Planning and Design of Water Supply Network for Pabna University of Science and Technology Campus in Bangladesh

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Abstract— Pabna University of Science and Technology (PUST) is one of the new universities in Bangladesh. At present there is no water supply network at PUST Campus. It is necessary to have an understanding the water distribution network in order to make right decision on maintenance and expansion of existing network. In this study two phases of water supply networks have been considered. One is Phase-I (Existing Buildings Construction) and another is Phase-II (Future Extension Buildings). The study provides necessary information on planning as well as design of proposed water supply network for PUST Campus in Pabna. The water demand in the campus during completion of Phase-I is 3, 31,814.5 litres/day and Phase-II is 13, 62,884 litres/day. The study team proposes two water pumps with Water Horse Power (W.H.P) 40 Hz. In planning for the development of water supply system both surface and ground water problems should be undertaken. The research paper concludes with various strategies such as cost effective network, surface and ground water management, and conservation practices which can be implemented to achieve a sustainable water supply for PUST Campus at Pabna in Bangladesh.

Index Terms— Water Supply Network, Water Demand, Water Pump, Surface and Ground Water Management.

1 INTRODUCTION

THE government passed the Act on 15 July 2001 to establish a Science and Technology University in Pabna District. The academic curriculum of the Pabna University of Science and Technology (PUST) was started on 15 July 2008. This newly established university requires an effective water supply network for the persons who are attached with this University. We know water is an essential natural resource for human existence. The water distribution system is that parts of the water works which receives the water from the pumping station or from conduits by the gravity flow and delivers it throughout the district to be served (Aziz, 2010). Ground water is a vital source of water supply of Bangladesh is almost entirely underlain by water bearing formations at depths varying from zero to forty feet below the ground surface. The focus of this paper is to analyse the water supply situation of Pabna University of Science and Technology Campus by assessing the present and future water demand. The study also tries to understand the ground water scenario in providing water to the campus.

One of the biggest concerns for water-based resources in future is the sustainability of the current and even future water resource allocation. (Wikipedia, 2014)). The United Nations has long been addressing the global crisis caused by insufficient water supply to satisfy basic human needs and growing demands on the world's water resources to meet human, commercial and agricultural needs. By 2025 one-third of the population of the developing world will face severe water shortages (Seckler et al. 1998). The PUST Campus water supply provides water for Academic Units, Administrative Units, Library, Cafeteria, Hall Residents, and Laboratory uses throughout the University. It might also serve as the source of water for campus fire hydrants. The maintenance of campus wells and the water distribution system will one of the responsibilities of the office of Chief Engineer. The purpose of this research is also to find out the most environmentally friendly and economical way to supply water to the community who are attached with this University Campus

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2 STUDY METHODS

The estimation of quantity of water requirement is the first prerequisite for the design of a water supply system. Present study was conducted in 2014 by taking into account the major water consumption units at PUST campus which are mosque, administrative building, library, household/residential buildings, hall residents, academic buildings, and cafeteria for water demand calculation in Phase-I. In addition, six storied extension of administrative building, seven additional teacher's dormitory, extension of ladies hostel, new academic building, extension of existing academic building, staff quarter, school building, TSC (Teacher Student Centre), and new and extension of existing gent's hall was considered for Phase-II water demand calculation with Phase-I demand. The Master Plan of PUST campus is depicted in the following **Map 01**. In this map, Phase-I and Phase-II buildings have been shown in yellow and blue colours respectively. The total quantity of water required by a community is computed according to the following equation-1 (Ahmed and Rahman, 2000):

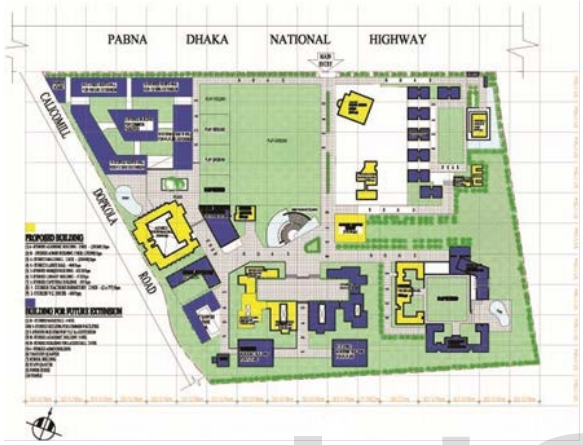
$$Qf = Pf \times q \quad \text{.....(1)}$$

