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FEASIBILITY OF YAMUNA RIVER FOR NAVIGATION PURPOSE

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ABSTRACT

Civilization has always been located near water, due partly to the fact that water enables more efficient travel compared to going overland. Waterways have proven to be critically important to the transportation of people and cargo throughout the world. This research intends to explore the potential of National Waterway (NW) - 110. The proposed route is along the Yamuna river stretching from Jagatpur 6 km upstream of Wazirabad Barrage in Delhi to the confluence of the Ganga and Yamuna river at Allahabad (Prayagraj) in the Uttar Pradesh. NW 110 is proposed to be developed as an alternative mode of transportation for cargo and passenger movement. The feasibility and sustainability of the Yamuna river for waterway need to be studied prior to its existing boundary and flow conditions for its development as NW. This research study emphasizes on the stretch between Etawaha to Hamirpur measuring around 251 km long. By using Hydrologic Engineering Center's River Analysis System (HEC-RAS) software, a hydrodynamic model is created along-with existing waterway infrastructure and flow conditions. After building model, with minimal modification in river flow and given check for sufficient draft to navigate in accordance to IWAI classification of vessels for class VI an alignment for the navigational channel is proposed.

Keywords: National Waterway, Navigation, HEC-RAS, Hydrodynamic Model, Draft.

I. INTRODUCTION

Transporting goods and passengers will be accomplished by road, water, rail, or air. Transportation cost per tonnage is lesser in case of waterborne transportation as compared to the other mode. Thus, Waterborne transport is cheapest and oldest mode of transport. Still, it remains largely underexplored. It operates in an exceedingly natural track and hence doesn't require huge capital investment and operational cost.

Inland Water Transportation (IWT) could be a good viable alternative to existing road and rail network if explored thoroughly. In India, IWT has the potential to form the most economic, reliable, safe, and environmental- friendly mode of transportation. IWT may prove to be best suited for carrying bulky goods and passengers over long distances. When developed to be use by modern inland waterway vessels, it can reduce investment needs in rail and road infrastructure to fulfill the demand for industrial growth in the region and reduce dependency on other modes of transportation.

Figure 1: National Waterway-110 along with prominent locations.

National Waterway (NW) - 110 (Delhi-Allahabad stretch) is 1,089 km long and passes through Delhi, Haryana and UP as shown in figure 1 and 2. In the confined stretch between Etawaha to Hamirpur measuring around 251 km, a mathematical model is prepared using HEC-RAS to access the flow parameters with and with none hydraulic structure. So, that required draft is available with minimal modification in river flow.

A. OBJECTIVES:

- To quantify the availability of required draft in the river stretch under consideration.
- To identify the obstacles for navigation and possible mitigation measures over them.

B. PROBLEM FORMULATION AND STUDY AREA:

This research assesses the feasibility of for navigation of cargo and passenger vessels in 'Yamuna River' and proposes the probable navigation alignment by using HEC-RAS software. This study emphasizes only the stretch between Etawaha to Hamirpur measuring around 251 km long.

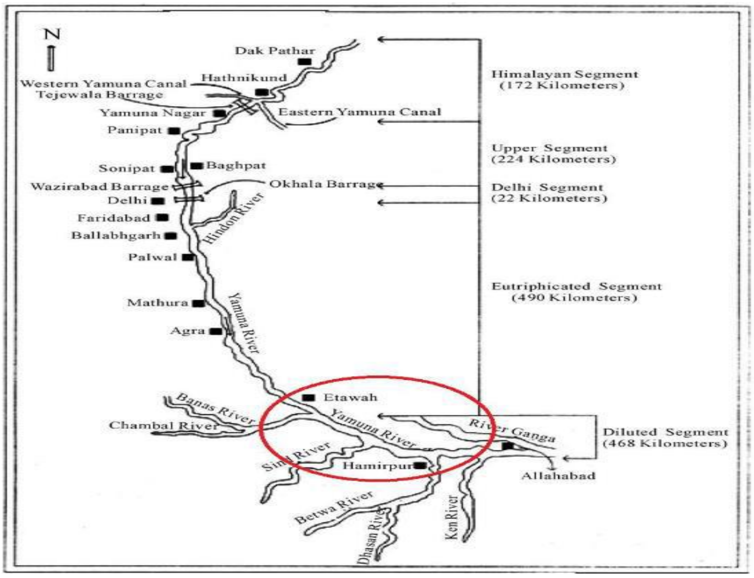

Figure 2: National Waterway-110 stretch.

