Conference Paper, Published Version

Khan, Abu Saleh

Augmentation of dry season flows in the peripheral rivers of Dhaka for improvement of water quality and round the year navigation

Dresdner Wasserbauliche Mitteilungen

Zur Verfügung gestellt in Kooperation mit/Provided in Cooperation with:
Technische Universität Dresden, Institut für Wasserbau und technische Hydromechanik

Verfügbar unter/Available at: https://hdl.handle.net/20.500.11970/103912

Vorgeschlagene Zitierweise/Suggested citation:
Khan, Abu Saleh (2004): Augmentation of dry season flows in the peripheral rivers of Dhaka for improvement of water quality and round the year navigation. In: Technische Universität Dresden, Institut für Wasserbau und technische Hydromechanik (Hg.): Risiken bei der Bemessung und Bewirtschaftung von Fließgewässern und Stauanlagen. Dresdner Wasserbauliche Mitteilungen 27. Dresden: Technische Universität Dresden, Institut für Wasserbau und technische Hydromechanik. S. 237-247.

Augmentation of dry season flows in the peripheral rivers of Dhaka for improvement of water quality and round the year navigation

Abu Saleh Khan

Abstract
The Buriganga-Turag river system provides an important riverine link with the Dhaka Metropolitan City. Other peripheral rivers such as Balu, Lakhya and Tongikhal are also important in maintaining circular water route and natural environment of the city. Through the ages, these rivers have silted up and offtakes from the main source with the Jamuna have been almost disconnected during the dry season causing obstructions to navigation in the surrounding rivers of Dhaka due to reduced drafts. As the flows of these rivers are practically nil during the dry season, the pollution of the river water has become a chronic problem, degrading the natural environment. Indiscriminate disposal of wastes has added pollution level in the rivers. A mathematical model supported study has, therefore, been taken up to develop strategy towards augmenting the dry season flows of the Buriganga-Turag river system and rehabilitation of the Tongikhal-Balu-Lakhya river system to ensure circular navigation route around the city and improve the river water quality to mitigate the chronic pollution problems. Study has analysed the flow phenomenon for augmentation under four options.

Option-1: Old Brahmaputra offtake-Jhenai-Futikjani-Bangshi-Turag-Buriganga
Option-2: Dhaleswari North offtake-Pungli-Bangshi-Turag-Buriganga
Option-3: New Dhaleswari offtake-Pungli-Bangshi-Turag-Buriganga
Option-4: Dhaleswari South offtake-Barinda-Bangshi South-Karnatali Khal-Buriganga

Option-3 has been selected as the preferred option based on favorable hydro-morphological conditions. Model study shows that about 400 cumec discharge is required to be diverted from the Jamuna at New Dhaleswari offtake during the dry season, particularly during January to March, when the flow in the Buriganga as well as in the route is practically nil. After satisfying the needs of future Low Lift Pumps and existing project as CPP, about 210 cumec could be augmented through the Turag-Buriganga and 30 cumec through Tongikhal-Balu-Lakhya system. The model study indicates the necessity of lowering of existing bed by dredging about 43 Mm^3 along the augmentation route in the first year.

1. INTRODUCTION

1.1 Background

The water of the rivers Buriganga, Dhaleswari, Turag, Tongi Khal, Lakhya and Balu flowing around the capital city of Dhaka, is being polluted for quite a long time. Water quality of these rivers is too poor to be considered as safe for human consumption. The Buriganga, once the main artery of communication has virtually been reduced now to a narrow canal of polluted slime. Dumping of solid and industrial wastes round the clock has not only changed the physical aspect of the river but also diminished much of its fish and other aquatic animals.

In 1992, the Department of Environment (DoE) prohibited the use of Buriganga water for both household and drinking purposes. The DoE found the level of oxygen to be below 2 mg. per litre against the standard minimum of 4 mg. per litre. The level of chromium was 6 ppm, an amount 60 times higher than the tolerable limit prescribed for the human body (*The Holiday, 14 December, 2001*).