Where, Qf is the quantity of water requirement per day

Pf is the projected population estimated at the end of the design period and
q is the rate of water consumption per capita per day
Total water requirement in the PUST campus was calculated by the following equation-2.

Total Water Requirement (TWR) = Water requirement in (Phase-I: Existing Buildings Construction + Phase-II: Future Extension Buildings) .....(2)

Map 01: Master Plan of Pabna University of Science and Technology Campus



The capacity of the pump required to supply the total quantity of water in Phase-I and Phase-II was also calculated. Water Horsepower (WHP) was calculated in the study by using the following equation-3 (Weiner and Matthews, 2003).

WHP = QH/3960.....(3)

Where, Q = Pump discharge (in gallons per minute)
H = Total Head (in feet)

Rainwater harvesting potential on the rooftop of PUST buildings was calculated by using the following equation-4 (Karnataka State Council for Science and Technology, 2012).

Roof Yield (L) = Roof Area (sq.m) x Annual Rainfall (mm) …….....(4)

It was reported in Banglapedia (2007) that the average rainfall in Pabna was 1872 mm.

3 RESULTS

Projected population of the PUST campus for Phase-I and Phase-II were estimated by receiving information from PUST authority and judicious judgement by authors which is provided in the following **Table 01**.

Table 01: Estimated Population of the PUST Campus in Phase-I and Phase-II

Phase-I: Existing Buildings Construction		Phase-II: Future Extension Buildings	
Water Demanding Unit	**Estimated Population (on average)**	**Water Demanding Unit**	**Estimated Population (on average)**
Mosque	300		
Administrative Building	180	Administrative Building Extension	280
Library	90		
Residential (V.C. Bungalow & Teacher's dormitory)	120	New seven Teacher's dormitory	350
Hall Residents (Gents)	800	Extension of Gents Hall with New Hall	5000
Hall Residents (Ladies)	400	Extension of Ladies Hall	1600
Academic Building	1600	Extension of Academic Building with New Building	6500
Cafeteria	500		
		Staff Quarter	200
		School Building	300
		TSC	600

Source: Engineering Section of PUST and authors' judgement, 2014

Table 02: Water Consumption Rate (per capita per day)

Nature of Consumption	Average Consumption Rate (pcpd) in gallon	Average Consumption Rate (pcpd) in liter
Mosque	15	56.85
Administrative Building	10	37.9
Library	5	18.95
Residential	40	151.6
Residential Hall	35	132.7
Academic Building	15	56.85
Cafeteria	20	75.8
School Building	5	18.95
TSC	8	30.32

Source: Aziz, 2010

The various factors that affect per capita water consumption are number of inhabitants, characteristics of population, climatic conditions, pressure of water, quality of water, efficiency of management etc. The rate of water consumption per capita per day that was used in the present study is provided in above (**Table 02)**. Water requirement for PUST campus in Phase-I and Phase-II was calculated by using the data in Table 01 and Table 02 and by applying equation-1 (in above) which is provided in the subsequent **Table 03**.

