Analysis of Discharge and Gauge-Level Data at Old Railway Bridge, Delhi

Mohammed Lateef Ahmed, Mohammed Sharif, and Mohammad Shakeel

***Abstract*—**An analysis of discharge and gauge-levels data for three locations in the reach of River Yamuna between Hathnikund and Okhla Barrages has been presented. Results of the analysis clearly showed that Yamuna rose above the danger mark of 204.83 m several times in the past 30 years. The primary reason for flooding in River Yamuna is the release of water into Delhi by Haryana through Hathnikund Barrage. The threat of flood in the NCR is significantly high whenever the release of water by Haryana is accompanied by heavy rainfall in the upstream of old railway bridge. Given the silting that has taken place in the vicinity of the old railway bridge, even a flood of relatively small magnitude inundates the bridge. It is, therefore, recommended that an additional bridge is urgently constructed close to the existing old railway bridge to replace the 150-year old railway bridge.

***Keywords*—** Delhi, flood, meteorological, Yamuna.

I. Introduction

THE flood is an unusually high stage in a river. It is an overflow of water outside its normal course. A flood results when a stream runs out of its confines and submerges surrounding areas. A flood from sea may be caused by a heavy storm, a high tide, a tsunami, or a combination thereof. As many urban communities are located near the coast this is a major threat around the world. The annual cycle of flood and farming was of great significance to many early farming cultures, most famously to the ancient Egyptians of the Nile River and to the Mesopotamians of the Tigris and Euphrates rivers. In less developed countries, humans are particularly sensitive to flood casualties because of high population density, absence of zoning regulations, lack of flood control, and lack of emergency response infrastructure and early warning systems. Bangladesh is one of the most susceptible countries to flood disasters. About one half of the land area in Bangladesh is at an elevation of less than 8 meters above sea level. Up to 30% of the country has been covered with flood waters. In 1991 more 200,000 deaths resulted from flooding and associated tropical cyclones.

In industrialized countries the loss of life is usually lower because of the presence of flood control structures, zoning regulations that prevent the habitation of seriously vulnerable lands, and emergency preparedness. Still, property damage and disruption of life takes a great toll, and despite flood control structures and land use planning, floods still do occur. In the design of hydraulic structures it is not practical from economic considerations to provide for the safety of the structure and the system at the maximum-possible flood in the catchments. Small structures such as culverts and storm drainage can be designed for less severe floods as the consequences of a higher-than design flood may not be very serious. On the other hand, storage structures such as dams demand greater attention to the magnitude of floods used in the design. The failure of these structures causes huge loss of life and damage to property located downstream of the structure. From this it is apparent that the type, importance of the structure and economic development of the surrounding area dictates the design criteria for choosing the flood magnitude.

The national capital region (NCR) of Delhi is highly vulnerable to floods. The townships of NOIDA and Greater NOIDA are major townships in the region. The proximity of these townships to River Yamuna and Hindon makes them highly vulnerable to the natural hazard of floods. The impacts of flooding in these townships are far ranging and pose significant threat to public safety and regional economic viability. The problem of floods assumes greater significance for the NCR region in view of the fact that numerous buildings of high importance factor have been constructed close to the banks of the rivers. Potential economic losses due to damage to agricultural lands, livestock in rural areas, buildings, and urban centres would have a devastating impact on the townships. The risk due to flooding, both in terms of economic losses and environmental losses are high for the townships. Therefore, the major objective of the present research is to analyze the available data for River Yamuna with the intent to assess the vulnerability of the NCR region to floods.

A two-dimensional hydrodynamic model, MIKE 21, coupled with Geographic Information System (GIS) to capture the hydraulic response of the Red River basin in the USA and Canada and its floodplains in extreme flooding conditions model is developed [1]. The flood zone and economic damages over an 8.2 km reach of the perennial Laeen Soo River in the northern Khorasan Province, Iran, using HEC-GEORAS, a combination of HEC-RAS with ArcView GIS software is estimated [2]. Hydrodynamic simulation of the river Yamuna under different designated flood flows to delineate the land availability under existing and modified riverbed geometry including channel dredging and riverbed dressing is presented [3]. The monitoring of the diffuse pollution characteristics from the agricultural land confining

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http://dx.doi.org/10.15242/IIE.E0614028

the River Yamuna in Delhi is focused [4]. Agricultural fields surrounding the Yamuna River are direct nonpoint source of pollution impacting the river quality. The study includes watershed delineation for the River Yamuna using SWAT (2005) and land use classification for the city using GIS and remote sensing. The design flood at Hathnikund and Okhla barrages for different return periods is estimated [5]. An analysis of the frequency of flood peaks for different threshold was also carried out at both the barrages. Two methods have been used for the estimation of design flood, namely Gumbel's extreme value distribution and Log-Pearson Type III distribution.