During the last decades, the low flow characteristics (both quantity and quality) of most of these rivers i.e. Buriganga, Dhaleswari, Turag, Tongi Khal, Lakhya and Balu flowing around the capital city of Dhaka, changed significantly. Moreover, each year most of these rivers become unsuitable for navigation in the dry season due to inadequate draft. The present, study has analysed the flow phenomenon for augmentation under four options (Figure 1.1)

1.2 Objective of the Study

The main objective of the study is to develop river system around the Greater Dhaka area and provide round the year flow through rehabilitation and flow augmentation from the Jamuna River. The overall purpose of the proposed study is to protect the Buriganga-Turag and Shitalakhya river system from pollution and to ensure navigation through the rivers round the year for preservation of natural environment throughout the Dhaka City.

2. AUGMENTATION OPTIONS AND REQUIREMENTS

2.1 General

The possibility of supply of flow through different offtakes during the dry season is a key factor for the augmentation in the downstream part i.e. Buriganga-Turag river systems. The offtakes of major distributaries from the Jamuna left bank (Figure 1.1) that may be considered for the diversion of flow during dry season are:

- Old-Brahmaputra
- Dhaleswari North offtake (Old Dhaleswari)
- New Dhaleswari Spill channel
- Dhaleswari south offtake (Dhaleswari)

