ENVIRONMENTAL IMPACT ASSESSMENT
OF THE PREPARATORY STUDY ON THE DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 5 FROM VATARA TO HEMAYETPUR)

Final Report

August 2017

Prepared for

Joint Venture of
ALMEC Corporation
Oriental Consultants Global Co,, Ltd.,
Nippon Koei Co., Ltd., and
Katahira & Engineering International

Prepared by

Joint Venture of
KS Consultants Ltd. And
EQMS Consulting Limited

ENVIRONMENTAL IMPACT ASSESSMENT OF THE PREPARATORY STUDY ON THE DHAKA MASS RAPID TRANSIT DEVELOPMENT PROJECT (LINE 5 FROM VATARA TO HEMAYETPUR)

AUGUST 2017

PREPARED FOR:

Joint Venture of
ALMEC Corporation
Oriental Consultants Global Co,, Ltd.,
Nippon Koei Co., Ltd., and
Katahira & Engineering International

PREPARED BY:

Joint Venture of
KS Consultants Ltd. And
EQMS Consulting Limited

Table of Content

List of Table

List of Figure

List of Annex

Abbreviation

AHs	Affected Households
ARB	Abundant River Bed
ARIPO	Acquisition and Requisition of Immovable Property Ordinance
BBS	Bangladesh Bureau of Statistics
BCAS	Bangladesh Center for Advanced Studies
BDL	Below Detection Limit
BDT	Bangladeshi Taka
BOD	Biochemical Oxygen Demand
BR	Bangladesh Rail
BRT	Bus Rail Transit
BRTA	Bangladesh Road Transport Authority
BRTA	Bangladesh Road Transport Authority
BRTC	Bangladesh Road Transport Corporation
BRTC	Bangladesh Road Transport Corporation
BTCL	Bangladesh Telecommunication Company Limited
CBE	Commercial and Business Enterprises
CCTV	Closed Circuit Television
COD	Chemical Oxygen Demand
CPR	Cardio-pulmonary resuscitation
CPR	Common Property Resources
DAV	Deep Alluvial Valley
DC	Deputy Commissioner
DCC	Dhaka City Corporation
DCR	Dhaka Central Region
DEE	Dhaka Elevated Expressway
DG	Director General (DG
DHUTS	Dhaka Urban Transportation Network Development Study
DMA	Dhaka Metropolitan Area
DML	Deep Marshy land
DMTC	Dhaka Metropolitan Transport Corporation
DMTCL	Dhaka Mass Transit Company Limited
DNCC	Dhaka North City Corporation
DoE	Department of Environment
DPHE	Department of Public Health and Engineering

DSCC	Dhaka South City Corporation
DTCA	Dhaka Transport Coordination Authority
DWASA	Dhaka Water Supply and Sanitation Authority
ECA	Environmental Conservation Act
ECC	Environmental Clearance Certificate
ECR	Environment Conservation Rules
EMP	Environmental Management Plan
EMR	Electromagnetic Radiation
EOC	Emergency Operation Centre
ER	Eastern Region
ERD	Environment and Rehabilitation Division
ESF	Emergency Support Function
GOB	Government of Bangladesh
GRM	Grievance Redress Mechanism
GW	Ground Water
HH	Households
HPT	Higher Pleistocene Terrace
IAC	Inundated Abundant Channel
IC	Incident Commander
IEE	Initial Environmental Examination
ILRP	Income and Livelihood Restoration Program
IUCN	International Union for Conservation of Nature
JICA	Japan International Cooperation Agency
LAO	Land Acquisition Officer
LC	Least Concern
MEPT	Moderately Erosional Pleistocene Terrace
MHPT	Moderately Higher Pleistocene Terrace
MOEF	Ministry of Environment and Forest
MOL	Ministry of Lands
MRT	Mass Rapid Transit
NAAQS	National Ambient Air Quality Standard
NCS	National Conservation Strategy
NEMAP	National Environment Management Action Plan
NEP	National Environment Policy
NGOs	Non-Government Organizations

NO	Nodal Officer
NR	Northern Region
NWPGCL	North West Power Generation Company Limited
OCC	Operation Control Centre
PABX	Private Automatic Branch Exchange
PAUS	Project Affected Units
PGCB	Power Grid Company of Bangladesh
PIU	Project Implementation Unit
QRT	Quick Response Team
RAJUK	Rajdhani Unnayan Kartripakkha
RDP	Regional Development Planning
RoW	Right of Way
RS	River System
RSTP	Rapid Strategic Transport Plan
SAV	Shallow Alluvial Valley
SCBA	Self-Contained Breathing Apparatus
SMW	Soil Mixing Wall
SOP	Standard Operation Procedure
SR	Southern Region
STP	Strategic Transport Plan
SWR	South Western Region
TBM	Tunnel Boring Machine
TL	Team Leader
UNEP	United Nation Environment Program
WASA	Water Supply and Sanitation Authority
WB	World Bank
WDB	Water Development Board
WR	Western Region

EXECUTIVE SUMMARY

1. Introduction

Dhaka City is the capital of the People's Republic of Bangladesh. The Dhaka Metropolitan Area (DMA) has a population of 9.3 million in 2011. Currently, urban transportation in the DMA relies mostly on road transport, where car, bus, auto-rickshaw, rickshaw, etc. coexist. This creates serious traffic congestion in addition to health hazards caused by traffic pollution including air pollution.

With this situation, the government of Bangladesh (GOB) formulated the "Strategic Transport Plan for Dhaka" (STP) in 2005 in cooperation with the World Bank (WB). And the Japan International Cooperation Agency (JICA) conducted the Dhaka Urban Transportation Network Development Study (DHUTS) Phase 1 from March 2009 with the DTCA as its counterpart agency. That study recommended the MRT Line 6 as a priority project. The GOB and JICA concluded the loan agreement on the "Dhaka Mass Rapid Transit Development Project" on February 2013 to construct MRT Line 6.

As for the transportation network plan, the STP, which was formulated in 2006, identified three BRT lines (i.e., BRT Lines 1, 2, and 3) that were supposed to commence before 2010. But except for MRT Line 6 and BRT Line 3 above, other projects stated in the STP have not started yet and so the STP needed to be reviewed and updated. And JICA conducted the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP) from May 2014 with the DTCA as its counterpart agency.

The Government of Bangladesh with the financial loan from Japan International Cooperation Agency (JICA) has undertaken a project in order to alleviate traffic congestion and improve air pollution in the Dhaka City by constructing mass rapid transit system, thereby contributing to the economic and social development of Greater Dhaka Region and MRT Line 1 and 5 was prioritized as the high priority project by Strategic Transport Plan (RSTP) for Dhaka. Now JICA study team is preparing the feasibility study of MRT line 1 and 5 under the RSTP. JICA study team entrusted on Joint Venture of KS Consultants Limited and EQMS Consulting limited for carrying out the Environmental Impact Assessment (EIA) of the Preparatory Study on the Dhaka Mass Rapid Transit Development Project (Line 1 and Line 5).

2. Project Description

The proposed MRT line 5 project will be constructed consist of both elevated and underground section. The MRT line 5 is a 22 km long east west corridor from Hemayetpur to Vatara via Dar-us-Salaam road, Mirpur road, Banani cantonment and Madani Avenue. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. MRT line 5 consist of total 14 stations of which 5 will viaduct station and other 9 stations is planned underground station.

There are five control points of the MRT line 5 firstly RHD has a plan to construct the access control toll road from the Gabtoli-Savar-Nabinagar, intersection with Turag River, Banani DoHS, Gulshan lake, Intersection with MRT line 6 at Mirpur 10. Underground section has been planned in different depth from ground level considering the control point. The underground section Rail Level (RL) varies from 16.87-36.85 meter whereas the GL to RL for elevated section varies from 13.0-22.2 m.

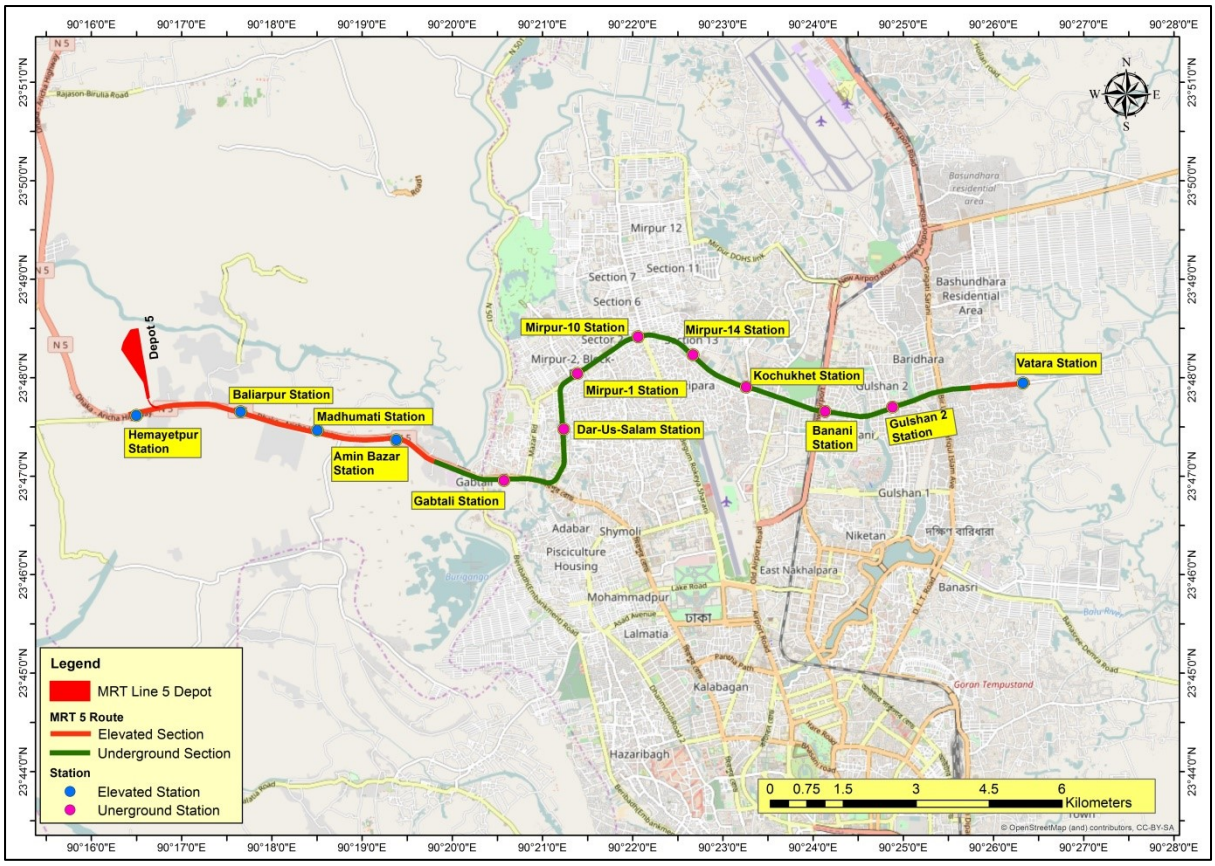
The pile foundation of the elevated section will be 40 m depth from the existing ground level and pile diameter is applied as 1.2 meter to 1.5 meter. Superstructure type is selected as PC Box girder considering structural performance, economy and workability. The standard span of superstructure is considered as 30 m, same as used in MRT Line 6. Maximum span could be 45 m considering the surrounding road and intersections. Noise barrier wall of 1.5 m height from rail level is installed in both edge of girder.

