International Journal of Scientific Engineering and Technology
Volume No. 7, Issue No. 2, PP : 17-19

ISSN : 2277-1581
1 Feb. 2018

Determination of Manning's Roughness Coefficient for Dhaleshwari River Using Hec-Ras

Tasmiah Ahsan, M. A. Matin
Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, Bangladesh
Corresponding Email: tasmiahahsan@ymail.com

ABSTRACT: The Dhaleshwari River is a distributary of Jamuna River and flows past Dhaka city into the Meghna estuary. The flow through the Dhaleshwari River is influenced by roughness characteristic of the channel material. Manning's n is used extensively around the world to predict the degree of roughness in channels. This paper presents a hydrodynamic HEC-RAS 1D model to estimate Manning's n for the Dhaleshwari River. The system requires data including cross-section, water level and discharge measurements. After a model is developed, it undergoes a calibration and a validation phase. Finally the calibrated and validated model result for Manning's n can be used for scenario analysis.

Keywords: Roughness coefficient, boundary condition, flow hydrograph, stage hydrograph, calibration, validation, RSR, NSE.

1. Introduction

Hydraulic roughness is the measure of the amount of frictional resistance water experiences when passing over land and channel features. One roughness coefficient is Manning's n-value. Manning's n is used extensively around the world to predict the degree of roughness in channels.

The Dhaleshwari River is a distributary, 160 kilometres long, of the Jamuna River in central Bangladesh. It starts off the Jamuna near the northwestern tip of Tangail District. After that it divides into two branches: the north branch retains the name Dhaleshwari and merges with the other branch, the Kaliganga River at the southern part of Manikganj District. Finally the merged flow meets the Shitalakshya River near Narayanganj District. This combined flow goes southwards to merge into the Meghna River.

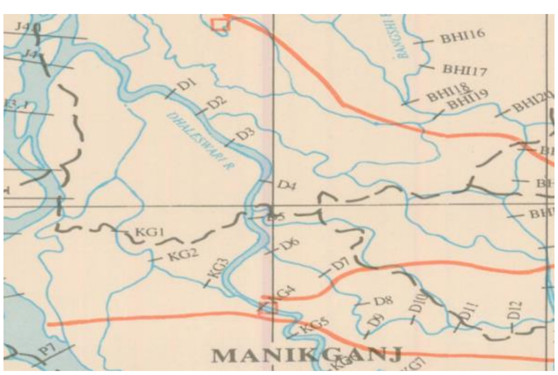

Fig 1: Stations on the Dhaleshwari River (Source:BWDB)

The hydrodynamic modeling system HEC-RAS 1D has been used for carrying out water modeling work under this study. The system requires data including cross-section, water level and discharge measurements. This done to determine its ability to reproduce phenomena actually observed in the field. This is a trial and error process in which any deficiencies in the model setup and input data are rectified and model elements fine-tuned until a reasonable agreement between simulation and observation is achieved. After a model is developed, it requires for undergoing a calibration phase. After the model is calibrated, it is verified against known recent events to ensure that the model is capable of simulating various hydrological scenarios correctly. Finally the calibrated and validated model gives the value of roughness coefficient which can be is used for scenario analysis.

2. Material And Methodology

Necessary data for model development were collected from Bangladesh Water Development Board at selected stations of the Dhaleshwari River.

Table 1: List of collected data (Source: BWDB)

Type of Data	Station	Available Time Period
Bathymetry Data	RMD 1 to RMD 12	2003, 2008, 2013
Discharge Data	SW 68.5 (Jagir)	2006 to 2015
Water-level Data	SW 50 (Porabari), SW68 (Tilli), SW68.5 (Jagir)	2006 to 2014 (seasonal)

After developing the model, it needs to be calibrated and validated. The calibration and validation processes give a suitable result for the roughness coefficient of the Dhaleshwari River.

3. Model Development

3.1 Processing of Geometric Data

A one dimensional model of the Dhaleshwari River Reach from Porabari to Savar has been developed under this study. Information of the river reach is given by inputting cross-sectional data (2013). Initially roughness coefficient is assumed to be 0.018.

3.2 Boundary Condition

The model has two open boundaries.

