stage and flow for boundary condition

Sl. NO.	Date & Time	Stage (ft)	Flow (cfs)
1	02Jul2021 2400	16.31	0
2	03Jul2021 0200	16.31	44882.53
3	03Jul2021 0400	16.31	62858.18
4	03Jul2021 0600	16.31	80874.59
5	03Jul2021 0800	16.31	99124.62
6	03Jul2021 1000	16.31	361306.81
7	03Jul2021 1200	16.31	265782.22
8	03Jul2021 1400	18.77	1984925.62
9	03Jul2021 1600	16.31	1109126.38
10	03Jul2021 1800	19.82	228257.36
11	03Jul2021 2000	20.95	2037103.25
12	03Jul2021 2200	23.78	1757593.5





**Fig-5.18** Stage and flow hydrograph of boundary condition

## **CHAPTER-5**

### **CONCLUSIONS**

1. DEM files of the collected data are merged together to form a single raster file.
2. The co-ordinates of the merged raster file are change to projected co-ordinate system.
3. 2D geometry of the study area is generated in HEC-RAS.
4. Unsteady flow analysis of study area is done using HEC-RAS.
5. The stage and flow hydrographs of refinement region and boundary condition are generated.
6. The flood simulation in the year 2021 for one day of July month is created.
7. Maximum depth of the study area is 281.566 inches or 34.613 feet.
8. Maximum velocity of the flow of study area is 5.872 kmph or 2.818 ft/sec.
9. Maximum water surface elevation is 1099.08 inches or 86.321 feet.

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