The underground tunnel will consist of shielded tunnels for single tracks. Typically, tunnels running directly underneath roads will be arranged horizontally in two rows side by side. However, if there are any underground obstacles, the tunnels will be built in a two tier configuration, or by separating the two lines for trains to overtake and pass. Underground section will be constructed using the shield tunneling method. The tunnel outer diameter considered as 7 m and thickness of segment is 300mm. Single track cross section shall be applied for the MRT line 5 project as for two tunnels are necessary for the MRT 5 route.

Out of 14 stations eight will be three stories flowed by four number of two stories and two number of four stories. The length of station varies from 190-220 m and width will be 18.6 m-22.8m. Station shall have escalators, elevator and stair and there is a provision for disable person for their smooth travelling.

6 cars train will be stated operation from 2028 considering the 3 min 30 sec headway and it congestion ratio will be 161%. Hence total passenger capacities of the train will 1449 persons whereas it will increase 1944 persons considering the 8 cars train operation in 2035.

The route of the MRT line 5 is shown in Figure 1.



Source: JICA Study Team

Figure 1: Map Showing the MRT Line 5 Alignment with Stations Location

The salient features of the project are described below:

Route Length	:	22 km
Underground	:	13.5 km
Elevated (Kamalapur-Purbachal)	:	6.5 km
Total Station	:	14
Underground Station	:	9
Elevated	:	5
Design Speed	:	110 km/h
Maximum train operating speed		
At the elevated section	:	100 km/h
At the underground section	:	90km/h
Capacity		
6 car formation 3M3T seated with 160% congestion rate	:	1546 persons
8 car formation 4M4T seated with 160% congestion rate	:	2074 persons
Rolling stock requirement (6 car configuration)	:	Total 30 train set, 180 car by 2028
Signaling & Train control	:	Communication Based Train Control, Automatic train control
Fare Collection	:	Automated fare collection system
Depot location	:	North side of Hemayetpur station
Train Operation	:	18 hours of the day (6 AM to 24 PM, i.e. midnight)
Headway	:	Peak 3'30"(2028 6 Cars) 3'00"(2035 6 Cars) 3'00"(2058 8 Cars)
	:	Off-peak 4'00"(2025 6Cars) 5'00"(2025 8Cars) 4'00"(2035 8Cars)
Platform	:	Length: 170 m
	:	Side: 7-10 m
	:	Island: 11 m
PSD (Platform Screen Door)	:	Full Height PSD (Underground)
	:	Half Height PSD (Elevated)
Design PHPDT	:	Year 2028: 26,460 persons
	:	Year 2035: 57,330 persons
Project Cost	:	BDT 299 billion

Source: JICA Study Team

3. Environmental Baseline Data

The baseline data has been collected through primary and secondary resources. Physical resources include geology and soils, topology, land use, meteorology, hydrology and drainage whereas biological resources comprise flora and fauna in the depot area as well as station location. Environmental quality includes the air quality, noise quality, surface water and ground water quality. Socioeconomic resources describe demography, community infrastructure, drinking water sources, religion, ethnicity community, housing and employment etc.

Physical Environment

Geology and Soils: Dhaka lies in the extreme south of the Madhupur Tract, which is situated in the central-eastern part of Bangladesh. The planning area is covered mainly by the Pleistocene Madhupur Clay, a yellowish brown to the highly oxidized reddish brown silty clay; and by Holocene sediments to the south, west and east made up of alluvial silt and clay and marshy clay and peat.

Seismicity: Dhaka city falls in seismic zone II of the seismic zoning map of Bangladesh which means the city is at moderate risk (basic seismic coefficient is 0.5 g).

Topology: The surface elevation of the area Dhaka are ranges between 1 and 14m and most of the built up areas located at the elevations of 6-8m. The land area above 8 meters msl covers about 20 square kilometers. The land ranging from 6-8 meters while 170 square kilometers of Greater Dhaka is below 6 meters.

Land use: Due to rapid urban growth of Dhaka city, Dhaka's land use has been changing since 1967. While the vegetation of area is almost fixed at 70,000 ha in the past 40 years, the current water body became a quarter since 1967, which is 5,520 ha in 2010 from 206,868 ha in 1967. The built-up area increased by about 5,000 ha in the period of 1989 to 1999 and by 7,500 ha in the period of 1999 to 2010.

Hydrology and Drainage: In recent years, major inundations occurred in 1988 and in 1998, bringing about significant damages. During these inundations, water level in Buringanga River in the western part of Dhaka exceeded 7.0 m.

The maximum depth to water table in the central part of the city i.e. Tejgaon and Sabujbagh areas, observed from BWDB piezometers, is about 67 to 57m below ground surface that is about 55m at Mirpur and 20-34m at Mohammadpur, Dhanmondi and Sutrapur areas close to the river periphery.

Meteorology: The monthly variation of the average maximum temperature which is between 39.6°C to 30.1°C. The monthly variation of the average minimum temperature is 22.5°C to 6.5°C. The average monthly rainfall during monsoon (June-September) season from 1980-2013 is 332 mm/month. The variance in the maximum rainfall during monsoon season is 836 mm/month to 552 mm/month, whereas the variance in the minimum rainfall is 136 mm/month to 59 mm/month.

Ecological Environment: different tree species, birds, amphibians, reptiles and mammals were found during the study period in the depot area. Total 938 trees were found out of these 279 are large, 109 medium, 363 small and 187 are sapling. Bengal Monitor (*Varanus bengalensis)* has been found Near Threatened according to the IUCN red list status 2015 whereas rest of the species is Least Concern.

Environmental Quality

Air Quality: The atmospheric concentration of air pollutants has been monitored at 5 locations in February-March 2017. Air Monitoring was carried out for parameters PM2.5, PM10, NOx, SO2, O_3, CO and Lead. The results show that except PM10, PM2.5 and NO_2, all the parameters are within permissible limits.

Noise Level: The survey has been conducted at nine locations along the alignment. The result indicates that the equivalent noise levels at eight locations out of nine locations are more than the limit prescribed limit.

Surface Water Quality: Total three surface water samples has been collected from 5 different locations along the metro alignment and analyzed. BOD and COD concentration of all samples are very high. Dissolved Oxygen level of all samples do not meet the national inland surface water quality standard for DO. TSS concentrations of all samples are very high.

Ground Water Quality: Ground water qualities of all nine samples are well within the permissible limit in accordance with the Environmental Conservation Rules, 1997.

Social Environment

A total of 3,047 people including 55% male and 45% female have been identified to be affected by the project. Average household size of the project area is 4.2 which is lower than the national average and less than 03 percent of the heads are female headed. The largest proportion of population is in the age group 15-29 followed by 30-44 age group and the remaining are up to 14 years irrespective of male and female population in all the locations. Population within the age group 45-59 is more than 1 6% and above 60 is just over 1 1 %.

Only 0.60% household heads are illiterate and about 1 4.4% have completed the secondary school and more than 06% of them are graduates. More than 42% have education up to class V. However, level of education is low among the female heads of the households as compared to the male heads. Young generations irrespective of sex have much higher level of education than compared to the older heads of the household.

4. Prediction of Impact

Air Quality

During construction transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. DG set will be used for backup power generation. This activity is resulting in dust generation and exhaust emission.

The proposed MRT Line 5 will be electrical operation and not use diesel fuel. Moreover the operation will improve congestion of roads along the MRT line and efficiency of the vehicle mobility. Consequently, increase in air pollution in Dhaka city may be mitigated as a positive impact.

Water Pollution

Pile driving work for elevated section, depot development may pollute the surface water whereas tunnel construction may affect the underground water quality.

Soil Pollution

The project may not have significant impact on soil pollution because most of the alignment of the project will be done in the underground. There have minor chance to soil pollution

during construction of viaduct sections, construction of stations. Oil leak from poor machine and vehicle may also cause soil pollution. Waste from construction yard and camp will lead to the soil pollution.

Waste

During construction of tunnel as well as underground station, huge amount of waste soil will be generated. Different types of fragments of construction materials and garbage also generate during the construction period. Improper management of waste during the construction stage might be causes soil and water pollution.

Solid waste will be generated from station and depot area during the operation period of Metro rail.

Noise and vibration

The main sources of noise at construction sites are heavy machineries and transportation of equipment, Materials handling equipment, stationary equipment, pile driving and other types of equipment etc.

The MRT operation will generate noise and vibration. As the most of the section of the MRT will pass through the underground section so the noise from underground will not come to the surface. Sound barrier will be installed on the viaduct section so the impact due to noise generation will be less at the viaduct section.

Ground Subsidence

At the construction phase of the metro rail, there will be possibilities to ground subsidence due to the tunnel boring activities at the underground. The geological survey not yet completed throughout the alignment so the impact is not clear at this moment. Detail geotechnical study is required during detail design stage to select the proper method for tunnel construction.

During the operation phase of the metro rail, the possibility of the ground subsidence is less as the tunnel will be shielded.