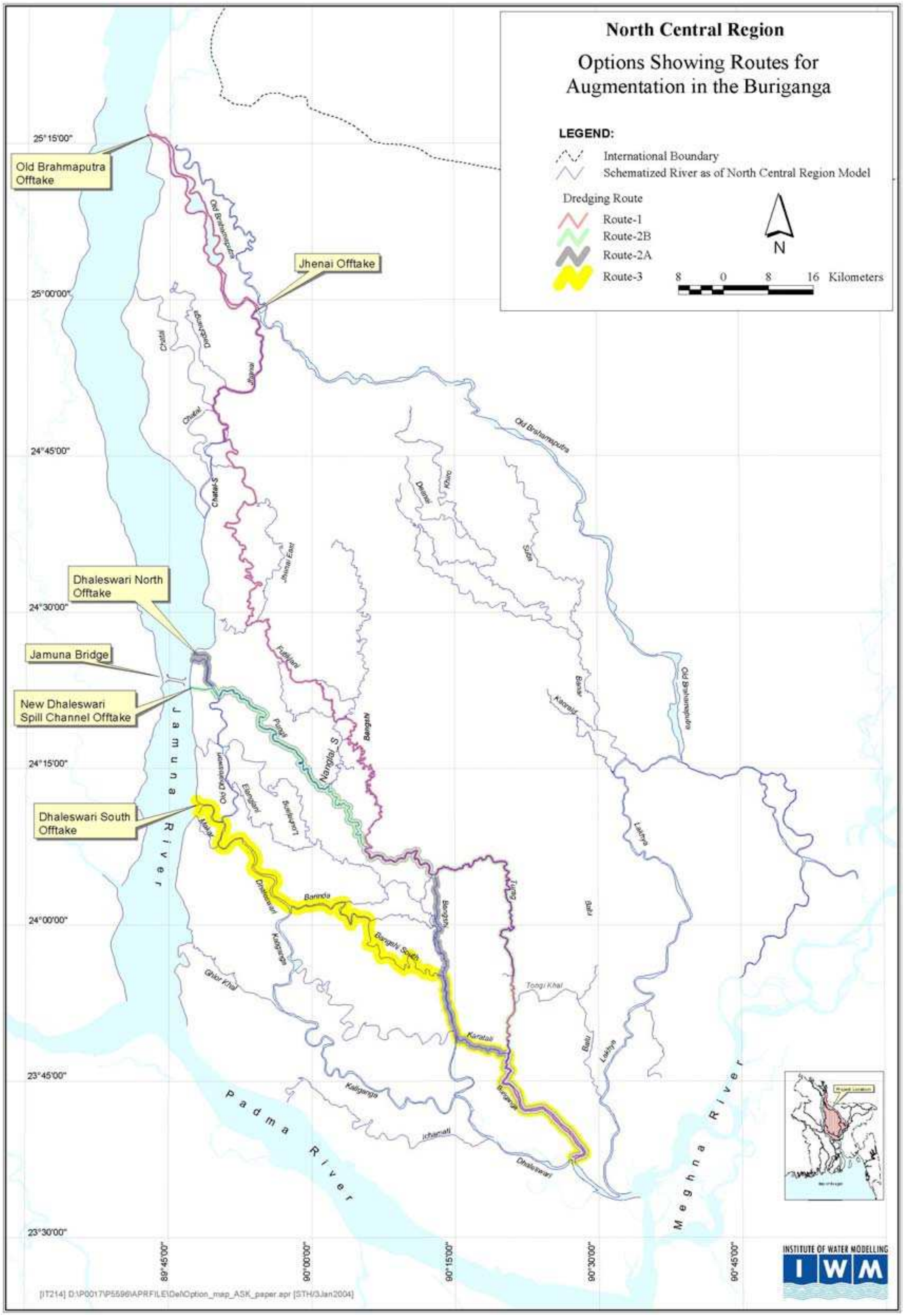

Figure 1.1 : Index Map Showing Options for Augmentation Routes

2.2 Offtake Conditions

Option-1 has the involvement of two offtakes: one is the Old Brahmaputra offtake and the other is the Jhenai offtake (Figure 1.1). Old Brahmaputra is the biggest offtake of the Jamuna, having two or even more channels during the dry season. Usual channel shifting from year to year would lead to uncertainty of the availability of water at the offtake point. The river width of the Jamuna at this point is about 12 km. and the morphological changes are quite unpredictable which would also lead to uncertainty in offtake management. Jhenai offtake is completely dependent on the Old Brahmaputra offtake. Even if some flow is made available by dredging the Old Brahmaputra offtake, additional engineering intervention might be necessary at the Jhenai offtake to divert the required augmentation through Jhenai during the dry season.

Option-2 & 3 have their offtakes very close to the Jamuna Bridge (Figure 1.1). The river reach, being constricted in the vicinity of the Bridge, is not susceptible to major morphological changes and, therefore, the flow pattern, particularly along the left bank has been stable over the past years after construction of the Bridge. It may, therefore, be predicted that the flow needed for augmentation would be available at these two offtakes during the dry season. It may also be possible to ensure sustainability of both the offtakes through construction of regulating structures and minor annual maintenance. The channel of Option-2 was closed (*JMBA, June 1995*) and the approach road has been constructed (Figure 1.1). The closure can be reopened either by a regulating structure at the road crossing or a regulator near the offtake and linking the upper and lower part of the channel by a siphon under the approach road.

Option-4 is basically dependent on the Dhaleswari South offtake. At this location, the river Jamuna has 3 or more channels and river width is more than 12 km. Channel shifting from year to year is a usual phenomenon due to unpredictable morphological changes of the bed form in the reach. Availability of flow from Jamuna during dry season is, therefore, uncertain.

Presently, all the offtakes remain dry during the dry season. Excavation of the offtakes would be necessary to initiate the dry season flow through the augmentation routes.

2.3 Comparison of Options

The identified four options have been compared based on preliminary assessment of the offtake conditions, route length, objective and sustainability in consideration to uncertain morphological changes. However, sustainability has been given its due priority in choosing the preferred option. The results of comparison are tabulated below:

Option Nos.	Route Length (km.)	Offtake Condition	Remarks
1	356	Two offtakes to be managed and additional intervention needed.	Route is too long and management of two offtakes might be unsustainable.
2	182	Flow from the Jamuna will be available at the offtake. Reopening of the closure and a regulator is necessary.	The offtake might be sustainable.
3	180	Flow from Jamuna will be available at the offtake. A regulator may be necessary to regulate inflow.	The offtake might be sustainable.
4	140	Availability of flow from Jamuna is uncertain due to probable shifting of the eastern channel.	The offtake might be unsustainable.Moreover, it would not augment flow to Turag, which is a part of the objective.

Table 2.1 Relative comparisons of offtake conditions

The above comparison reveals that Option-1 & 4 would not be sustainable. Option-2 is sustainable, but its reopening needs an additional structure and detailed morphological investigation with respect to the reopening. Option-3 may be considered as the preferred option in comparison to other options.

2.4 Augmentation Requirements

Augmentation requirement in the rivers Buriganga-Turag during the dry season have been determined considering the following criteria:

1. The flow that would ensure required navigation draft.
2. The flow that would ensure minimum quality of the river water to ensure survival of acquatic life.
3. The flow that would mitigate tidal effect.