II. Study Area

The main stream of Yamuna originates from Yamnotri Glacier at an elevation of 6387 m above mean sea level. After travelling through Himalayas, Yamuna enters the valley of Doon. Many tributaries join the river on its way to Tajewala Headworks in Haryana where a headwork exists for eastern and western Yamuna Canal which feed the states of Uttar Pradesh and Haryana respectively. A new barrage named Hathnikund has been constructed 3 km downstream of the Tajewala Barrage. The Yamuna enters in the National Capital Region (NCR) of Delhi approximately 1.65 Km north of Palla village. It runs for about 45 kms in the southeast direction before leaving NCR of Delhi at a point to the east of Jaitpur downstream of Okhla Barrage. The entire reach of river Yamuna from origin to its end point can be broadly divided into the following reaches

- Himalayan Segment-Origin to Hathnikund Barrage (172 km)
- Upper Segment-From Hathnikund to Wazirabad Barrage (224 km)
- Delhi Segment-Wazirabad Barrage to Okhla Barrage (22 km)
- Eutriphicated Segment-Okhla Barrage to Chambal Confluence (490 km)
- Diluted Segment-Chambal Confluence to Ganga Confluence (468 km)

The reach of the River Yamuna downstream of Hathnikund Barrage is shown in Fig1. The Upper Segment and the Delhi segment of the Yamuna spanning from Hathnikund to Okhla/Kalindi Barrage are important for the assessment of vulnerability of the Delhi and NCR region to floods. There are mainly three barrages in the Delhi segment of the River Yamuna-Wazirabad, Indraprastha Barrage, and Kalindi Barrage. The length of the reach between Wazirabad and Kalindi Barrage is 22 km. The distance between Hathnikund and Kalindi barrage is approximately 245 Km.

There are following gauge points on the river in its reach from Palla to Jaitpur.

- Palla
- Wazirabad
- Old Railway Station
- Indraprastha Barrage
- Okhla Barrage

Monitoring of water levels is carried out at these stations during the flood season. In Fig. 2, the total of 22 major drains fall in the Yamuna in the Delhi segment of the river. Out of these 18 major drains fall directly into the river and 4 through Agra and Gurgaon Canal. The Hindon-cut canal meets River Yamuna just downstream of NOIDA toll bridge. The Shahdra drain and the NOIDA drain finally discharges into river Yamuna downstream of Kalindi Barrage. The River Hindon ultimately joins River Yamuna downstream of Kalindi Barrage at a place called Tilwara in Haryana, which ultimately confluences with River Ganga at Allahabad. During the period of floods, the discharge from NOIDA drain, Shahadra drain and River Hindon add to the discharge in River Yamuna. Due to this, heading up of water is expected to take place in the river upstream of the Barrage. The flow in River Yamuna in the Delhi segment is regulated by the Wazirabad Barrage, Indraprastha Barrage (ITO Barrage) and the Okhla Barrage. The flow in the drains is controlled using the gates provided at the drains before entry to River Yamuna.