Protected Area

There is no protected area such as natural park, sanctuary and conservation site in the project alignment. In line with the project, the underground structure of MRT Line 5 crosses Turag River and Gulsha Baridhara Lake which is designated ECA in 2009 and 2001. As the MRT line 5 will be underground in the ECA area therefore no impact in expected . No impact is expected during operation phase.

Biota and Ecosystem

Total 249 trees will be affected out of these 113 are large, 31 medium, 99 small and 06 are sapling. Timber trees are more in number in the project area. No major impact has been assessed on ecosystem due to the metro operation.

Hydrology

The drainage system will be hampered due to construction activities like as infilling, construction of the depot, construction yards and haul routes. A major impact during construction stage is due to suspended solids entrained in runoff that can bring soil surfaces and clog drainage system. Less impact is expected as most of the line will be underground.

Dhaka city is flood prone area. Flooding may impact the operation of the metro rail especially underground tunnel. Historical flooding data analysis needs to be carried out during the detail design stage for the safety.

Ground Water

Underground tunnel construction may impact on ground water quality and depth of the underground water level. Potential impacts on groundwater are insignificant. In Dhaka City, Ground Water extraction started from a depth of 100m and in some extreme condition the well goes up to 300 meters to reach the main aquifer.

Due to the tunnel construction the ground water percolation might be interrupted. Detail hydrological study need to be carried out during the detail design study.

Involuntary Resettlement

A total of 26.85 ha land will be required to be acquired and 1.57 ha for pockets along the RoW and 4.01 ha of land will need subsurface easement to implement the project. The project will have direct impact on 721 Project Affected Units (PAUs). The project works will affect 25 residential households, 111 Commercial & Business enterprises (CBEs) and 06 residential cum CBEs, 04 household are going to lose varieties of properties like wall, trees, drains etc and 579 vendors or temporary shops are going to be affected with a total affected units of 721. Out of 96 households 10 of them will be displaced due to loss of residential structure, 15 will be displaced from rented residential structure. Among the Affected Units only 25 are title holders i.e. Owns the land and rest 696 are on government land. Total affected persons are 3,047.

Poor

Total 3.30% affected households may be considered as hardcore poor. Due to acquisition of the property these poor people will be affected adversely.

As the special attention will be taken for poor people to minimize livelihood impact therefore the impact will be negligible.

Indigenous or ethnic minority people

No ethnic minority family in the affected household has been found during the study therefore the impact is nil.

Local economics such as employment, livelihood

The project will affect 694 businesses including 04 APs who will lose both residential structure as well as business. Among the business losers more than 81% are losing small businesses, 10.5% medium businesses and rest are losing large business.

Local economy will be gear up during the operation of the MRT especially near the depot and station area.

Land use and utilization of local resources

The most of the acquired land is being used for agricultural purpose and portion of it being used as homestead. Land use of the depot area, elevated section and elevated station will be changed.

The proposed depot area is going to be developed as urban area and it is assumed that this area will be developed in near future. The depot of MRT line 5 will gear up the development of the surrounding area as well as it will increase the land price.

Water Use

At this stage the water demand of the proposed project is not finalize yet therefore the impact due to water use has not been assessed. Detail will be mentioned in the detail design stage.

Social Service Facilities

No social service facilities exist in the viaduct section. Major route of the MRT line will pass through the underground as a result the impact on social service facilities is negligible.

MRT line is a major social service facility that will reduce the travel time and enhance the economic growth of the people.

Social institutions and local decision-making institutions

The identified 22 Common Property Resources (CPR) as social institutions or resources which are going to be affected by the project. The CPRs include mosque (1), school/college (2), Samity/Club/Community (1), Offices (4) and other (14).

No negative impact has been expected during the operation stage. People can move their location easily using the MRT within short time.

Cultural Resources

The RoW of the project mainly followed the city road network. It is observed that in the project area presence of any infrastructure related to cultural heritage is absent.

Landscape

The main component of MRT line 5 that may impact the surrounding landscape and aesthetics are the station, ventilation shafts and parts of the metro line that will be constructed by cut and cover method. Construction sites, if not well managed, have also negative impacts on visual amenities and on the aesthetics of the surroundings.

Present landscape of the project area will be changed but the change assumed as negligible as major section of the MRT line will be underground and elevated section will follow median of road in the suburban area. Impact is assumed when the height of viaduct is so high to over other structures.

Gender

The socio-economic survey of RAP study stated that 93 vulnerable households in the project area. These households are female headed households (21.6%), households headed by elderly persons (30.10%), disable persons (9.70%), male headed household but under the poverty line (37.60%). They will be adversely affected due to the acquisition of land.

Female person might be deprived in the ticket counter as well as to get seat in the train during the operation of MRT.

Infectious disease such as HIV/AIDS

During construction period with the in-migration of large number of workers, mainly male might be an alarming issue for infectious disease to the local community. No impact has been assessed during operation phase.

Global warming/Climate change

Construction machines and vehicles generate greenhouse gases; quantities of generated gases do not contribute serious impact to the atmosphere.

During the operation stage, green house emission will be reduced as the rail will be run by electricity that will carry almost 1546 passengers at a time. It is assumed that the increase of traffic and residents will cause the exhausted gas. However, it is expected that the modal shift and increase of travel speed will mitigate the greenhouse gas.

Accident

Accident might be happen during the construction period due to the work at height, Traffic accident during the carrying construction material using the existing road, Heavy equipment's can bring on various significant accidents. Traffic accident will decrease because of the modal shift which will enhance the change from automobile to MRT.

5. Evaluation of Impact

Each impact was evaluated based on a rating instead of numeric scale. Impacts are rated in A, B, C and D. The definition of the rating is as follows.

A: significant impact is assumed,
B: Impact is assumed but less than A,
C: Impact is not clear because the design is not finished and further survey is needed to confirm,
D: No Impact

The following table shows the evaluation of the predicted impact.

Table 2: Scoping Matrix of MRT Line 5

	Items of Impact		Total Assessment			Factors of Adverse Impacts														Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
Anti-pollution measures	1.	Air Pollution		B-	B-/B+							B-	B-	B-		B-		B-		B+	B+	B+	
	2.	Water Pollution		B-	D							B-	B-		B-								
	3.	Soil Pollution		B-	D							B-	B-		B-								
	4.	Waste		A-	B-							B-	B-		B-			B-					
	5.	Noise and Vibration		B-	B-							B-	B-	B-			B-		B-				
	6.	Ground Subsidence		C	C								C						C				

			Total Assessment			Factors of Adverse Impacts														Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
	Items of Impact		Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
	7.	Offensive Odors		B-	D							B-			B-		D-						
	8.	Bottom Sediment		B-	D							B-	B-										
Natural Environment	9.	Protected Area		D	D							D	D						D				
	10.	Biota and Ecosystem	B-	B-	D		B-		B-	B-									D				
	11.	Hydrology		C	C								C				C						
	12.	Ground Water		B-	D								B-				D						
	13.	Topography and Geology		B-	D						B-		B-		B-		D						

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
Social Environment	14.	Involuntary Resettlement	A-	D	D	A-																	
	15.	Poor	A-	D	D			A-															
	16.	Indigenous and Ethnic Minority People	D	D	D			D										A-					
	17.	Local Economics such as employment, livelihood etc.	A-	B+	B+	A-							B+										B+

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
	18.	Land use and Utilization of Local Resources		B-	B+								B-		B-					B+			B+
	19.	Water use		C	C								C				C							
	20.	Social Service facilities		D	A+								D							A+			A+
	21.	Social Institutions and Local Decision Making Institutions,	B-	D	A+	B-														A+			A+
	22.	Misdistribution of Benefits and		B-	B-								D				B-						

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
		Damages																					
	23.	Local Conflicts of Interest		B-	B-								B-		B-			B-					
	24.	Cultural Heritage		D	D								D						D				
	25.	Land Scape		B-	B-						B-						B-	B-					
	26.	Gender	B-	B-	B-	B-		B-					B-						B-				
	27.	Children Rights	B-	D	D			B-															
	28.	Infectious Diseases such as HIV/AIDS		B-	D										B-			D					
	29.	Working Conditions		B-	D							B-	B-	B-	B-								

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
Other	30.	Global Warming		B-	B+ /B-							B-	B-	B-		B-		B-		B+	B+	B+	
	31.	Accidents		B-	B- /B +							B-	B-	B-	B-	B-				B+			

Assessment： A: significant impact is assumed, B: Impact is assumed but less than A, C: Impact is not clear because the design is not finished and further survey is needed to confirm, D: No impact
The scoping items are referred from JICA guidelines

6. Environmental Management Plan

Compensatory Afforestation: 249 trees are likely to be removed and 996 trees are to be transplanted. Four number of tree will be planted for each tree cut. The total cost of compensatory afforestation is about BDT. 99,600.

Specific management Plan: Prior to start of site works, Environmental Management action Plans in the form of the following specific management plans shall be prepared by the contractor and shall be submitted to the project supervision consultant for approval.

- Dust Control Plan
- Noise Control Plan
- Spoils/Muck Disposal Plan
- Spill Management Plan
- Traffic Management Plan
- Occupational Health and Safety Plan
- Emergency Response Plan

Air Pollution Control Measures: During construction period, the impact on air quality will be mainly due to increase in Particulate Matter (PM) and emission due to construction vehicles and construction machineries. Transportation during non-peak hours, optimisation of construction machinery's use, silent DG sets with pollution control device, sprinkling of water and covered Lorries are some measures which will be taken to reduce the air pollution during construction.

Noise Control Measures: The noise generated during construction will be minimized by using silent DG sets, acoustic enclosures, temporary noise barriers, job rotation to the extent possible for construction workers, and scheduling of truck loading, unloading and hauling operation.

Water Pollution Control Measures: Water pollution during construction period will be minimized by providing adequate sanitary facilities and drainage in the temporary colonies of the construction workers, Sediment trap will be provided to reduce sediment load in construction wastewater, Water quality parameters will be monitored at the construction period within regular basis.

Solid waste management: Separate solid waste into hazardous, non-hazardous and reusable waste streams and store temporary on site and Undertake regular collection and disposal of wastes to sites approved by authority

Safety Management Measures: Project Authority has to establish the safety programmes following rules, regulations and guidelines prior to the construction. These would help to avoid and reduce the number of accidents.

Traffic Diversion/ Management: The traffic management plan includes advance traffic information on communication systems and partial blocking of road etc. proper traffic management plan should be prepared by the contractor prior to start construction.