Highest of the above three flows shall be considered as the augmentation requirement in the Buriganga-Turag during the dry season.

3. SELECTION OF PREFERRED OPTION AND SCENARIO

3.1 Selection Criteria

For selecting the suitable option for consideration of the detailed study through particular route, following major aspects have been considered:

- Diversion requirements
- Offtake morphology and offtake management
- Development of Jamuna eastern channel
- Offtake sustainability
- Overall route length
- Loop cuts
- Dredging volume
- Structural interventions
- Results of initial model simulations

The outcome of the above analysis is given in Table 3.1

Table 3.1: Comparative study of different options

Criteria	Option –1	Option-2 & 3	Option-4	Remarks
Diversion requirements	500 m^3/s	400 m^3/s	400 m^3/s	
Offtake morphology (w.r.t. Jamuna)	Offtake swings frequently (more than 6 km), difficult to define a single offtake, high rate of siltation, too wide to manage (more than 6km) (*CEGIS, July 2000*)	Single defined off-take (*CEGIS, Feb. 2003*) and (*IWM, Mar. 1997*)	Too wide to manage, high morphological activity (siltation and scouring)	Option-3 seems favourable
Jamuna eastern channel	Very unstable, swings laterally by 3-5 km	Channel position is certain and favourable since 1995. Moving towards east (horizontal and vertical shifting)	Very uncertain and unstable, gets disconnected with the main water course (going away from the offtake)	Option-3 seems favourable
Offtake sustainability	Questionable	Might be sustainable	Questionable	
Overall route length	356 km	182 & 180 km	140 km	
Matured Loops	More than 30	Less than 5	More than 8	
Dredging volume	64 Mm^3	45 Mm^3 & 43 Mm^3	52 Mm^3	Coarse estimate based on scanty and old cross-sections
Major structural interventions	14 nos.	10 nos. and 9 nos.	12 nos.	
Results of initial model simulations	Not favourable	Favourable	Not favourable	

3.2 Option Simulations by 1D Hydrodynamic Model

Figure 3.1a through 3.1c show the flow diversion through various nodal points in Option-1, Option-2, Option-3 and Option-4 for existing condition and closed diversion condition to make the flow pass through the required route only. For each option, 2 simulations have been carried out. However for Option-3, one additional simulation has been carried out where distribution through the Tongi khal has been allowed to get benefit of dry season flow for both the system-Tongi khal as well as Turag-Buriganga river. It is to be noted that losses due to LLP and seepage are not considered in this calculation.

Figure 3.1a shows that there are at least 14 major points that need to be controlled for flow diverting through this route during the dry season. This route has the maximum length and before Baushi, almost 90% of the Jhenai flow diverts through Chatal and Chatal_south and returned back to the Jamuna.

From Figure 3.1 (b) it is seen that more than 60 % of flow of the New Dhaleswari Spill channel passes through the Pungli and rest 40 % passes through the Old Dhaleswari and some small connecting channels (link channels). Almost 60% of the Bangshi flow passes through the Turag with the existing condition. With the existing condition, around more than 70% of the Turag flow passes through the Turag downstream of Tongi bifurcation and less than 30 % of the flow passes though the Tongi Khal. If all upstream diversion closed before Tongi Khal, there is a possibility of around 30 % of flow may divert through the Tongi Khal. Remaining amount of flow may be considered sufficient through the Buriganga if the water quality with this flow is adequate for the critical DO levels, which has been discussed in the next section. Following this route, there are nine major points that has to be controlled by structural operation.

From Figure 3.1(c) it is seen that almost entire flow is passing through the Kaliganga at the Barinda offtake. Following this route, there are eight major points that need to be controlled for flow diversion. With the existing situation, apart from the uncertainty in the Jamuna eastern channel, this route has a major drawback in passing the flow naturally through Barinda-South Bangshi system and after implementing closure in the diversion points, there is no possibility of improving the Tongi Khal thereby downstream of Balu.

Finally considering the Option 3, the model simulations have determined the optimum bed level required to transfer the flow to the Buriganga and Turag rivers to achieve the study objectives. The long profile is shown in Figure 3.1(d).