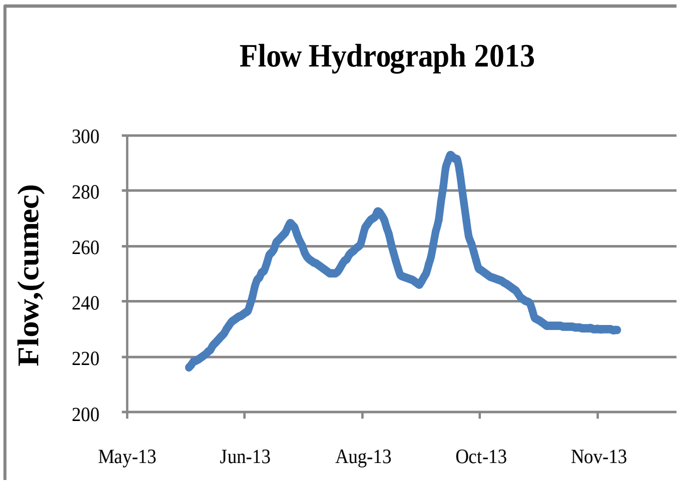

Figure 2: Upstream Boundary Condition (SW 50)

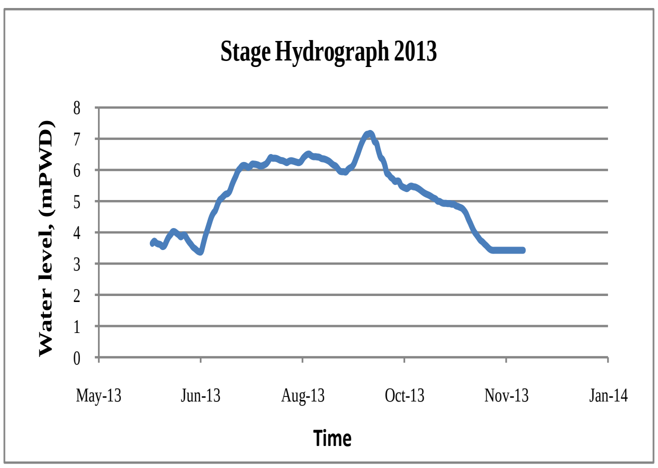

Figure 3: Downstream Boundary Condition (SW 68.5)

3.3 Flow Analysis

After entering all necessary data, flow analysis was done from the run menu. And then the geometry processor, unsteady flow simulation, post processor was given tick and the computation started. After performing the flow analysis the 3-D view of the Dhaleshwari River is obtained.

Now the observed water surface elevation is compared with simulated water surface elevation at intermediate station for calibration.

3.4 Model Calibration

Calibration has been done through the adjustment of Manning's roughness coefficients. For calibrating this model simulated stage hydrographs are compared with observed stage hydrograph at station Tilli for Manning's n value 0.019.

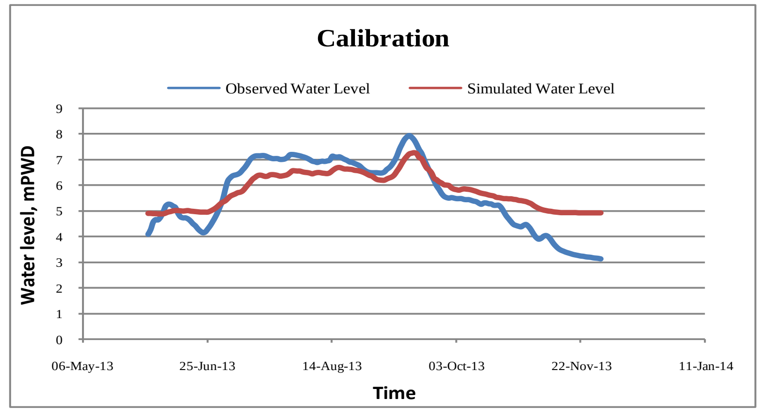

Figure 4: Calibration of Hydrodynamic Model at Tilli (SW68)

3.5 Model Validation

The model is validated at Jagir Station (SW68.5) for the year 2014.

For calibrated value n=0.019, simulated water level have followed almost same pattern of the observed water level.

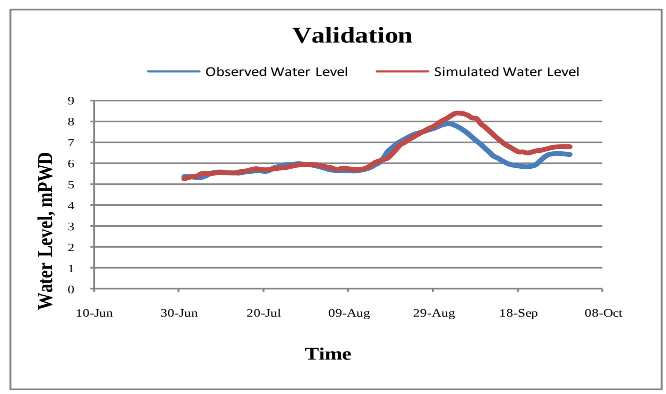

Figure 5: Validation of Hydrodynamic Model at Tilli (SW68) for the year 2014

4. Result and Discussion

The calibrated and validated value of Manning's roughness coefficient, n=0.019.