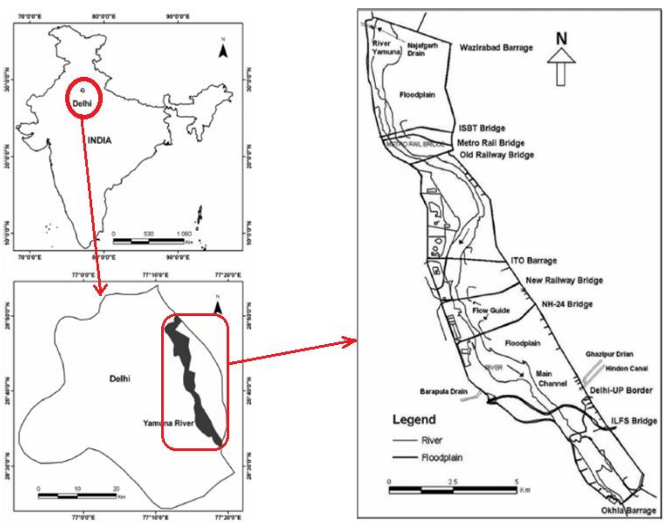

Fig. 1 Index map and reach of river Yamuna downstream of Hathnikund barrage

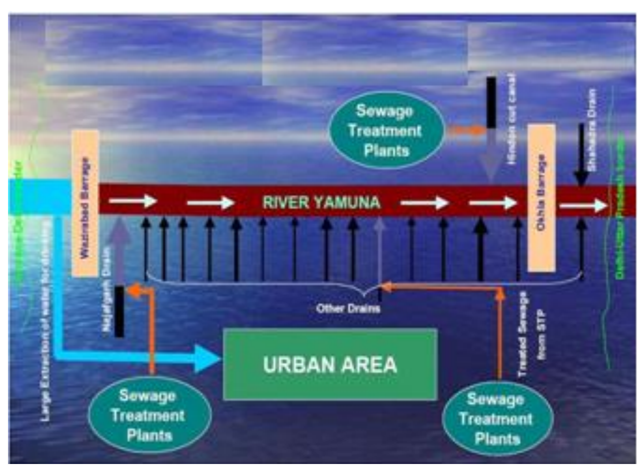

Fig. 2 Schematic of Drainage System in Delhi

III. Data And Methodology

Gauge and peak flood discharge data at various gauge points along the reach of River Yamuna from Palla to Okhla Barrage has been collected from various government agencies. The discharge, rainfall, gauge-level data at old railway bridge has been obtained from Central Water Commission, Delhi. These data are available for the months of July, August, September and October over a period of 1983-2011. In this paper, the analysis of data at old railway bridge has been carried out in order to get an insight into past floods in the region. The results have been presented in the form of line graphs and Box plots. Box plots are a favoured method of data analysis in many hydrological applications as they provide a straightforward way of representing the range of variation in statistics of simulations. With Box plots, the statistics of simulations can be easily compared with the observed data. Boxplots provide a straightforward method of comparing the statistics of simulations with historical data.

The bottom and top horizontal lines in the box in a box plot indicate the 25th and 75th percentile, respectively, of the statistics computed from the simulated data. The horizontal line inside the box represents the median. The whiskers are lines extending from each end of the box to show the extent of the rest of the data. The whisker extends to the most extreme data value within 1.5 times the inter-quartile range of the data. Dots are used to show the outliers - the values beyond the ends of the whiskers.

IV. Results

The plots of gauge levels for the months of July, August, September, and October are shown in Fig. 3 to Fig. 6. With 204.83 m as the danger mark at old railway bridge, there were 4 instances of the river flowing above the danger mark in July. The river crossed the danger mark 12 and 9 times in the months of August and September respectively. It was only once in October that the river crossed the danger mark. It is clear from the plots shown in Fig. 3 to Fig. 6 that the river crossed the danger mark several times in the past 30 years.

