INUNDATION PROBLEM AND DRAINAGE SYSTEM ANALYSIS OF BUET USING EPA SWMM

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ABSTRACT

Dhaka, Capital of Bangladesh, is known for water-logging and drainage congestion, losing its past glory of natural khals and wetlands full of fresh water. The situation is seriously provoked during the monsoon. BUET is not exceptional in this case. The main reason behind the water logging in BUET is the lacking of organized drainage network and capacity of it. There is no valid data on, how much water, BUET area does carry to the outlet of Education Board area, Bakshi Bazar, Dhaka. This study mainly focuses on determining the total outfall at the outlet of that area and the pipe capacity to extract water from it or not.A study area of 69.65 acres (0.288 sq. km) of BUET is chosen for the study.The study area has been divided into three parts. West Palashi campus is not included in this study, as the outlet of that campus is different. The water logging problem is severe in the main campus and the Southern side of the campus.After assessing the drainage network, it was found that some network is mixed with the sewer system. Also, some new network is not modified in the main drawing. As the study area is small, DEM was not used, rather the area was extracted from the Google Earth. A stream network was added later. After that, the model was simulated using EPA SWMM and find out the basic reason for inundating the area in high intensity rainfall.As the Southern part of BUET is lower than the Eastern side, a lot of stormwater comes outside of the catchment area and goes through the main BUET WASA line of stormwater. That's why an extra flow is assumed in this study at the first junction point. Peak discharge at two outlets have been determined considering 50 years rainfall data for 5 year return period.

Keywords: *Drainage problem, BUET area, EPA SWMM, Stream network, Peak discharge.*

1. INTRODUCTION

The surface water area of Dhaka Central Region is about 13% of the total land area. Our drainage has two aspects: Flood protection and storm-water discharge, which are interrelated. The capital's water resources are threatened by both human activity as well as natural causes. Climate change is affecting our city, in particular, in three ways: Increased frequency of floods, drainage congestion, and heat stress. Because of its geographic location, Dhaka suffers from river floods annually. The city also suffers from frequent storm water flooding. The illegal encroachment of rivers, water bodies, lands filling, and indiscriminate dumping of domestic and industrial waste into rivers and canals are accelerating the drainage congestion (Ahammad, 2018).

As a result, Dhaka faces severe storm water flooding during heavy rainfall. The local surface water hydrology around Dhaka is complex -- the Dhaleswari River, a tributary of the Jamuna River, flows by the south-eastern part of the North Central Region of Bangladesh, close to the confluence of the Padma River and Upper Meghna River. The Lakhya River joins Dhaleswari at 11km downstream of the Buriganga confluence. About 5km below the Dhaleswari-Lakhya confluence, the Dhaleswari meets the Meghna River, which in turn flows into the Padma River, a further 20km downstream (Ahmed, 2019).

All of these results with the city's drainage system being under the influence of backwater effects from surrounding rivers. The city has been experiencing a gradual increase in water-logging over the last decade, of course. Moderate-to-heavy rain causes serious drainage problems in many parts of the city. The process of rapid urbanization is not focusing enough on adequate drainage facilities, which causes water-logging and temporary inundation in parts of Dhaka for several days during monsoon.

The inundation problem in BUET has been deteriorating in the recent years because of poor drainage system. One of the basic reasons behind this, the campus is in a natural depression because of the surroundings ground elevation has been increased by the authority of municipality and this campus is also situated low-lying area compare to the surroundings. When a moderate or high intensity rainfall occurs, storm runoff from inside and outside the campus comes together in the low-lying southern part of the campus. And it creates drainage congestion. This issue has become more serious when the drainage system of the education Board area has become worsen. Most of the water from BUET area generally passes through the Education Board outlet and their final outlet is in Buriganga River. But, two final outlets are being found according to DWASA Design. One outlet is in Gabtoli-Sadarghat Outlet & another is Babubazar Outlet (Ahmed, 2008).