Table 03: Water Requirement in PUST Campus

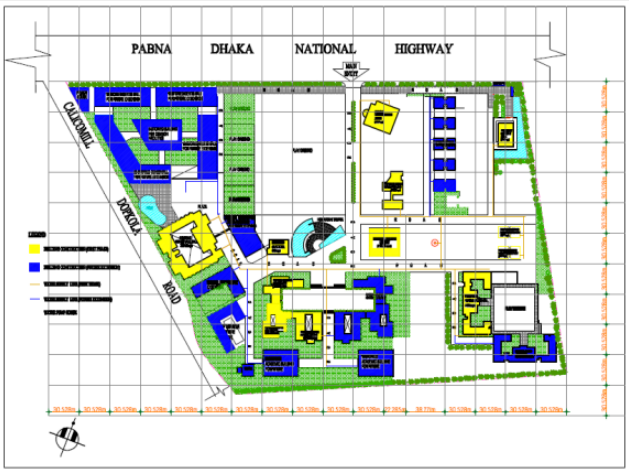
Phase-I: Existing Buildings Construction		Phase-II: Future Extension Buildings	
Water Demanding Unit	Water Requirement (in litres/day)	Water Demanding Unit	Water Requirement (in litres/day)
Mosque	17055		
Administrative Building	6822	Administrative Building Extension	10612
Library	1705.5		
Residential (V.C. Bungalow & Teacher's dormitory)	18192	New seven Teacher's dormitory	53060
Hall Residents (Gents)	106120	Extension of Gents Hall with New Hall	663250
Hall Residents (Ladies)	53060	Extension of Ladies Hall	212240
Academic Building	90960	Extension of Academic Building with New Building	369525
Cafeteria	37900		
		Staff Quarter	30320
		School Building	5685
		TSC	18192
Total Demand	**3,31,814.5**	**Total Demand**	**13,62,884**

According to **Table 03** the water requirement in Phase-I and Phase-II is **3,31,814.5 litres/day** and **13,62,884 litres/day** respectively. Therefore, the total water requirement after completion of phase-II construction would be the sum of phase-I requirement and phase-II water requirement which would be **16,94,698 litres/day**. Based on the water requirement two water pumps with 40 Hz (25 Hz + 15 Hz) have also been proposed.

4 DISCUSSION

The proposed water supply network for PUST Campus has been presented in the following **Map 02**. In the map both Phase-I and Phase-II building structures have been shown in yellow and blue colours respectively. The proposed water supply lines during these two phases have also been marked with those same colours. The study proposes two water pump houses in two different suitable places around the campus. Valves will be needed to operate and control the water pipe system. These should be sufficient in number and suitably located.

Map 02: Master Plan of Pabna University of Science and Technology Campus



4.1 Surface water management due to ground water depletion

The capacity of a pump installed in a well to deliver water depends on several factors, including the size of the pump and the power of the motor as well as the lift, or vertical distance over which the water must be raised (Boonstra and Soppe, 2007). Conceptually, after pumping starts, the water level in the well will decline over time and the lift (and total dynamic head) required to discharge at a fixed point and elevation above the land surface will increase. As the total dynamic head increases, more work is required to lift and discharge a unit volume of water, so the discharge from a standard constant-speed pump will tend to decrease.

Groundwater zoning map of Bangladesh has been updated after six years by Bangladesh Agricultural Development Corporation (BADC). The first one was prepared by BADC engineers with the technical support of Bangladesh University of Engineering and Technology (BUET) in 2005 using the data of 2004. According to Department of Public Health and Engineering (DPHE), Pabna yearwise drawdown of water table from the base of tubewell at Sadar Upazila can be shown in the following **Table 04**.

Table 04: Yearwise drawdown of water table at Pabna Sadar Upazila

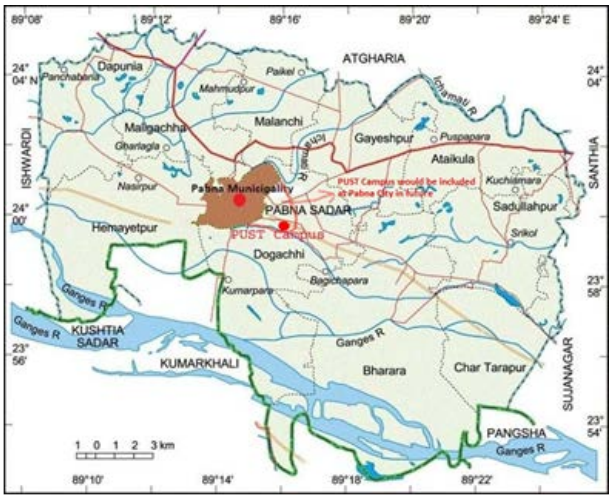
Year	Water level (foot)
2010	38.75
2011	32.75
2012	32.75
2013	34.75
2014	34.83