Muck Disposal Plan: The muck could be managed by the following way

- Strictly implement approved Spoils Disposal plan
- The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water.
- Material will be stabilised each day by watering or other accepted dust

suppression techniques.

- The height from which soil will be dropped shall be minimum practical height to limit the dust generation.
- The stockpiling of earth in the designated locations with suitable slopes.
- During dry weather, dust control methods such as water sprinkling will be used daily especially on windy, dry day to prevent any dust from blowing.
- Sufficient equipment, water and personnel shall be available on dumping sites at all times to minimise dust suppression.
- Dust control activities shall continue even during work stoppages.
- The muck shall be filled in the dumping site in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures.
- If possible use the spoil soil for development work surrounding the Dhaka city as well as brick kiln as there are lots of brick field near to the Dhaka city

Institutional Framework

It has been recommended for MRT line 6 that titles for current positions of DMTC will be changed and total number of staff positions be increased to eight. In addition to the position of General Manager (GM), Deputy GMs for Project Development and Facility Operations should be established. After operations begin at the depot, a Depot Environmental expert should be appointed with skills in treatment plan operations and laboratory analysis. An open organizational structure has been proposed (see Figure 2) for MRT line 6 in, as this is likely to provide the greatest degree of flexibility in use of staff time. The following Environment and Rehabilitation Division (ERD) unit shown in Figure 2 will also work for the MRT line 5.

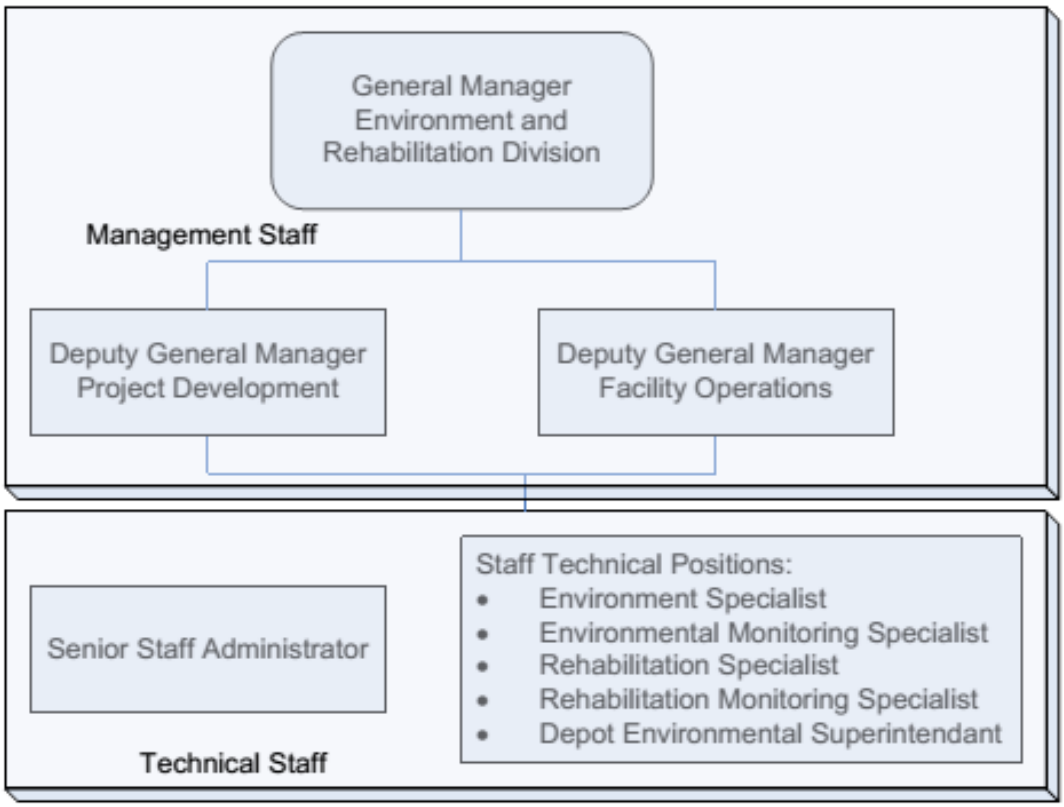


Figure 2: Proposed Organizational Arrangement for ERD

7. Environmental Monitoring Plan

The Contractor and the DMTCL will allocate separate budget for environmental and social management plan implementation, training, environmental monitoring, analysis and reporting, verification monitoring and capacity building. It should be noted that cost for many in-built mitigation measures, such as, air pollution control measure, acoustic enclosures for noise control, water and water treatment etc. need to be included in the contract cost estimate and/or operating cost estimates.

Air quality, noise, soil quality monitoring will be conducted for regular basis before construction, during the construction and operation period. DO, BOD_5, COD, PH, TSS, Heavy metal, oil and grease parameter for both surface and ground water will be tested once in every 6 month during the construction stage. At the operation phase surface and ground water will be tested 2 times in dry season and two times in wet season. Detail of the environmental monitoring plan has been depicted in the section 8.4 of this report.

8. Emergency Response Plan and Disaster Impact Assessment

Disaster can occur due to subsidence, accidents, fire hazards, etc. during construction while system failure (power supply, break down etc), fire hazards and accidents during operation stage. The DMP should include Preventive Action, Full Proof Communication System, Emergency Action Committee and Emergency Measures.

9. Consultation with Stakeholder/Public Consultation

In Bangladesh, there is no clear guideline for involvement of concern organization in a public consultation. The Metro Rail authority encourages consulting with local stakeholders about their understanding of development needs, the likely adverse impacts on environment for the project and analysis of alternatives at any early stage of the project.

To meet the requirement of the study, total four stakeholder consultation meetings were held for MRT line 5 during the first round. The 1st stakeholder consultation was held on March 15, 2017, the 2nd stakeholder meeting was held on March 16, 2017, 3rd meeting was held on March 18, 2017 and 4th was on March 19, 2017 with the relevant participants.

Second round public consultation were held in different locations beside the proposed alignment of the MRT line-5. To meet the requirement of the study, the 1st stakeholder consultation was held on July 25, 2017, the 2nd stakeholder meeting was held on July 26, 2017, 3rd one was held on July 26, 2017 and 4th one on July 30, 2017 with the relevant participants.

Output of the stakeholder consultation meeting has been presented in the chapter 9 in the EIA report.

10. Conclusion

It can be concluded on positive note that after the implementation of Environmental Management Plan and Monitoring Plan, the project will have negligible impact on environment and will also lead to sustainable transport development of the Dhaka city.

1. INTRODUCTION

1.1 Background

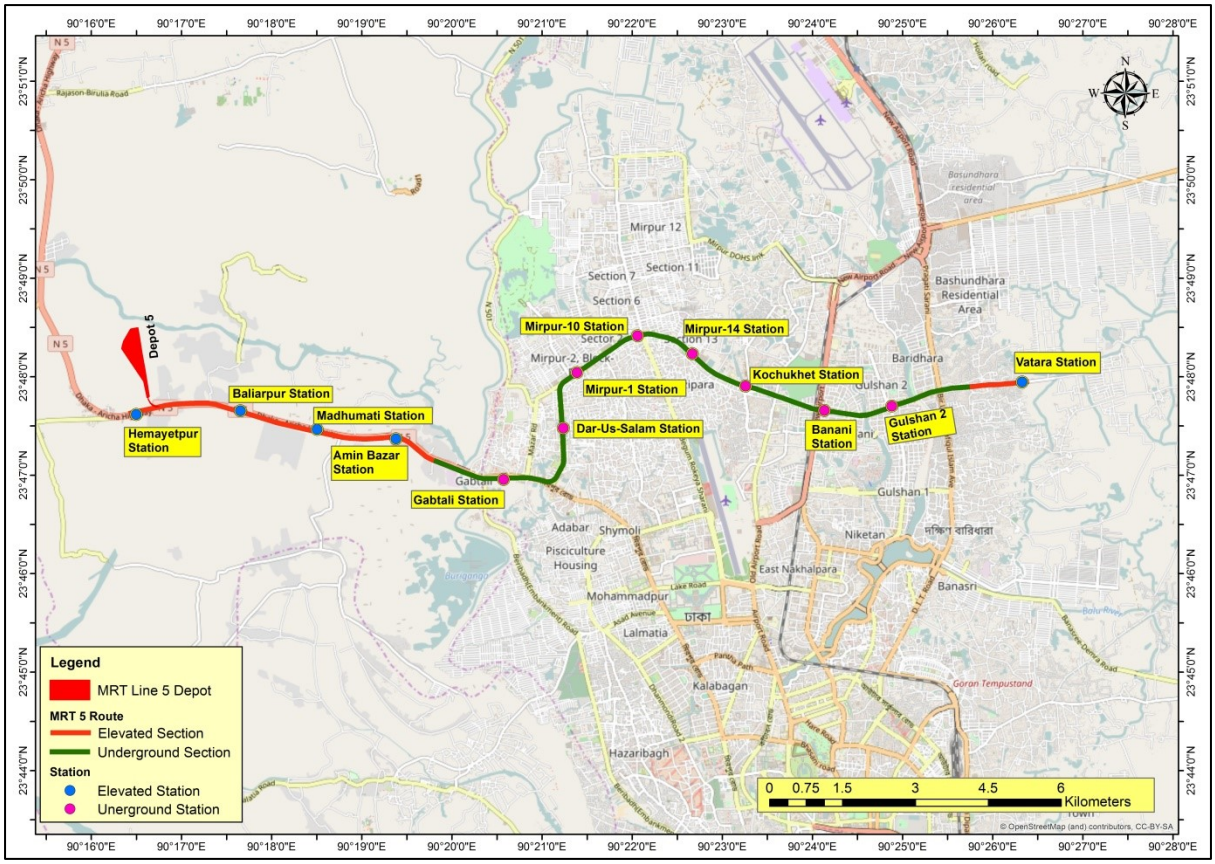
Dhaka City is the capital of the People's Republic of Bangladesh. The Dhaka Metropolitan Area (DMA) has a population of 9.3 million in 2011. Currently, urban transportation in the DMA relies mostly on road transport, where car, bus, auto-rickshaw, rickshaw, etc. coexist. This creates serious traffic congestion in addition to health hazards caused by traffic pollution including air pollution. With the rapid national economic growth, the urban population is expected to increase and so will the number of privately owned automobiles. Therefore, improving the urban (public) transportation system in the DMA has become a critical issue to ease traffic congestion and arrest environmental deterioration.