Dhaka city experiences a deluge every time it rains heavily. Every time major floods occur in the country and every time it rains; the city of Dhaka faces acute drainage problem. Parts of the city go under water. In the densely populated city, woes of people know no bounds.

In spite of huge investment over the years, particularly after 1988 floods when almost whole city of Dhaka went under water, the 1998 floods appeared most devastating. About Dhaka city, drainage situation aggravated due to silted-up, blocked drainage channels. WASA's limited storm water drainage is too inadequate for a city of 850 sq.km. (Abdullah, 2017).

In this study, ArcGIS is basically used for the assessment and analysis of Drainage system and inundation problem identification through some data which are basically made in ArcGIS. SWMM Model also has been used for the calibration of the surface runoff coefficient and the analysis of actual surface runoff in this area. The specific objectives of the study are:

(i) Review the major causes, extent of the severity and management approaches of the past storm water flooding in the BUET drainage area.
(ii) Develop a Model using SWMM for the coordination approach to improve the urban flood management and drainage system.

(iii) Study of the existing storm water drainage facilities and maintenance system of the BUET zone of Dhaka city.

This study is expected to provide significant insight to find out the causes addressing its effects of waterlogging due to storm water flooding. Developing guidelines of integrated management approach will provide effective storm water flood mitigation and management.

2. METHODOLOGY

2.1 Study area

BUET is located at the southern part of Dhaka which is shown in Figure 1-1. It is located in Zone-3 of Dhaka South City Corporation. The natural slope of BUET campus is from north to south. There is a natural depression in the southern part of the campus, the Bakshibazar residential area, Dr. Fazley Rabbi Hall and education board. Consequently, the runoff is driven under gravity to the southern part of the campus. It has some large academic and residential building in both sides. There is a big play ground at the eastern end of the BUET. The area is drained by the surface and sub-surface and underground drains. The drainage is slow due to blockage of the underground sewer and a major drainage system under BUET central road have been deactivated before years. Even a few years back, flooding in the campus usually did not occur during early monsoon under average rainfall condition. But it is observed in recent years that even an average rainfall is causing a big water logging.

Figure 1-1: Map of Study Area of BUET (Source: Google Earth Pro).

2.2 Data collection

For the analysis of the Storm water Drainage System, rainfall and drainage network data of the study area is required which are shown in Table 1-1. Rainfall data for Dhaka city has been collected from Bangladesh Meteorological Department (BMD). As the study area is a part of Dhaka city, the rainfall should be same for both cases. Moreover, there is no special station to capture the rainfall of BUET area. So, the overall rainfall of Dhaka city has been considered in this study.

Table 1-1: Data collection

Data type	**Source**	**Data location**	**Period**
Rainfall	BMD	Dhaka	1965-2015
Conduit invert elevation	DWASA	Buet	
Buet area image	GOOGLE EARTH	Buet	