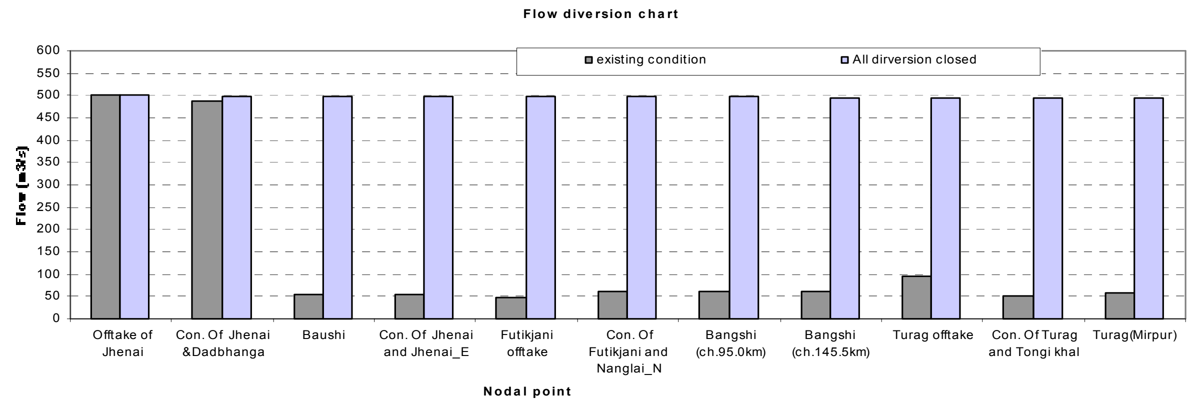

Figure 3.1(a): Flow diversion chart for Old brahamaputra route

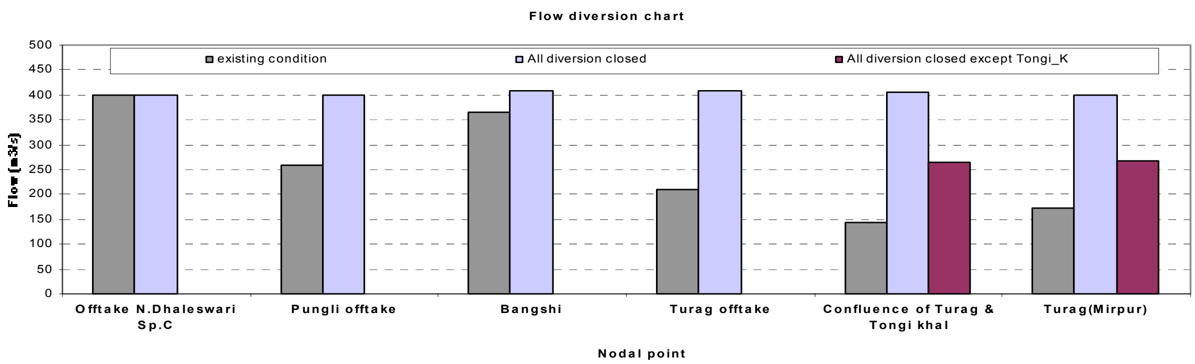

Figure 3.1(b): Flow diversion chart for New Dhaleswari spill channel route

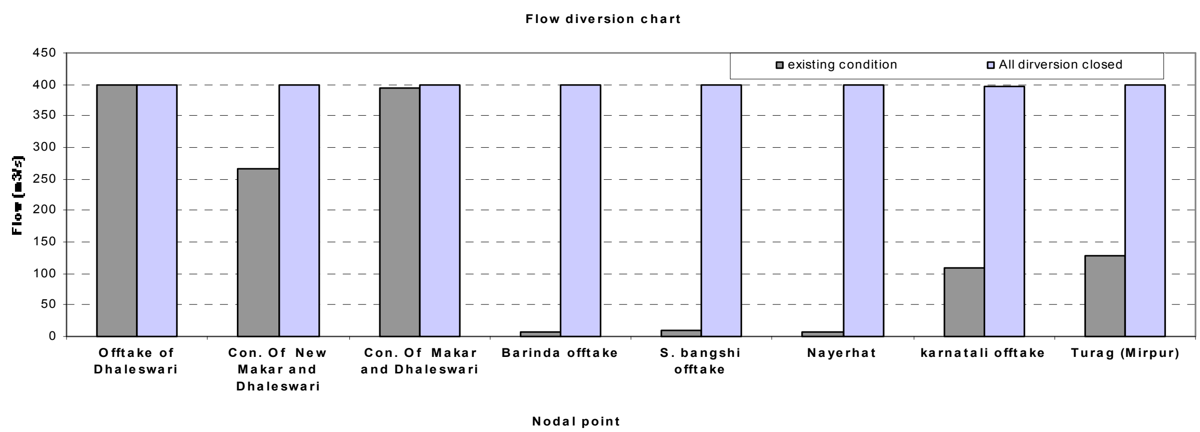

Figure 3.1(c): Flow diversion chart for Dhaleswari route

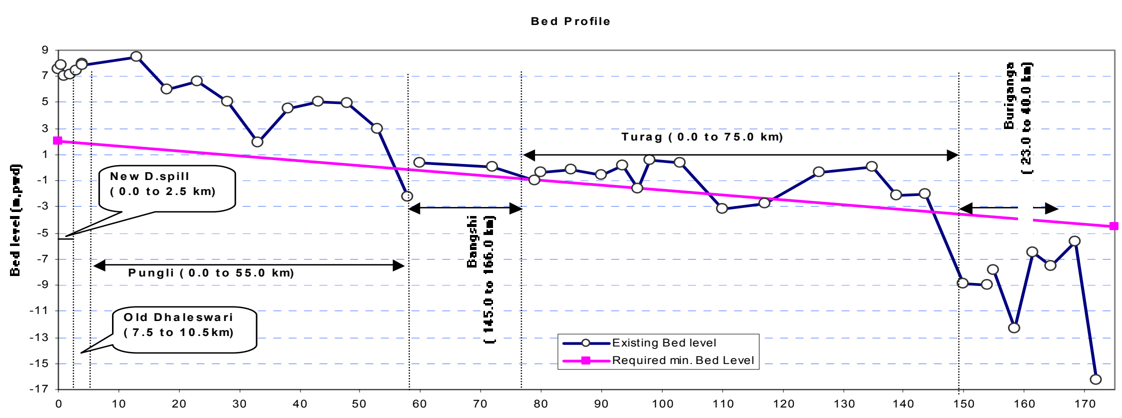

Figure 3.1(d): Thalweg pofile for New Dhaleswari Spil channel- Old Dhaleswari-Pungli-Bangshi-Turag-Buriganga System

3.3 Simulation of selected Scenario by 1D Water Quality Model

Existing 1D water quality model of IWM has been utilized in this preliminary study to see the flow requirements in Buriganga with respect to the critical DO (dissolved oxygen) values. The model comprising part of Turag, Buriganga, Tongi Khal, part of Balu, downstream of Lakhya and other peripherial rivers. The hydrodynamic and water quality model has been verified for the dry period of 1997-98(December 97 to February 1998), (*SWMC, November 1998*). Pollution loading at almost all the known points have been estimated and provided into the model as point concentration boundary. The upstream boundaries of the model have been chosen in such a way that biodegradable wastes do not significantly affect the boundaries. Downstream water level boundary at Kalagachia has been constructed by identifying average water level during December to February for the period of 1990-2001. The other water level boundaries also have been constructed using historical data of respective stations. At Turag (chainage 30 km) different augmented discharge starting from 300 m^3/s to 400m^3/s has been applied to see the impact of additional discharge on the critical DO level. It has been observed from model results that for a discharge of 400 m^3/s at the upstream of bifurcation, around 30% of flow passes through the Tongi Khal and rest 70% of flow passes through the Turag-Buriganga system.