With this situation, the government of Bangladesh (GOB) formulated the "Strategic Transport Plan for Dhaka" (STP) in 2005 in cooperation with the World Bank (WB). Since the STP was officially approved by the GOB, it is expected that each donor will hereafter provide the assistance based on this STP to improve the urban transportation situation. And the Japan International Cooperation Agency (JICA) conducted the Dhaka Urban Transportation Network Development Study (DHUTS) Phase 1 from March 2009 with the DTCA as its counterpart agency. The study's objectives were to conceptualize the basic urban development scenario for the DMA by 2025 and to select priority projects that would help build such a scenario. That study recommended the MRT Line 6 as a priority project. As a result, JICA conducted the feasibility study on MRT Line 6 under DHUTS Phase 2. Following these studies, the GOB and JICA concluded the loan agreement on the "Dhaka Mass Rapid Transit Development Project" on February 2013 to construct MRT Line 6. Meanwhile, the World Bank finished the feasibility study and basic design of BRT Line 3 and is now preparing the project's detailed design. On the other hand, the Asian Development Bank (ADB) already completed the basic design of the BRT Line 3 extension project (from the airport to Gazipur) and since April 2013 has conducted the activities for the detailed design stage.

As for the transportation network plan, the STP, which was formulated in 2006, identified three BRT lines (i.e., BRT Lines 1, 2, and 3) that were supposed to commence before 2010. But except for MRT Line 6 and BRT Line 3 above, other projects stated in the STP have not started yet and so the STP needed to be reviewed and updated. And JICA conducted the Project on the Revision and Updating of the Strategic Transport Plan for Dhaka (RSTP) from May 2014 with the DTCA as its counterpart agency.

It is thus under these circumstances that the GOB and JICA have made several preliminary discussions in order to identify priority projects in the field of transport sector, and agreed to make preparation for Dhaka Mass Rapid Transit Development Project (Line 1 and Line 5). Accordingly, JICA dispatched a mission on the project to GOB from March 7, 2016 to March 10, 2016 in order to develop scope and implementing arrangements of a further survey which would study feasibility of the project.

The Government of Bangladesh with the financial loan from Japan International Cooperation Agency (JICA) has undertaken a project in order to alleviate traffic congestion and improve air pollution in the Dhaka City by constructing mass rapid transit system, thereby contributing to the economic and social development of Greater Dhaka Region and MRT Line 5 was prioritized as the high priority project by Strategic Transport Plan (RSTP) for Dhaka. The route of the MRT line 5 is shown in **Figure 1-1**.



Source: JICA Study Team

Figure 1-1: Map Showing the MRT Line 5 Alignment with Stations Location

1.2 Brief Description

Traffic congestion is the common scenario in the Dhaka city. Every day people expend their valuable time on the road. Considering the traffic congestion, population density in Dhaka city as well as air pollution, Government of Bangladesh has taken different mega project in the Dhaka city to resolve the traffic problem. To alleviate the traffic congestion Government of Bangladesh with the financial assistance by JICA, first metro rail project (MRT Line 6) in Dhaka city construction work has already been started. JICA has taken the initiatives to find out the other MRT routes to accelerate the communication system in Dhaka city. According to the Strategic Transport Plan (RSTP), the MRT line 5 is one of the priority route.

MRT Line 5 is a 22 km long east-west corridor from Hemayetpur to Vatara via Dar-us-Salaam road, Mirpur road, Banani cantonment and Madani Avenue. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. MRT line 5 consist of total 14 stations of which 5 will viaduct station and other 14 stations is planned underground station. The station will be placed approximately every 1 km.

The pile foundation of the elevated section will be 40 m depth from the existing ground level and pile diameter is applied as 1.2 meter to 1.5 meter. Superstructure type is selected as PC Box girder considering structural performance, economy and workability. The standard span of superstructure is considered as 30 m, same as used in MRT Line 6. Maximum span could be 45 m considering the surrounding road and intersections. Noise barrier wall of 1.5 m

height from rail level is installed in both edge of girder. Noise barrier wall is made by precast concrete, and it is connected by anchor rebar with girder.

Underground section will start after the Amin bazar station following the Gabtoli- Mirpur 1- Mirpur 10 – Kachukhet – Banani – Gulshan 2 – Natun Bazar route and will come to the surface ground after the Natun bazar station. Underground section will be constructed using the shield tunneling method. The tunnel outer diameter considered as 7 m. Single track cross section shall be applied for the MRT line 5 project as for two tunnels are necessary for the MRT 5 route.

In total 14 stations are proposed for MRT Line 5. 4 stations at westernmost and 1 station at easternmost are elevated stations, 9 intermediate stations are underground stations.

Stations are classified as below.

- Hemayetpur station and Vatara station: Elevated terminal stations.
- Baliarpur station, Bilamalia station and Amin Bazar station: Elevated intermediate stations.
- Gabtoli station: Particular station (2 platforms, 4 tracks, 3 underground floors)
- Dar-us-Salam station: Particular station (2 platforms, 3 tracks, 2 underground floors)
- Mirpur1 station, Mirpur14 station and Kochukhet station: Typical stations with 2 underground floors
- Mirpur1 station and Gulshan2: Typical stations with 3 underground floors.
- Banani station: Typical station with 4 underground floors, vertical stacked side platform

Table 1-1: Station Characteristics

No	Station Name	Station Type	Stories	Platform Type	No of Platform	No of Tracks
St1	Hemayetpur	Elevated	3 stories	Lateral	2	2
St2	Baliarpur	Elevated	3 stories	Lateral	2	2
St3	Bilamalia	Elevated	3 stories	Lateral	2	2
St4	Amin Bazar	Elevated	3 stories	Lateral	2	2
St5	Gabtoli	Underground	3 stories	Island	2	4
St6	Dar-us-Salam	Underground	2 stories	Island	2	3
St7	Mirpur 1	Underground	2 stories	Island	1	2
St8	Mirpur 10	Underground	3 stories	Island	1	2
St9	Mirpur 14	Underground	2 stories	Island	1	2
St10	Kochukhet	Underground	2 stories	Island	1	2
St11	Banani	Underground	4 stories	Lateral	2	2
St12	Gulshan 2	Underground	3 stories	Island	1	2
St13	Notun Bazar	Underground	4 stories	Island	1	2
St14	Vatara	Elevated	3 stories	Lateral	2	2

Source: JICA Study Team

6 cars train will be stated operation from 2028 considering the 3 min 30 sec headway and it congestion ratio will be 161%. Hence total passenger capacities of the train will 1449 persons whereas it will increase 1944 persons considering the 8 cars train operation in 2035. Detail project description has been described in the chapter 3.

1.3 Scope of Study

The EIA report was prepared on the basis of proposed construction planning, field investigations, stakeholder consultation, primary and secondary data collection, screening of all baseline environmental parameters, environmental quality baseline monitoring, and review of other similar project reports in Bangladesh and other countries. The study was taken up during February – July, 2017.

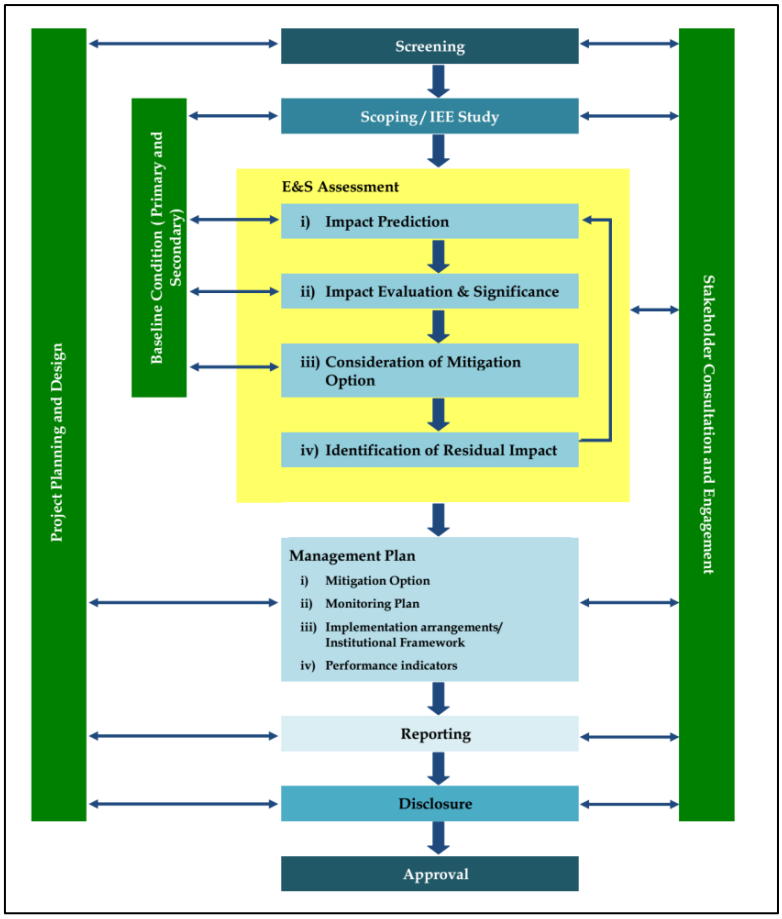
The EIA covers the general environmental profile of the Project area including physical, ecological, environmental, social, cultural and economic resources. Baseline environmental monitoring was carried out on water (surface and ground), air and noise quality measurements and ecological monitoring. The EIA includes an overview of the potential environmental impacts and their severity, and proposes necessary mitigation measures and environmental management plan for each of the identified impacts.

The EIA report has been prepared according to the approved ToR (Annex-1) and specific terms and conditions in the DoE letter no. DoE/Clearance/5726/2017/107 dated 22/02/2017 for obtaining Environmental Clearance Certificate (ECC) from the Department of Environment (DoE).

1.4 Methodology

The methodology used for this study is based on the procedures described in EIA guidelines published by Department of Environment and the other relevant regulation of Bangladesh as well as “JICA Guidelines for Environmental and Social Considerations” (April 2010).