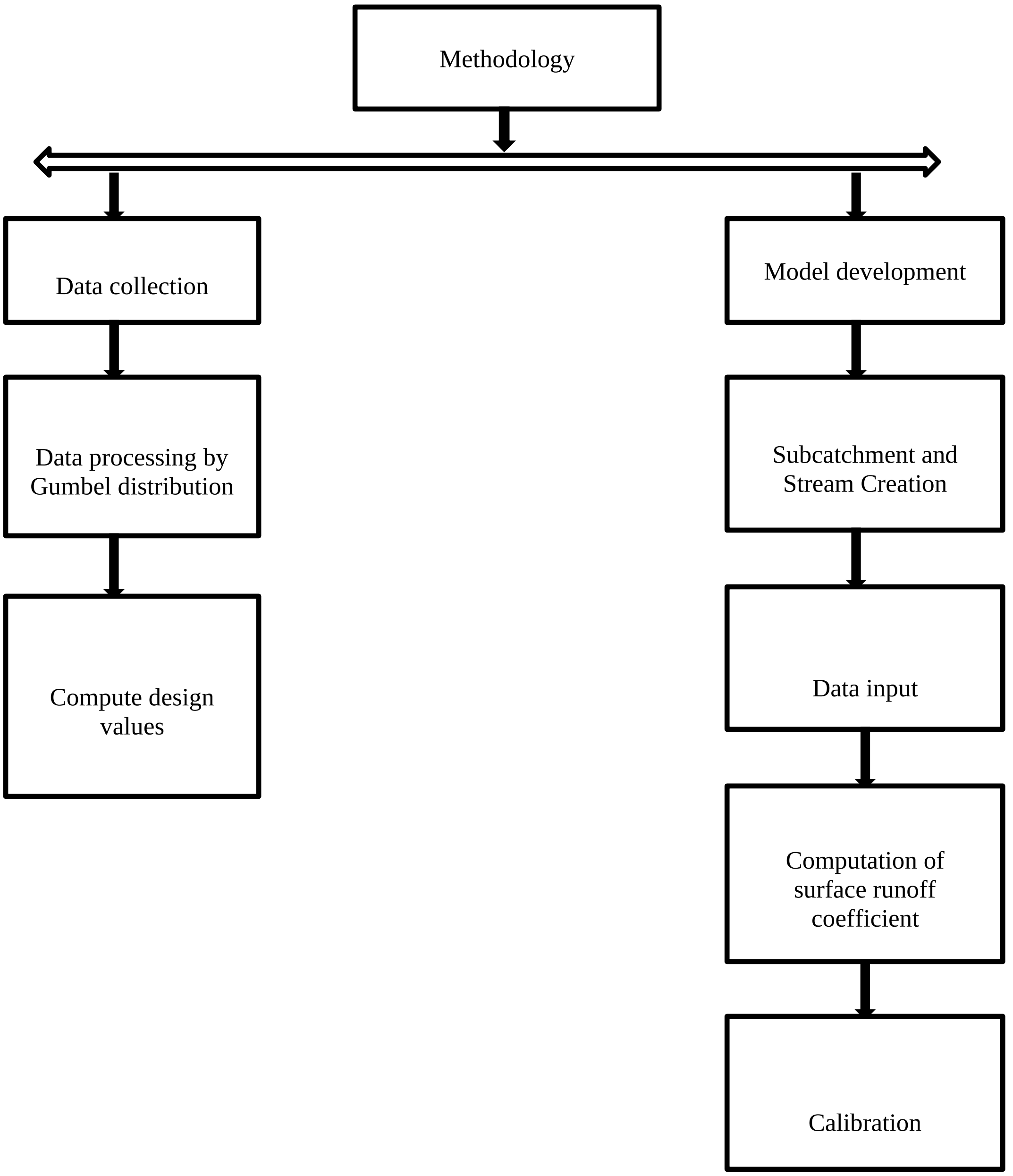

Figure 2-1: Diagram of methodology

3. DATA ANALYSIS AND RESULTS

EPA SWMM provides runoff quantity generated within each sub-catchment. The Watershed (Study area) is divided according to the elevation and it is plotted in ARC-GIS. Hydrological analysis is done to determine 5 years return period rainfall. This analysis is done by Gumbel's distribution. Annual maximum rainfall data is shown in Table 3-1. Table 3-2 is for percentage of rainfall for different time steps.

3.1 Manhole Data Analysis

An analysis of invert elevation and ground elevation over distance between manholes from BUET main gate to the final outlet in Buriganga was observed and also the main outlet of BUET area near Education Board data also attached to understand the volume of water passing from manhole.