Source: DPHE, Pabna (2014)

The proposed Pabna-Sirajganj Link Road and Railway Line around Pabna Municipality would also have profound effect on ground water resources in future. Due to urbanization, Pabna University of Science and Technology (PUST) might be included under the jurisdiction of future Pabna

City. River (*Padma river*) water would also be an alternative source as surface water supply both for local residents and PUST Campus. The municipal authority can find a suitable place for river water treatment plant to serve purified supply water to its local people. The proposed river water treatment network is shown in the following **Map 03**.

Map 03 : Proposed Surface Water Supply by using Padma River Water



4.2 Groundwater recharge

A variety of methods have been developed and applied to artificially recharge groundwater reservoirs in various parts of the world. Generally these methods are classified as surface and subsurface groundwater recharge. Direct surface recharge techniques are among the simplest and most widely applied methods.Subsurface groundwater recharge conveys water directly into an aquifer without the filtration or oxidation that occurs when water percolates naturally through an unsaturated zone (UNEP, 1998). **Spreading Basins** method involves surface spreading of water in basins that are excavated in the existing terrain. For effective artificial recharge, highly permeable soils are required and maintenance of the water layer above the soil surface is necessary. Recharge in spreading basins is most effective where there are no impending layers between the land surface and the aquifer and where clear water is available for recharge (BATES, 2004).

4.3 Rooftop rainwater harvesting

Rainwater is one of the purest sources of water available. Most of the time its quality is better that of ground or surface water. However, rainwater quality is influenced by where it falls. Rooftop rainwater collection system might be a potential option for sustainable water management in buildings that can be used for various purposes after minor treatment. According to equation-4 mentioned before, the potential amount of rainwater from the rooftops of PUST buildings has been given in **Table 05** below. The following table shows that annually 1,60,05,600 litres and 3,20,09,200 litres rainwater might be harvested during Phase-I and Phase-II respectively.

Table 05: Rooftop Rainwater Harvesting Potential in PUST Campus

Phase-I: Existing Buildings Construction			Phase-II: Future Extension Buildings		
Water Consumption Unit	**Rooftop Rainwater Collection Area (sq. m)**	**Rainwater Harvesting Potential (litres/year)**	**Water Consumption Unit**	**Rooftop Rainwater Collection Area (sq. m)**	**Rainwater Harvesting Potential (litres/year)**
Administrative Building	900	1684800			
Library	900	1684800			
Residential (Teacher's dormitory)			New seven Teacher's dormitory	3150	5896800
Hall Residents (Gents)	2700	5054400	Extension of Gents Hall with New Hall	4050	7581600
Hall Residents (Ladies)	1350	2527200	Extension of Ladies Hall	2700	5054400
Academic Building	2700	5054400	Extension of Academic Building with New Building	4500	8424000
			School Building & Staff Quarter	1800	3369600
			TSC	900	1684800
Total	**8,550**	**1,60,05,600**	**Total**	**17,100**	**3,20,09,200**

5 CONCLUSION

The proposed water supply at PUST Campus provides the visual flow network in different sites. The calculated data also gives an idea of present and future water demand for daily purposes. Under all but the most optimistic scenarios, there is a dearth of freshwater storage. If climate change as a result of global warming manifests, the need for freshwater storage will become even more acute. Increasing storage through a combination of groundwater and large and small surface water facilities is critical to meeting the water of the twenty-first century.

ACKNOWLEDGMENT

The authors would like to convey thanks to Executive Engineer Md. Emrul Hasan of PUST for his constant support during the study. We wish to express our deep sense of gratitude to the Department of Public Health and Engineering at Pabna in providing necessary information. Once again we would like to thank all 2nd Year 2nd Semester students of Urban and Regional Planning Department of PUST for their academic support in Lab classes.

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