The main focus of the EIA will be to anticipate environmental and social effects, both positive and negative impact that may result from the project or its alternatives as well as their potential magnitude, reversibility, period of occurrence, nature, etc. predictions will consider all aspects and phases of the project and any indirect environmental and social effects, cumulative effects, and any environmental effects that may result from accidents or malfunctions. The approach proposed for the EIA study is presented in following **Figure 1-2**:



Source: EQMS

Figure 1-2: Approach of the EIA Study

Methodology adopted for completion of the EIA study of the MRT line 5 is as follows:

- Study of the relevant documents on policy, legal and administrative framework and their review, particularly on environmental aspects and effluent discharge limits, health and safety requirements, identification of sensitive areas and endangered species, land use etc;
- Reconnaissance survey was taken up to collect baseline information in devised formats;
- Analysis of collected data was carried out;
- Documentation of baseline conditions was done by doing on site environmental monitoring;
- Identification of major project activities, both during construction and operational phases of the project.
- Identification and prediction of environmental impacts of project activities on the surrounding environment
- Identification of the most significant environmental and social impacts and suggestions for mitigation measures in order to reduce/eliminate negative impacts and to enhance positive impacts.
- Arrangement of public consultation meetings to consult with potentially affected people as well as community people ;
- Development of Environmental Management Plan (EMP) for both construction as well as operational phases of the project;

1.5 Limitation

This EIA is limited to investigating and managing potential impacts associated with during construction and operation stage. This EIA should not be in any way construed as providing impact assessment for any further work or developments on this or any other site. No assessment has been made for any future projects or activities that may arise as a result of this Project. If or when any such developments are proposed, additional environmental impact assessment should be carried out at that stage in accordance with the legal requirements of Bangladesh.

This EIA is confined to the study of the potential impacts of the Project on the physical, biological, and socio-economic environments of the study area. This study has been carried out by accessing data from a wide range of primary and secondary data. These include literature reviews, reports and other documents, which have been supplemented with primary field data collection. Assessment of the Project is limited by the quantity and quality of available data.

Certain provisions in this EIA report assume reliance on conceptual design and technical information. If the design of the Project changes from that assessed due to design development, inclusion of new information, changing motivations or any other reason, the results of any impact assessment or mitigative measures provided in this report may be inconsistent.

1.6 EIA Team

Joint venture of KS Consultants Ltd. and EQMS Consulting Limited has been contracted by joint venture of ALMEC Corporation, Oriental Consultants Global Co. Ltd., Nippon Koei Co., Ltd., and Katahira & Engineers International to prepare and deliver the EIA report for the said Project. EQMS Consulting Limited has utilized a multi-disciplinary team comprising of environmental and social experts. The team members have extensive professional experience working in the fields of environmental and social impact assessment in Bangladesh. The composition of the study team can be seen below in **Table 1-2**.

Table 1-2: Team Composition for EIA Study

Name	Position
Kazi Farhed Iqubal	EIA Expert
Mirza SA Habib	Ecologist
Tauhidul Hasan	Environmental Expert
Asharaful Alam	Jr. Environmental Expert
Zahidul Islam	Water Resource Expert
Md. Mostafizur Rahman	Sociologist
Ashis Dhar	Jr. Sociologist
Anik Mondal	GIS Expert

1.7 References

Akter, F., Jafor, A., Abdul Kader, M., Sarkar, M. H., & Mori, Y. (2003). Minerology of soils from different agroecological regions of Bangladesh; Region 18-Young Meghna Estuarine Floodplain.

Ali, M. (2008). Unplanned Urbanization of Dhaka City: Increased of Rainfall Induced Flood Vulnerability. Dhaka: BRAC University.

Azim, U. A., & Baten, M. (2011, October). Water Supply of Dhaka City: Murky Future.

Bari, F., & Hasan, M. (2001). Effect of Urbanization on Storm Runoff Characteristics of DHaka City.

BES. (2009). Bangladesh Earthquake Society. Dept. of Civil Engineering, BUET.

Bhuiyan, F. H., & Bhuiya, S. U. (2005). Study on the characterization of the agro-ecological context in which (FAnGR: Farm Animal Genetic Resources) are found.

BWDB. (2007). Effects of Over Withdrawal of Groundwater in Dhaka City. Dhaka: Bangladesh Water Development Board.

CDMP. (2009). Engineering Geological Mapping of Dhaka, Chittagong and Sylhet City Corporation Area of Bangladesh. Dhaka.

Chowdhury, J. (1998). Measurement and Analysis of Rainfall RUnoff in Selected Catchments of Dhaka City. Wallingford, UK: Institute of Hydrology.

Cox, W. (2012, August 08). http://www.newgeography.com. Retrieved July 9, 2017, from newgeography: http://www.newgeography.com/content/003004-evolving-urban-form-dhaka

Dhaka WASA. (1991). Dhaka Region Groundwater and Subsidence Study. Dhaka.

DoE, BCAS and UNEP. (2006). In Dhaka City State of Environment 2005. United nations Environment Programme.

DWASA. (2006). Annual Report 2004-2005. Dhaka: Dhaka Water and Sewage Authority.

FAP. (1991). Master Plan Study for Greater Dhaka Protection Project. In Flood Action Plan. Dhaka: Japan International Cooperation Agency.

Higgins, S. A., Overeem, I., Steckler, M. S., Syvitski, J. P., Seeber, L., & Kabir, H. A. (2014, August 22). InSAR Measurements of Compaction and Subsidence in the Ganges-Brahmaputra Delta, Bangladesh. Journal of Geophysical Research: Earth Surface, 119(8).

Huq, S., & Alam, M. (2003). Flood Management and Vulnerablity of Dhaka City.

Islam, S., Haque, A., & Bala, S. (2008). Hydrological Flood Aspects-2007. Dhaka.

JICA. (1987). Study on Storm Water Drainage Improvement in Dhaka City. Dhaka: Ministry of Local Government, Rural Development and Co-operative, The Peoples Republic of Bangladesh.

JICA. (1991). Master Plan for Greater Dhaka Protection Project. Dhaka: Japan International Cooperation Agency.

JICA. (2000). Baseline Information Study of the Dhaka Combined Flood Control cum Eastern Bypass Road Project (Vol. 1).

Kamal, A., & Midorikawa, S. (2006). Geomorphological Approach for Seismic Microzoning within Dhaka CIty Area. International Association for Engineering Geology and the Environment.

Kamrul, M., William, B., & Dottridge, J. (1999). The Vulnerability of the Dupi Tila Aquifer of Dhaka, Bangladesh. In Impacts on Urban Growth on SUrface Water and Ground Water Quality.

Khan, N. (2001). Assessment of Water Logging COnditions Using Integrated GIS and Remote Sensing Techniques: A Study of DHaka Mega City. Oriental Geographer.

Miah, M., & BL, B. (1968). Some Aspects of Geomorphology of the Madhupur Tract. Oriental Geographers.

Rahman, M. (2007, September 14). thedailystar.net. Retrieved from The Daily Star: http://www.thedailystar.net/news-detail-3883

RAJUK. (1997). In Dhaka Metropoliton Development Plan (1995-2015) (Vol. 1). Dhaka: RAJUK.

The Daily Prothom Alo. (2008). Rajdhanijure Panir Kosto. Dhaka: The Daily Prothom Alo.

Yeasmin, S. (2003, August). Water Logging in City.

2. LEGISLATIVE, REGULATION AND POLICY CONSIDERATION

Regulatory requirements toward protection and conservation of environment and various environmental resources and also toward protection of social environment from adverse impact of projects and activities associated with them have been enunciated by the Government of Bangladesh as well as financiers. Pertinent among these requirements are summarized as under.

2.1 Applicable Environmental Legislation in Bangladesh

2.1.1 National Environment Policy, 1992

The National Environment Policy of 1992 sets out the basic framework for environmental action, together with a set of broad sector action guidelines. The Policy provides the broader framework of sustainable development in the country. It also stated all major undertakings, which will have a bearing on the environment; (including setting up of an industrial establishment) must undertake an IEE and EIA before initiation of the project. Key elements of the policy are:

- Maintaining ecological balance and ensuring sustainable development of the country through protection and conservation of the environment
- Protecting the country from natural disasters
- Identifying and regulating all activities that pollute and destroy the environment
- Ensuring environment-friendly development in all sectors
- Ensuring sustainable and environmentally sound management of the natural resources
- Maintaining active association, as far as possible, with all international initiatives related to environment.

With regard to the transport sector the environmental policy aims at prevention of pollution and degradation of resources caused by roads and inland waterways transport. The policy mentions that EIA should be conducted before projects are undertaken.

2.1.2 National Environment Management Plan 1995

The National Environment Management Action Plan (NEMAP) is a wide ranging and multi-faceted plan, which builds on and extends the statements set out in the National Environment Policy (NEP). NEMAP was developed to address the issues and management requirements for a period between 1995 and 2005 and set out the framework within which the recommendations of the National Conservation Strategy (NCS) are to be implemented. NEMAP has the following broad objectives:

- Identification of key environmental issues affecting Bangladesh;
- Identification of actions necessary to halt or reduce the rate of environmental degradation;
- Improvement of the natural and built environment
- Conservation of habitats and biodiversity;
- Promotion of sustainable development; and
- Improvement in the quality of life of the people.

2.1.3 Bangladesh Environmental Conservation Act (1995) and Amendments

The Bangladesh Environment Conservation Act of 1995 is the key legislation in relation to environment protection in Bangladesh. This Act is promulgated for environment conservation, standards, development, pollution control, and abatement. It has repealed the Environment Pollution Control Ordinance of 1977. The Act has been amended in 2000, 2002, 2007 and 2010.

The main objectives of the Act are:

- Conservation and improvement of the environment; and
- Control and mitigation of pollution of the environment.

The main strategies of the Act can be summarized as:

- Providing appropriate organizational structure and regulatory powers to the
- Department of Environment to monitor environmental issues, and enforce control measures where appropriate;
- Declaration of ecologically critical areas and restriction on the operations and processes, which can or cannot be carried out / initiated within these;
- Promulgation of standards for quality of air, water, noise and soil for various applications;
- Regulation of allowable vehicle emissions;
- Regulatory responsibility for the environmental clearance process for new and existing project and developments;
- Regulation of discharge limits and discharge permits for industries and other developments;
- Promulgation of a standard limit for discharging and emitting waste; and
- Formulation and declaration of environmental guidelines for key issues.