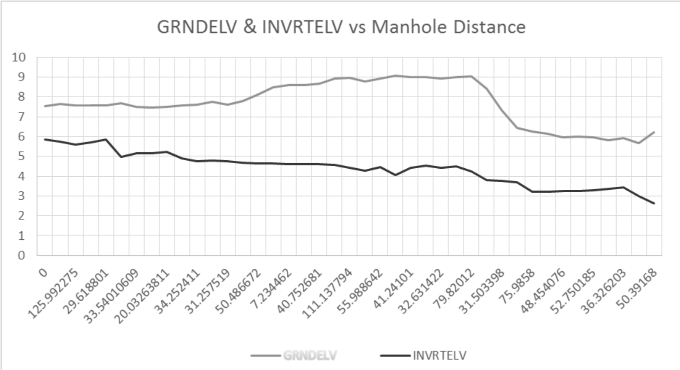

Figure 3-1: Ground Elevation, Invert elevation of manhole over manhole distance observation

3.2 Hydrological Analysis

The collected rainfall data from BMD data are analysed which is shown in Table 3-1

Table-3.1: Annual Maximum Daily Rainfall Data in Dhaka City from year 1965-2015

Year	Max daily rainfall(mm)	Year	Max daily rainfall(mm)
1965	177	1992	90
1966	257	1993	140
1967	125	1994	74
1968	145	1995	83
1969	86	1996	150
1970	152	1997	121
1971	251	1998	122
1972	231	1999	141
1973	168	2000	158
1974	143	2001	71
1975	163	2002	88
1976	100	2003	93
1977	128	2004	341
1978	108	2005	125
1979	91	2006	185
1980	81	2007	152
1981	81	2008	190
1982	146	2009	333
1983	133	2010	87
1984	151	2011	94
1985	92	2012	62
1986	176	2013	122
1987	138	2014	75
1988	135	2015	90
1989	118	2016	
1990	94	2017	
1991	123	2018	

By Gumbel's distribution, it has been found that for 5 yr.'s return period, rainfall is 187.26 mm which means this rainfall will occur at least once in 5 years in Dhaka City. BUET experiences same amount of rainfall as BUET is within the main Dhaka city.

Table 3.2: For 5-year return period, Percentage of Rainfall for Different Time Steps

Time step	Percentage	5-yr return period
0-4	9%	16.86
4-8	15%	28.09
8-12	44%	82.41
12-16	16%	29.97
16-20	9%	16.86
20-24	7%	13.11

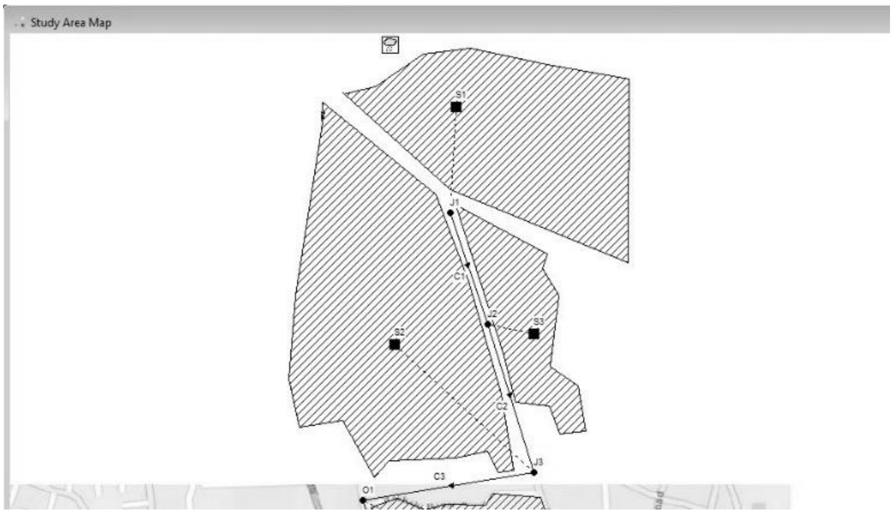

Figure 3-2: Delineated Watershed of Study Area using EPA SWMM

3.3. Model results

Watershed delineation using EPA SWMM gives 3 sub-catchments (Figure 3-2). In Table 3-3, the runoff values of each sub-catchment are given. The peak runoff is 332.03 CFS in S1 sub-catchment for 5-year return period. Flow rate, flow velocity (ft/sec), Time of maximum flow occurence of link such as conduit, outlets are obtained from EPA SWMM simulation are shown in Table 3-4.