II. METHODOLOGY

Method and analysis which is performed in your research work should be written in this section. A simple strategy to follow is to use keywords from your title in first few sentences.

A. Appropriate selection of software

Amongst available Softwares like HEC-RAS and MIKE 11, etc. which would help in computing water depth, discharge induced flood in the River, and other hydraulic parameters, HEC-RAS software was finalized as been open source software.

B. Discussion with experts

Experts from same area and our guide were consulted for choosing the suitable computing software amongst the wide range of available softwares.

C. Confining the scope of study

After consulting with experts, and keeping in mind the accuracy, the scope and area of study from Etawah to Hamirpur (having most numbers of gauge stations), was finalized for computing with HEC-RAS software for creating the mathematical model.

D. Data collected

To create a mathematical model, data is to be incorporated from relevant sources. The river cross-section data in the entire study reach at about 1 km interval in the intermittent places and at the meandering river stretch interval of 200m is obtained.

1) The cross-sectional data of river Yamuna are provided in WGS84 datum, Universal Transverse Mercator (UTM) Projection (Zone 44).

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2) On LOB and ROB river station bathymetric surveys are carried up to +2m above High Flood Level at every chainage.

3) Manning's roughness values vary between 0.022 to 0.025, average 0.0235 are given into a model for left of bank, right of bank, and channel of the river with considering the bed slope (S = 0.00035).

4) Hydrological data for the gauge sites along the River Yamuna understudy stretch and water depth around the year have been ascertained and provided as input data in the form of water surface elevation of gauging stations.

5) Details of the existing Hydraulic structures like Bridges, weirs, barrages, intakes, etc along the study reach were taken into account.

III. MODELING AND ANALYSIS

The mathematical modelling using HEC-RAS was performed in the following steps. The analysis of each step is presented in the form of output below:

1. Geometric data:

In the present study of the selected reach, the geometric data are entered which includes the cross-section data and manning's coefficient of river Yamuna for selected reach. This data will give the available depth of the water at the particular discharge in the river. The data to be entered is from the upstream to downstream direction of the river in geometric data editor of HEC-RAS as shown in fig. 3.

Figure 3: Geometric Data

2. Lateral structure data:

It involves entering details of existing bridges and crossings over the waterway in the software. There are a number of road/railway bridges in the confined stretch which has been taken into consideration in simulation. The data of lateral structures are entered in the geometric data editor of HEC-RAS. The following fig. 4 shows the water level at the upstream side of the bridge. The different watermark depicts the water level at variable discharge also known as the Profile Faces (PF).

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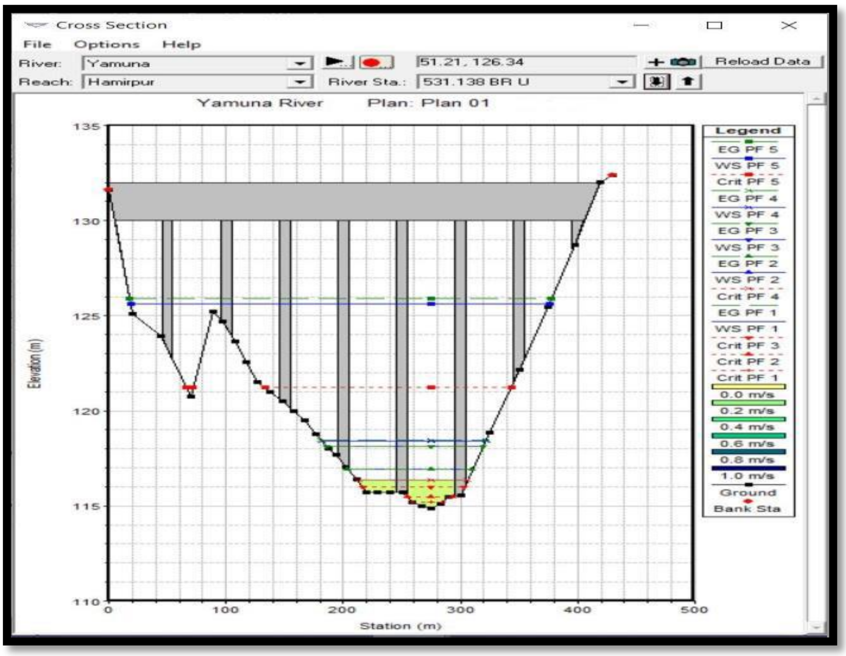