The Department of Environment (DoE) executes the Act under the leadership of the Director General (DG). As stipulated under the ECA, the Project proponent must obtain Environmental Clearance from the DG of DoE before any new project can be approved. An appeal procedure exists for those proponents who fail to obtain clearance, however failure to comply with any part of this Act may result in punishment equivalent to a maximum of five years imprisonment, or a maximum fine of Tk. 500,000, or both.

The Environmental Conservation Act (Amendment 2000)

The Bangladesh Environment Conservation Act (Amendment 2000) focuses on ascertaining responsibility for compensation in cases of damage to ecosystems. It allows for increased provision of punitive measures both for fines and imprisonment, and the authority for nominated officials to record the details of alleged offences and to prosecute the offenders.

The Environmental Conservation Act (Amendment 2002)

The 2002 Amendment of the ECA elaborates on the following parts of the Act:

- Restrictions on automobile emissions;
- Restrictions on the sale and production of environmentally harmful items like polythene bags;
- Assistance from law enforcement agencies for environmental actions; and

- Authority to try environmental cases in court (also supported by the *Environmental Court Act, 2000*).

The Environmental Conservation Act, 2010

The amendment of ECA'95 has been published on 5 October, 2010 as Bangladesh Environmental Conservation Act, 2010. Some changes and inclusions has been made in different clauses particularly in defining the Ecological Critical Area, farming certain rules and conditions in cutting and/or razing hills, handling disposal of hazardous wastes, managing ship braking industries & wetlands, fixing responsibilities of environmental and safety management, obligations of obtaining and issuance of environmental clearance certificates and imposing penalties for violations including but not limited to filing cases for compensations, fixing fees and framing different rules under this Act.

2.1.4 Environment Conservation Rules (1997) and Amendments

The ECR is a set of rules, promulgated under the Environmental Conservation Act, which specifies environmental approvals processes for various project types and provides allowable limits for environmental disturbance or pollutative discharge / emissions. The Environment Conservation Rules (1997) (ECR) provides categorization of industries and projects and identifies types of environmental assessments required against respective categories of industries or projects. The rules set:

- The National Environmental Quality Standards for ambient air, various types of water, industrial effluent, emission, noise, vehicular exhaust etc.;
- The requirement for, and procedures to obtain, Environmental Clearance; and
- The requirement for IEE / EIAs according to categories of industrial and other development interventions.

The proposed metro rail project clearly falls under any category according to the ECR, 1997.

2.1.5 Ecological Critical Area

At first in 1992 National Conservation Strategy of Bangladesh has identified 31 areas of Bangladesh as Environmentally Critical Area. In 1995 after the enactment of the Bangladesh Environment Conservation Act, 1995 the Government is empowered to declare an area which is enriched with unique biodiversity and environmentally significant and shall need protection or conservation from destructive activities as ecologically critical area (ECA). When the government i.e. the Ministry of Environment and Forest (MoEF) thinks that due to environmental degradation the ecosystem of an area is in a critical situation or is threatened to be in such situation can declare such area as an ECA by issuing notification in the official Gazette. In the Gazette notification, the boundary and legal description including map of the area concerned shall be mentioned and all these map and legal description shall be displayed in the concerned area and it shall be considered as document in the said area. The Government takes management plan for the said area after declaring it as ECA and shall immediately take necessary measures to overcome such critical situation.

The Government after considering the human habitat, ancient monument, archeological site, forest sanctuary, national park, game reserve, wild animals' habitat, wetland, mangrove, forest area, biodiversity and other relevant factors of the area can declare as ECA. As per the legal mandate the MoEF till now declared 12 areas as ECA. Department of Environment (DoE) as a statutory body is entrusted to manage the ECAs. Following are the description of ECAs:

Table 2-1: Ecological Critical Area of Bangladesh

Sl.	Name of ECA	Ecosystem Type	Location	Area (ha)	Declaration
1.	Sundarban Reserved Forest as a whole and 10 km landward periphery	Coastal Marine	Bagerhat, Khulna and Satkhira	292,926	30/08/1999
2.	Cox's Bazar Teknaf Peninsula	Coastal Marine	Cox's Bazar	20,373	19/04/1999
3.	St. Martin Island	Marine Island with coral reef	Cox's Bazar	1,214	19/04/1999
4.	Sonadia Island	Marine Island	Cox's Bazar	10,298	19/04/1999
5.	Hakaluki Haor	Inland fresh water wetland	Sylhet and Moulavibazar	40,466	19/04/1999
6.	Tanguar Haor	Inland fresh water wetland	Sunamganj	9,797	19/04/1999
7.	Majrat Baor	Ox-bow lake	Jhenaidah	325	19/04/1999
8.	Gulshan-Baridhara Lake	Urban wetland	Dhaka City	101	26/11/2001
9.	Buriganga	River	Dhaka	Total area of the Rivers is 7,606 (including foreshore and river bank)	01/09/2009
10.	Turag	River	Dhaka		01/09/2009
11.	Sitalakhya	River	Dhaka		01/09/2009
12.	Balu	River	Dhaka		01/09/2009
				383,105	

Source: DoE, 2012

The Government in the Gazette notification prohibited some activities or processes, which cannot be initiated or continued in an ECA, including- felling or collecting trees; hunting, catching or killing wild animal; industrial establishment; fishing and other activities those are harmful for aquatic life; polluting water by disposing waste; and any other activity that could destroy or change the natural characteristics of soil and water. Continuing any such activities or processes in the ECA will be punishable with imprisonment up to 2 years, or fine up to taka 2 lac for the first offence; for the repetition of the same offence s/he will be punishable with imprisonment up to 10 years or a fine up to taka 10 lac. Establishment of brick kiln in or within minimum 1 kilometer distance from the boundaries of any ECA is also prohibited and punishable.

2.1.6 EIA Guidelines for Industry

This guideline has been prepared by DoE on the basis of the work done by various types of industry projects as well as on the requirements of the Environment Conservation Rules (1997). Owing to this, this guideline specifically covers industry projects and shows how the EIA for industry projects in Bangladesh should be implemented. The brief composition is:

- Introduction to EIA in Bangladesh
- Criteria for locating industrial plants
- Steps involved in conducting IEE
- Steps involved in conducting EIA
- Review of an EIA report

All requisite clearance from the DoE shall be obtained prior to commencement of civil work. DTCA will proceed with the application for clearance in due course.

2.2 Relevant Legislation in Bangladesh

There are a number of other laws and regulations applicable which are relevant for the project. These are the following, see Table 2-2**.** The EIA is prepared in compliance with these instruments.

Table 2-2: National Policies, Legislation and Rules relevant to the Proposed Project

Policy or Legal Instrument	Key Features	Agency
The Sound Pollution (Control) Rules, 2006	Provides mechanism for bringing noise complaints before local authorities for adjudication of injury	Department of Environment
Environment Court Act, 2000 and subsequent amendments in 2002	To facilitate environment related legal proceedings	Ministry of Environment and Forest (MoEF)
National Land Transport Policy, 2004	Reduction of pollution from all kinds of vehicles Environmental protection management Mass transit plans developed in conjunction with institutional strengthening of the transport sector	Ministry of Communication
The National Water Policy, 1999	Protection, restoration and enhancement of water resources Protection of water quality, including strengthening regulations concerning agro-chemicals and industrial effluent Sanitation and potable water Fish and fisheries; and Participation of local communities in all water sector development	Ministry of Water Resources

Policy or Legal Instrument	Key Features	Agency
The Vehicle Act, 1927 The Motor Vehicles Ordinance, 1983 The Bengal Motor Vehicle Rules, 1940	Exhaust emissions Vehicular air and noise pollution Road/traffic safety Vehicle licensing and registration Fitness of motor vehicles Parking bylaws	Bangladesh Road Transport Authority
Water Supply and Sanitation Act, 1996	Management and Control of water supply and sanitation in urban areas	Ministry of Local Government, Rural Development and Cooperatives
The Ground Water Management Ordinance, 1985	Management of ground water resources and licensing of tube wells	Upazilla Parishad
National Land Use Policy, 2001	Land use policy for agriculture (crop production, fisheries and livestock), housing, forestry, industrialization, railways and roads, tea and rubber.	Ministry of Land
Draft Wetland Policy, 1998	Establishment of principles for sustainable use of wetland resource Maintenance of existing level of biological diversity Maintenance of the function and value of wetlands in resource management and economic development	Ministry of Environment and Forest

2.3 Occupational Health and Safety related laws and rules

During construction, the project will confirm the labor laws, for occupational and health related rules as outlined in **Table 2-3**.

Table 2-3: Occupational health and safety related law and rules

Title	Overview
Bangladesh Labor Act 2006	Provides for safety of work force during construction period. The act provides guidance of employer's extent of responsibility and the workmen's right to compensation in case of injury caused by accident while working.
Water Supply and Sewerage Authority Act 1996	The act calls for ensuring water supply and sewerage system to the public, preservation of system, and other related health and environmental facilities for the community

Title	Overview
Labor Relations under Labor Laws, 1996 (Revisions to scattered Acts and Ordinances to formulate a unified code)	General concerns during the project implementation state that the project manager must recognize labor unions.
Public Health Emergency Provisions Ordinance, 1994	Calls for special provisions with regard to public health. In case of emergency, it is necessary to make special provisions for preventing the spread of disease, safeguarding the public health, and providing adequate medical service, and other services essential to the health of respective communities and workers during construction-related work
The Employees State Insurance Act, 1948	Health, injury, and sickness benefit should be paid.
The Employer's Liability Act, 1938	Covers accidents, risks and damages with respect to employment injuries
Maternity Benefit Act, 1950	Framed rules for female employees, who are entitled to various benefits for maternity.