Table 3-3: Sub catchment runoff coefficient in SWMM Model

Sub-catchment	Total Precipitation(mm)	Total Runoff (mm)	Peak runoff (CFS)	Runoff coefficient
S3	187.26	5.82	125.23	0.777
S2	187.26	4.72	269.55	0.630
S1	187.26	4.56	332.03	0.609

Table 3-4: Conduit flow summary, simulated by GeoSWMM for 5 years return period

Link	Type	Maximum flow (CFS)	Day of maximum flow	Hour of max flow	Max velocity (ft/sec)
C1	CONDUIT	2.78	0	01:50	1.79
C2	CONDUIT	0.74	0	02:28	0.58
C3	CONDUIT	6.75	0	01:12	4.20

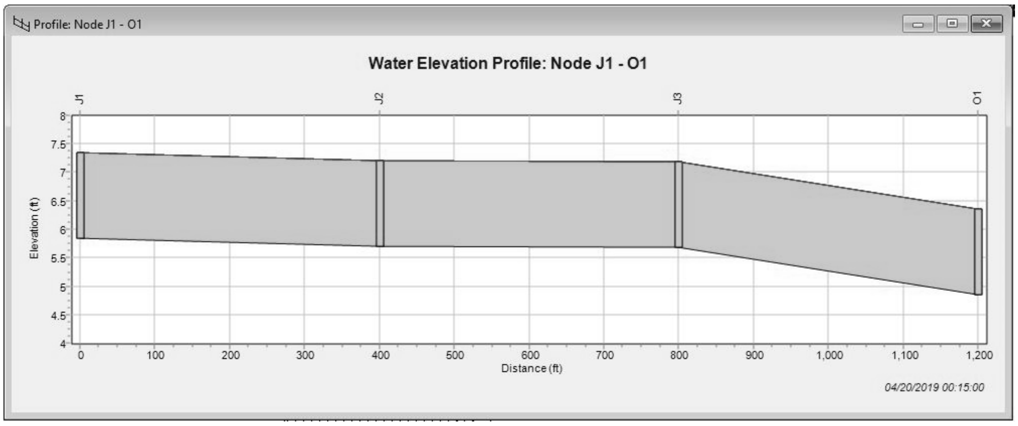

Figure 3-3 : Water elevation profile plot of Study Area

The water profile plot is obtained for conduits from node J1 to O1 is as shown in Fig. 3-3. The simulation status report shows that sections between these nodes are surcharged (flooded). The depth of surcharging at node J1,at node J2 and at node J3 is 1.5 ft above crest level, whereas for node O1 is 1.8 ft.

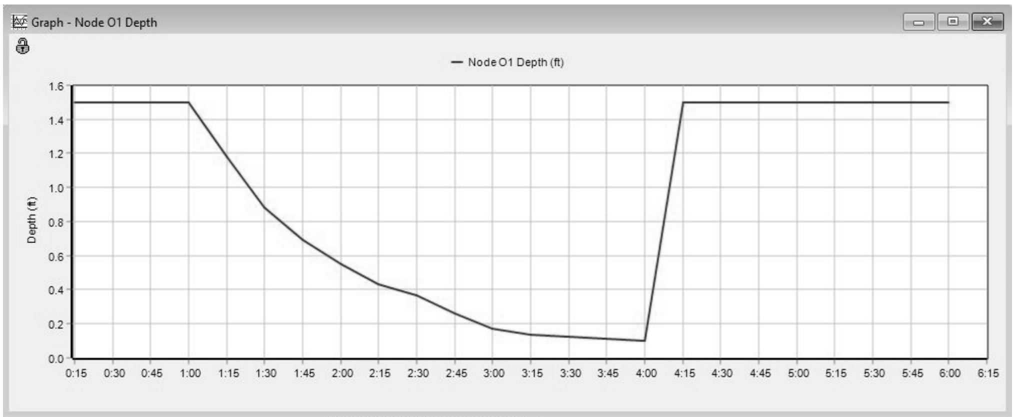

Figure 3-4 : Node O1 depth plot of the study area

In outfall Node in Figure 3-4, Depth is variable for certain time but before flooding node depth decreased and after flooding node depth again increased.