Figure 4: Lateral structure

IV. RESULTS AND DISCUSSION

The type of flow data to be entered depends upon the type of analysis to be performed. In this study, a steady flow analysis is performed shown in figure 5. Minimum discharge is provided at each gauge station considering the boundary condition of confined stretch such as upstream and downstream of the river. In mathematical modelling, the known relationship between water levels and discharges are used as a data incorporating flow velocity associated with Froude Number and steady flow. The model is simulated with existing waterway infrastructure and Proposed barrage at their respective locations. To maintain the minimum river draft with minimum discharge gate opening is scheduled based upon a trial and error process. For simulation, barrages with 12 x 5m and 12 x 6m gates with varying gate opening height are taken into consideration.

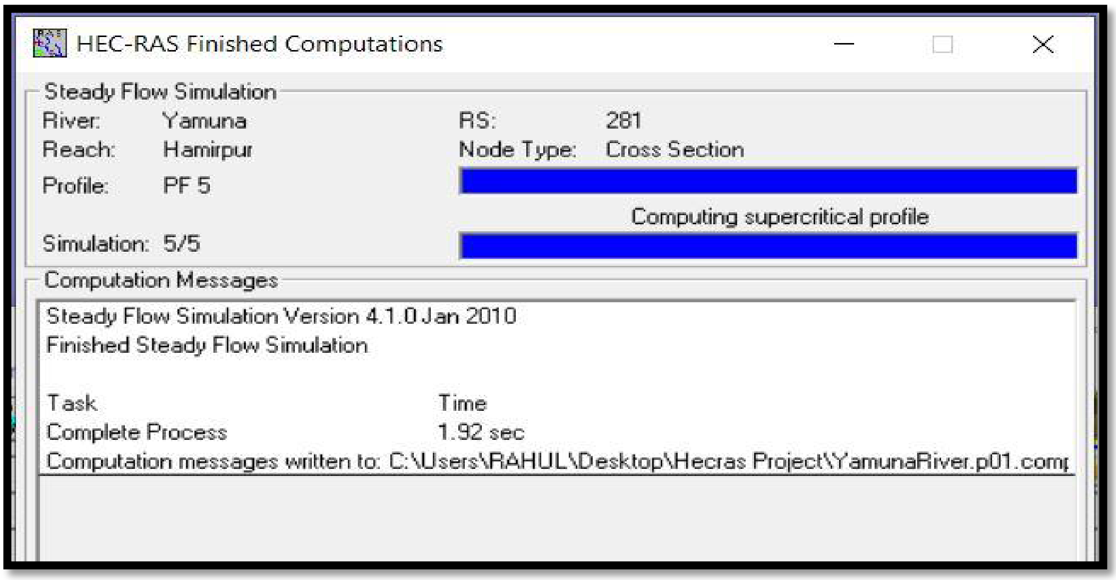

Figure 5: Steady flow analysis

After giving all the input parameters to the software for the computation, software output in terms of the table and graphs, which includes a cross-sectional plot, perspective plot, longitudinal cross-section of river flow and general profile plot is obtained. These outputs are shown in the fig. 6,7, 8 and 9 below:

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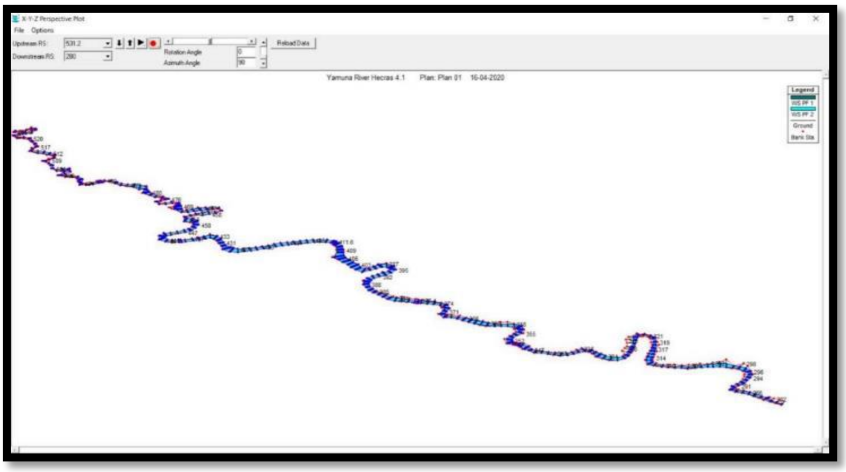