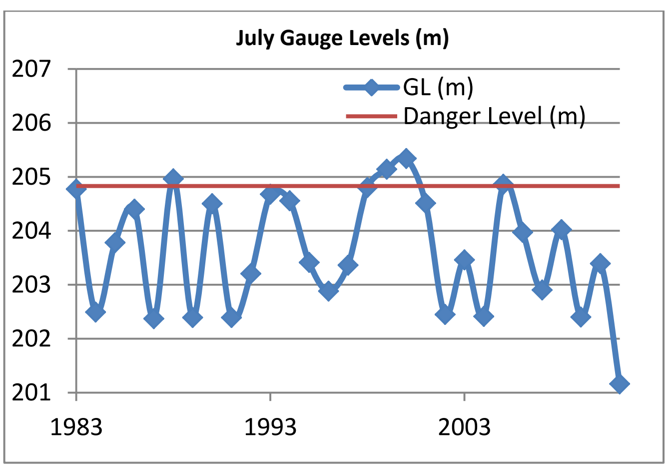

Fig. 3 Maximum gauge levels observed in July

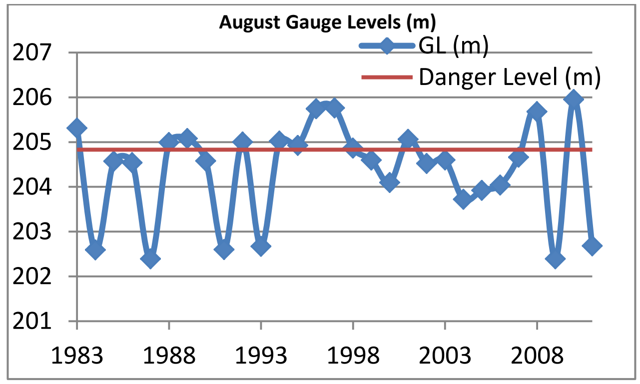

Fig. 4 Maximum gauge levels observed in August

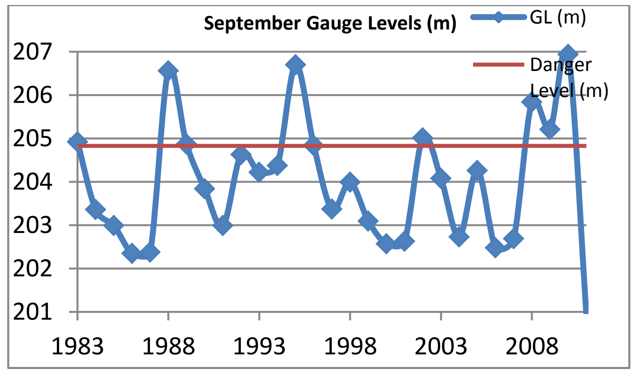

Fig. 5 Maximum gauge levels observed in September

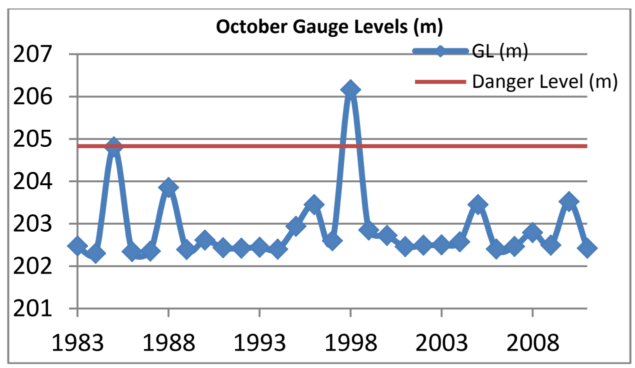

Fig. 6 Maximum gauge levels observed in October

Fig. 7 shows the Box plots of discharge for June through October. It can be seen from Fig. 7 that the median discharge for all months is of the order of 1000 cumec, which is a relatively low value given the frequency of floods in NCR of Delhi. In one of the years of available data, the maximum discharge is June exceeded 7000 cumec (approximately 2.5 lakh cusec). The Box plot in Fig. 8 shows the distribution of flood peak values at old railway bridge, Delhi. The maximum value of the peak flood is of the order of 7000 cumec whereas the median value is 2000 cumec. Fig.9 shows the Box plots of gauge-levels in different months. For the month of June, the maximum gauge-levels exhibit a narrow range with a median value of around 202.5 m. The median of the maximum gauge-level is highest (204.7 m) for the month of August followed by September (203.9 m). Fig. 9 indicates that the range of gauge-levels is minimum during the month of June and October

http://dx.doi.org/10.15242/IIE.E0614028

whereas the range is relatively high for the months July, August and September. The maximum yearly gauge levels is shown in Fig.10.