Table 3-5 : Node flooding at different locations

Summary Results

Topic: Node Flooding   Click a column header to sort the column.

Node	Hours Flooded	Maximum Rate CFS	Day of Maximum Flooding	Hour of Maximum Flooding	Total Flood Volume 10^6 gal	Maximum Ponded Volume 1000 ft3
J1	3.77	323.10	0	04:10	4.026	0.000
J2	4.33	124.92	0	04:10	1.435	0.000
J3	3.17	259.03	0	04:10	2.905	0.000
O1	3.95	346.35	0	04:10	4.762	0.000

The Table 3-5 is shown for Node flooding.The maximum rate at Node J1,J2,J3,O1 are 323.1 CFS,124.92 CFS,259.03 CFS and 346.35 CFS respectively.

3.3.1 Calibration

According to New Neighbourhood Design and development standard manual (2012),

In this study, the total area of the study is 0.288 km^2 or 65.69 acres.
In this study, Runoff Coefficient for Roofs and streets are almost 0.75 to 0.95

Runoff Coefficient for Playgrounds/Residential is almost 0.20 to 0.40

From ArcGIS, from 34.9 acres, 46% playground (Around 16.12 acres) and 54% building (Around 18.78 acres), 26.97 acres 74% building (17.202 acres) and 36% playground (Around 9.768 acres), 7.78 acres 28% playground (Around 2.189 acres) and 72% building(around 5.591 acres).

The value of runoff co-efficient, C

$$= \frac{(34.9(0.54*0.75+0.46*0.25)+26.97(0.74*0.75+0.36*0.25)+7.78(0.28*0.75+0.72*0.25))}{(34.9+26.97+7.78)}$$

$$= 0.553$$

From Model,the average value of runoff co-efficient,C = 0.672
From the Calibration, it can be said that the model has shown about 77.52% accuracy found in 5 year return period.

3.4 The outlet pipe size calculation:

From Model,the average value of runoff co-efficient,C = 0.672

Runoff Coefficient of the study area, C = 0.553

Rainfall Intensity for 5-yr 1-hr Rainfall, i = 2.59 inch/hr =65.786 mm/hr

Total area of the study, A = 65.69 acres = 0.288 sq. km

So, Peak Discharge, Q = 0.278 CiA = 2.917 m3/s

From Model, Peak Discharge, Q= 0.278 CiA= 6.56 m3/s where, C=0.672
From rational method, D = 1.726 m = 5.66 ft.
According to model discharge, D= 2.55 m = 8.38 ft.

So, 8.5 ft diameter pipe needed for the total flow passing which is generated in total area but now, at present, 5.5 ft diameter pipe exists there. Though, A manhole with 13.21 m^3 volume generated there but still pipe size isn't enough to flow the total runoff

4. CONCLUSIONS

It has been seen from the field visit that the sewer system and storm water drainage system has been mixed at various places and the catchment outside BUET area (BUET to Buriganga outlet), pipe size isn't enough to remove the city's excess water completely. That's why BUET area is inundated. As moving forward, discharge will be increased spontaneously. Final outlet pipe diameter is 5.5 ft. but it needs min. 8.5 ft. diameter pipe to runoff the stormwater completely. Natural depression is another cause but if the drainage is being properly maintained, that's not create any problem.

- A few maintenance occur in BUET drainage and drainage system is very poor in condition.
- Behind the reduction in the drain capacity, Dumping wastages and blockage in the drains are important reasons.
- One of the system which starts from BUET shahid minar to BUET teachers quarters (Education board) has been disabled in recent years. So, this is one of the major cause for water logging in this area.

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