The results of the WQ model simulation have been analysed to see the present and future DO levels in the peripheral rivers of Dhaka. The critical DO values for Turag-

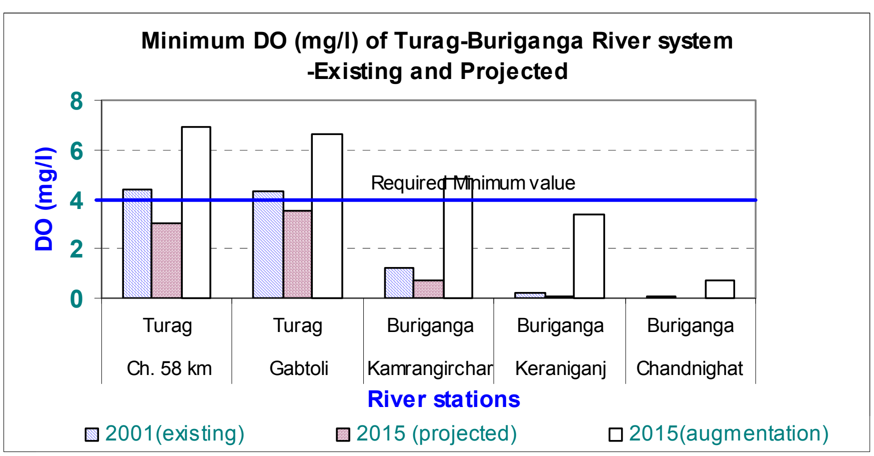

Figure 3.2 Minimum DO in different rivers of Turag-Buriganga system for existing and future scenarios

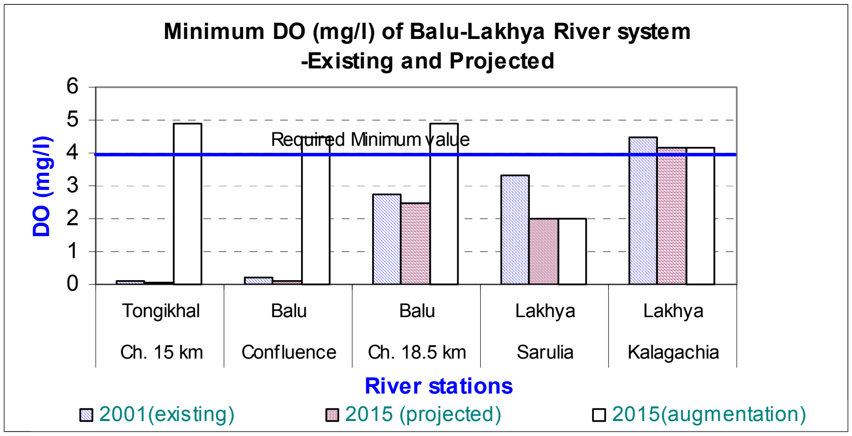

Figure 3.3 Minimum DO in different rivers of Balu-Lakhya system for existing and future scenarios

Buriganga and Balu-Sitalakhya systems have been presented in Figure 3.2 and 3.3 respectively. The present DO level of Buriganga River is very low which would decrease further in the year 2015, but augmented flow would increase the DO level in most part of the Turag-Buriganga system except the most polluted part of the Buriganga River. The condition of the Tongi khal would improve but there is little/no effect in the Sitalakhya river.

4. CONCLUSION AND RECOMMENDATION

The analysis has been done to assess the hydro-morphological consequences of the selected four options for improving the dry season flow condition through the offtake as well as through the respective routes. It has been found that Option-3 may be considered best among others and thus Option-3 would further be required to be detailed out through application of modelling scenarios as well as other analysis for selecting the best scenario for the dry season flow augmentation.

Finally, the evaluation of a particular scenario will be assessed with the results of the individual scenario having single or combination of engineering measures for comparing the performance or the effect of a scenario.

5. REFERENCES

CEGIS (July 2000); Planform analysis of the Old Brahmaputra River in Connection with the Sherpur Bridge project.
CEGIS (February 2003); Planform analysis of the Dhaleswari River in Connection with the Elasin Bridge project.
HOLIDAY (14 December 2001); The Weekly Holiday Newspaper, 14th December 2001 Issue.
IWM (March 1997); Hydraulic Modelling study of the New Dhaleswari Spill Channel
JMBA (June 1995); Final Report by the Dhaleswari Committee
SWMC(November 1998); Updating and validation of NCRM for 1997-98 hydr. year, BWDB.

Mr. Abu Saleh Khan, PEng.
Institute of Water Modelling (IWM)
House # 476, Road #32, New DOHS,
Mohakhali, Dhaka 1206, Bangladesh
Tel: 880-2-8822105, Fax: 880-2-8827901