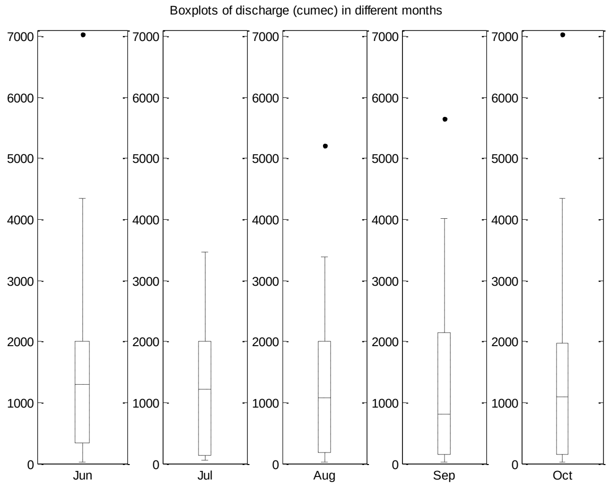

Fig. 7 Box plots of discharge during different months

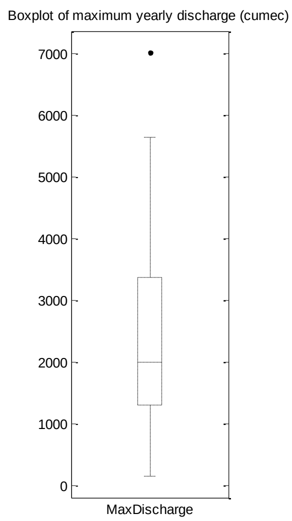

Fig. 8 Box plot of maximum yearly discharge

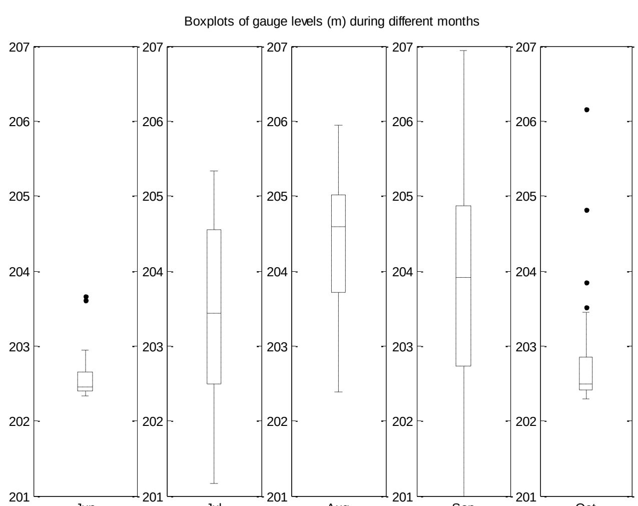

Fig. 9 Box plots of maximum gauge levels during different months

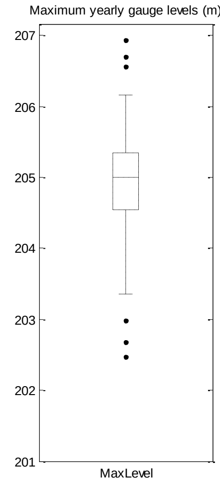

Fig. 10 Maximum Yearly Gauge Levels

V. Conclusions

Analysis of gauge level data clearly showed that Yamuna rose well above the danger mark several times in the past 30 years. Threat of flood looms large over the national capital whenever the gauge-level rises above the danger level of 204.83 m in Yamuna. The primary reason for flooding in River Yamuna is the release of water into Delhi by Haryana through Hathnikund Barrage. The threat of flood in the NCR is significantly high whenever the release of water by Haryana is accompanied by heavy rainfall in the upstream of old railway bridge. It becomes necessary to evacuate people from various low-lying areas in east Delhi like Usmanpur, Yamuna Bazar, Bhajanpura and Shastri Park and set up relief camps for their shelter. The Old Yamuna Bridge, connecting east Delhi with the heart of the national capital, is shut down for rail and road traffic early whenever the water level in Yamuna rises dangerously, thereby causing huge inconvenience to commuters. Given the silting that has taken place in the vicinity of the bridge, even a flood of relatively small magnitude inundates the bridge. It is, therefore, recommended that an additional bridge is urgently constructed close to the existing old railway bridge to replace the 150-year old railway bridge.

References

[1] Ahmad, S, "Comparison of one-dimensional and two-dimensional hydrodynamic modeling approaches for Red River Basin," Natural Resources Institute Facility for Intelligent Decision Support, University of Manitoba Winnipeg, Manitoba, Canada, 1999.

[2] Zadeh, A. H., Ahmadi, M. Z., Sharifi, M. B. and Masoudian, M., "Flood zoning using the HEC-RAS hydraulic model in a gis environment," Journal of Environmental Hydrology, vol. 13, paper 2, 2005.

[3] Vijay, R., Sargoankar, A. and Gupta, A, "A hydrodynamic approach to address Yamuna riverbed development in Delhi," J. Civ. Eng. 36: 2009, pp.1155–1163.
http://dx.doi.org/10.1139/L09-059

[4] Sharma, D. Gupta, R., Singh, R. K. and Kansal, A., "Characteristics of the event mean concentration (EMCs) from rainfall runoff on mixed agricultural land use in the shoreline zone of the Yamuna River in Delhi, India," Appl. Water Sci. 2, 2012, pp.55–62.
http://dx.doi.org/10.1007/s13201-011-0022-1

[5] Arunesh, R. K., "Assessment of vulnerability of delhi to floods," thesis, Department of Civil Engineering, Faculty of Engineering and

Technology, Jamia Millia Islamia, (Central University), New Delhi, 2012.