Figure 6: Perspective plot

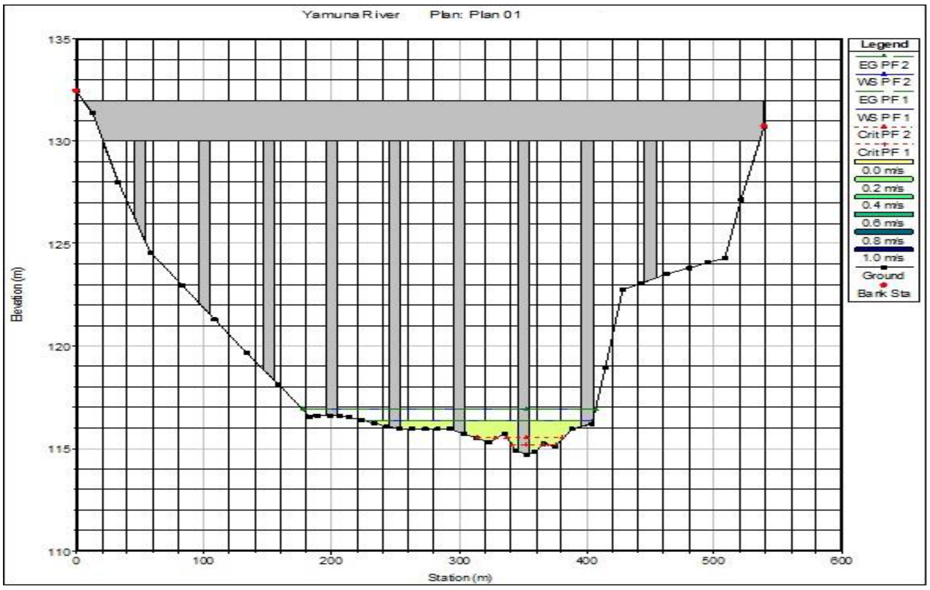

Figure 7: Cross- section at U/S Bridge

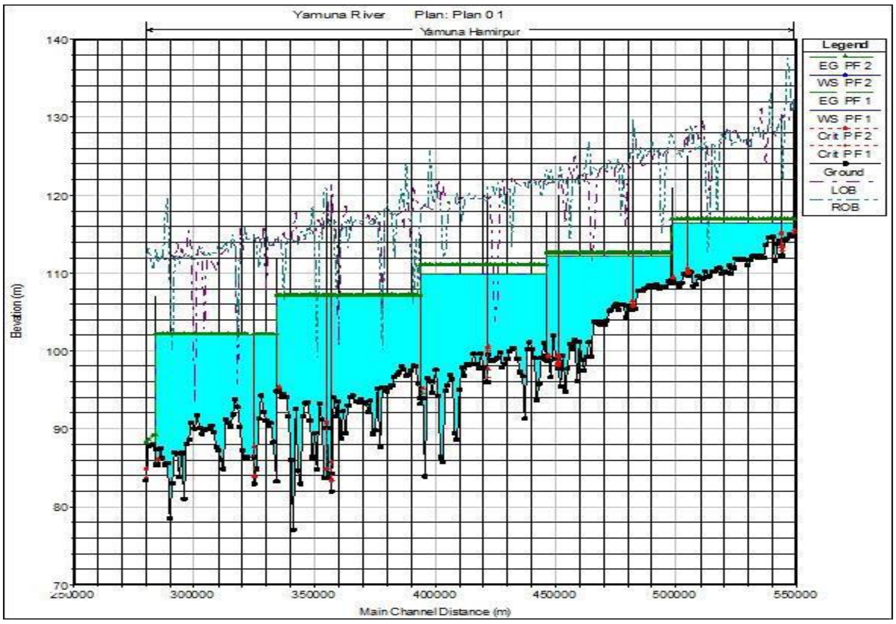

Figure 8: Longitudinal Section of river (Along with proposed barrages)

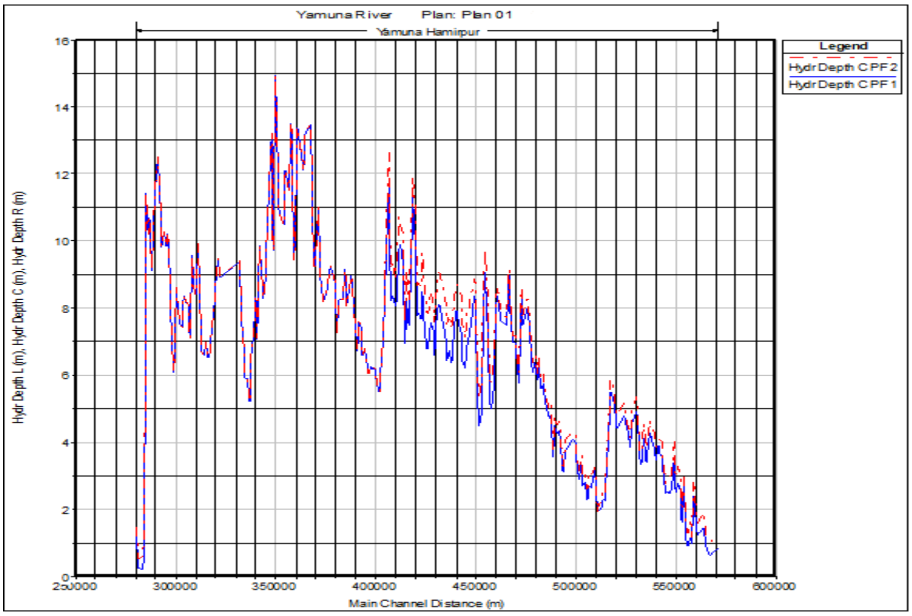

Figure 9: General Profile (Hydraulic depth vs Chainage)

V. CONCLUSION

1) The model is developed for reach Etawah to Hamirpur.

2) Mathematical Model Studies for Inland Waterways in River Yamuna for a confined stretch, Computations are carried out for a minimum of minimum discharge from rainfall data of 20 years (1999-2019), 100, 200 m3/s in addition to that 50-year return period for the existing condition.

3) The computed water depths available during the lean period flows are less than 2.5 m at many places for the existing condition even for the river flows greater than 200 m3/s in the study reach.

4) Proposed 5 barrages in the reach from 531.2 km to 280 km raises water depths even with the minimal lean season discharge of fewer than 20 m3/s. 2.5 m water depths will be available in the entire stretch barring some intermittent places.

5) With the provision of 5 barrages, around 50km apart from each other, water increases depth at most of the places. However, at many places, even after barrages in place, water depths are less than or near to 2.5 m. The draft can be obtained through channel modification.

6) The 3 Stage hydraulic lock is required to be used along the barrage, to navigate in-between U/S and D/S of the river.

7) The horizontal clearance between 2 bridge pier varies between 25m to 76.2m which is twice wider than a vessel of class VI (i.e. 12m) and safe for navigation beneath it. Steel and concrete Jacketing shall be provided at the pier in a navigation channel to avoid any havoc situation.

8) Water level after constructing barrages in study reach is obtained through simulation respectively.

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