From calibration and validation curve of hydrodynamic model, it is observed that there has been slight difference between observed and simulated water level. So the following statistical criteria are used for evaluation of the performance of the models.

Correlation coefficient (R^2), RMSE (root mean square error) observations standard deviation ratio (RSR), Nash-Sutcliffe efficiency (NSE) has been used for determine the performance of calibration and validation curve.

$$RSR = \frac{RMSE}{STDEV_{obs}} = \frac{\left[\sqrt{\sum_{i=1}^{n}\left(Y_i^{obs} - Y_i^{sim}\right)^2}\right]}{\left[\sqrt{\sum_{i=1}^{n}\left(Y_i^{obs} - Y^{mean}\right)^2}\right]}$$

$$NSE = 1 - \left[\frac{\sum_{i=1}^{n}\left(Y_i^{obs} - Y_i^{sim}\right)^2}{\sum_{i=1}^{n}\left(Y_i^{obs} - Y^{mean}\right)^2}\right]$$

Where, $Y_{i(obs)}$ = i^{th} observation for the constituent being evaluated,

$Y_{i(sim)}$ = i^{th} the simulated value for the constituent being evaluated,

$Y_{i(mean)}$ = i^{th} the mean of observed data for the constituent being evaluated, and

n = number of observations

For n = 0.019, RSR and NSE value are calculated for calibration and validation curve

Table 2: Obtained value of R^2, RSR and NSE

	R^2	RSR	NSE
Calibration	0.86 (Satisfactoty)	0.56 (Good)	0.68(Good)
Validation	0.85 (Satisfactoty)	0.56(Good)	0.69(Good)

4. CONCLUSION

HEC-RAS hydrodynamic model has been run for distinct Dhaleshwari channel section. The model has been calibrated and validated with value n=0.019 and shows satisfactory result. In simulating the model, correlation coefficient, RSR and NSE Nash-Sutcliffe model efficiency for both calibration and validation are achieved. Considering the acceptable limits of model evaluation criteria; these results indicate a good match between measured and simulated water level. The value of roughness coefficient indicates the channel to be close to a smooth and clean earth channel. A relatively low value of roughness coefficient refers to low resistance for flow and hence a higher discharge. The obtained value may be used for further analysis. For better assessment recent data for both dry and monsoon period data are required.

Acknowledgement

I would like to express my gratefulness to the almighty Allah. I acknowledge my deepest gratitude to my thesis supervisor for his cordial supervision and valuable suggestion. I am grateful to all my teachers for their guidance and motivation. I would like to thank my parents for their encouragement and inspiration.

References

i. *Bangladesh Water Development Board (2011). "Rivers of Bangladesh; North-Central Zone"; Dhaka, Bangladesh.*
ii. *Chow, V. T. (1959). "Open Channel Hydraulics"; New York, USA: McGraw-Hill.*
iii. *Daugherty, R. L., Franzini, J. B. & Finnemore, E. J. (1965). "Fluid Mechanics with Engineering Applications"; New York, USA: McGraw-Hill.*
iv. *Islam, M. R. (2016). "Hydrodynamic Modeling of Old Dhaleshwari River for Dry Period Flow Augmentation"; B.Sc. Thesis, Department of Water Resources Engineering, Bangladesh University of Engineering and Technology, Dhaka.*
v. *Li, Z. and Zhang, J. (2001). "Calculation of Field's Manning's Roughness Coefficient"; Agricultural Water Management 49 (2001), 153-161. Retrieved from https://www.eastwestcenter.org/fileadmin/stored/pics/Li%26Zhang_2001_AgriculturalWaterManagement.pdf*
vi. *Moriasi, D. N., Arnold , J. G. , Van Liew, M. W. , Bingner, R. L. , Harmel, R. D. & T. L. Veith, T. L. (2007). "Model Evaluation Guidelines for Systematic Quantification of Accuracy in Watershed Simulations"; American Society of Agricultural and Biological Engineers 50(3), 885−900. doi:10.1.1.532.2506. Retrived from http://citeseerx.ist.psu.edu/viewdoc/download?doi=10.1.1.532.2506&rep=rep1&type=pdf*
vii. *https://en.wikipedia.org/wiki/Dhaleshwari_River*
viii. *https://en.wikipedia.org/wiki/Hydraulic_roughness*
ix. *https://www.engineeringtoolbox.com/mannings-roughness-d_799.html*
x. *https://en.wikipedia.org/wiki/Nash%E2%80%93Sutcliffe_model_efficiency_coefficient*