2.4 Legal Framework for Land Acquisition

The current legislations governing land acquisition for Bangladesh is the Acquisition and Requisition of Immovable Property Ordinance 1982 (ARIPO) and subsequent amendments during 1993 - 1994. The Ordinance requires that compensation be paid for (i) land and assets permanently acquired (including standing crops, fisheries, trees, houses other structures etc); and (ii) any other damages caused by such acquisition. The Deputy Commissioner (DC) determines the market price of assets based on the approved procedure and in addition to that pays an additional 50 percent (as premium) on the assessed value as the market price established by Land Acquisition Officer (LAO) which remains much below the replacement value. The 1994 amendment made provisions for payment of crop compensation to tenant cultivators. The Ordinance, however, does not cover project-affected persons without titles or ownership record, such as informal settler/squatters, occupiers, and informal tenants and lease-holders (without document) and does not ensure replacement value of the property acquired. The act has no provision of resettlement assistance and transitional allowances for restoration of livelihoods of the non-titled affected persons. The Acquisition and Requisition of Immovable Property Ordinance (ARIPO, 1982) with its subsequent amendments will be applied for this project.

The Deputy Commissioner (DC) processes land acquisition under the Ordinance and pays compensation to the legal owners of the acquired land. The Ministry of Lands (MOL) is authorized to deal with land acquisition through the DCs. Khas (government owned) lands should be acquired first when a project acquires both khas and private land. If a project acquires only khas, the land will be transferred through an inter-ministerial meeting following the preparation of acquisition proposal submitted to DC/MOL.

The land owner has to establish ownership by producing a record-of-rights in order to be eligible for compensation under the law. The record of rights prepared under Section 143 or 144 of the State Acquisition and Tenancy Act 1950 (revised 1994) are not always updated and as a result legal land owners have to face difficulties in trying to "prove" ownership. The APs must also produce rent receipt or receipt of land development tax, but this does not

assist in some situations as a person is exempted from payment of rent if the area of land is less than 25 bighas (3.37 ha).

However, the ARIPO (1982) does not give any direction to compensate the subsurface property for imposing restriction in use. In Bangladesh the Metro Rail through tunnel and underground stations are going to be built for the first time through this project. Review of the legal procedure of the Government of Bangladesh to include the acquisition of subsurface or easement rights is an immediate need now. The compensation to sub-surface easement is not legislative in the Metrorail Act, 2015. It is recommended that adding of the supplemental section is necessary in “Section 4 of Chapter 4: Acquisition of Land for Implementation of Metrorail” or “Section 13 of Chapter 4: Right to Entry” other than this Feasibility Study.

2.5 EIA System and Procedure set by Domestic Law/Regulation

All development projects require clearance from the DG, DoE for initiating the implementation process. Environmental clearance certificate (ECC) from DoE is issued based on the findings of IEE that also stipulate whether an EIA be carried out by the project proponent or the IEE is enough. EIA study focuses on addressing the unresolved environmental issues in IEE report. The unresolved environmental issues may be because of inadequacy of data, lack of impact identification and/or lack of mitigation measures. The steps to be followed during EIA study are (i) collection of baseline study, (ii) identification of environmental impacts on IECs,(iii) prediction regarding potential impacts,(iv) evaluation of the impacts, (v) prescribing the mitigation measures,(vi) monitoring program, (vii) risk analysis and (viii) documentation and communication (DoE 1997, BCAS 1999).

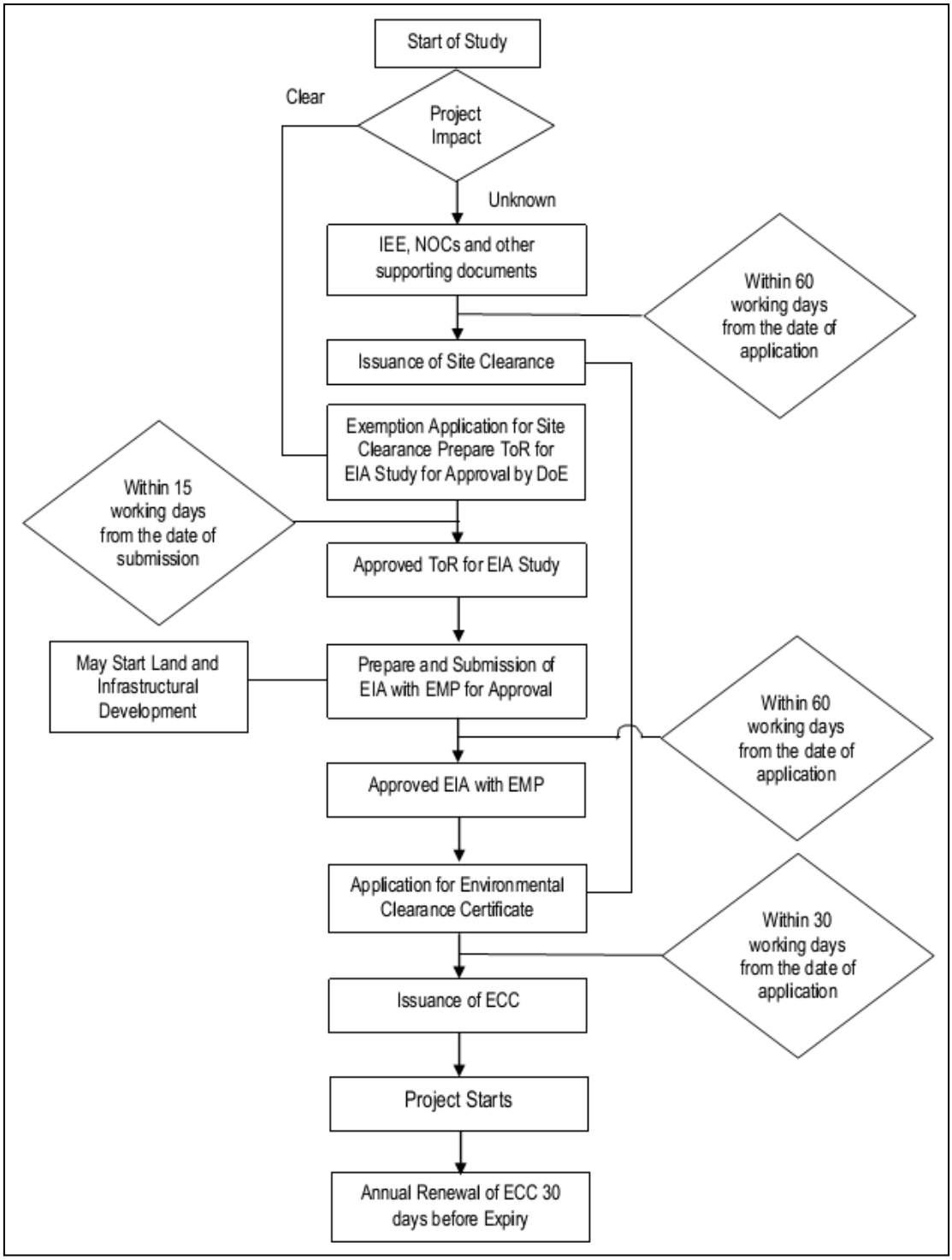
Environmental Clearance Certificate (ECC)

An ECC from DoE is required before initiating the project implementation activities. An application to the DG DoE is to be submitted through the local office in prescribed application form (Vide Rule 7.5) fulfilling the requirements detailed in BECR 1997 (BCAS 1999). DTCA will apply to DoE for getting the ECC for the said project.

2.5.1 Flow of EIA Approval

Under the Environmental Conservation Rules (1997) a classification system was established for development projects and industries on basis of the location, the size and the severity of potential pollution. There are four categories of projects: green, orange A, orange B and red with respectively no, minor, medium and severe environmental impacts. For the red category of projects a full EIA is required. All regional and national highway, railway and bridge projects of over 100 m length fall in the red category. The proposed metro rail project clearly falls under RED category.

The Proposed MRT line 5 project falls under the red category considering the length of the line as well as nature of impact on environment and social. The Environmental Impacts Assessment should include the prediction, evaluation and mitigation of environmental impacts caused, based on the characteristics of project, and an Environmental Management Plan (EMP) shall be prepared. The approval of the EIA and EMP is required before submitting an application for an Environmental Clearance Certificate (ECC). The procedure is shown in **Figure 2-1**.



Source: Environmental Conservation Rule, 1997

Figure 2-1: Steps for Obtaining Environmental Clearance Certificate of Red Category Project

2.6 The Japan International Cooperation Agency Policy

JICA environmental Guidelines which is applied to the Project is "Guidelines for Environmental and Social Considerations" (April 2010).

The JICA Guidelines confirm that project proponents are undertaking appropriate environmental and social considerations, through various measures, so as to prevent or

minimize the impact on the environment and local communities which may be caused by the projects for which JICA provides funding, and not to bring about unacceptable effects. It will thus contribute to the sustainable development of developing regions. In its confirmation of environmental and social considerations, JICA places importance on dialogue with all involved partners (e.g. the host country, local governments, borrowers and project proponents) regarding environmental and social considerations. Transparent and accountable processes, as well as active participation of key stakeholders (e.g. local residents and local NGOs affected by the project) in all stages of the project are highly considered. The JICA Guidelines are formulated in reference to the World Bank Operational Policy.

The JICA Guidelines provide following four categories of projects as per its environmental classification system.

- Category A: A proposed project is classified as Category A if it is likely to have significant adverse impact on the environment. Borrowers and related parties must submit Environmental Impact Assessment (EIA) reports. For projects that will result in large-scale involuntary resettlement, basic resettlement plans must be submitted. EIA and other reports need to be submitted through the borrower before the JICA environmental reviews.
- Category B: A proposed project is classified as Category B if its potential adverse environmental impact is less adverse than that of Category A projects.
- Category C: A proposed project is classified as Category C if it is likely to have minimal or no adverse environmental impact.
- Category FI: A proposed project is classified as Category FI if it satisfies all of the following:
  - JICA's funding of the project is provided to a financial intermediary etc.;
  - the selection and assessment of the actual sub-projects is substantially undertaken by such an institution only after JICA's approval of the funding and therefore the subprojects cannot be specified prior to JICA's approval of funding (or assessment of the project); and
  - Those sub-projects are expected to have potential impact on the environment.

The Project, as per the above categorization, falls under Category A for the purpose of environmental investigations. Final EIA report approved by DoE needs to be laid open for public inspection at the JICA headquarter 120 days before a loan agreement for category A projects.

2.7 Gaps between Environmental Regulations of GoB and the JICA Guidelines

There are gaps about categorization process, necessity of alternative study and information disclosure as shown in Table 2-4.

Table 2-4: Major Gaps between Environmental Regulations of GoB and the JICA Guidelines

Aspect of Operational Framework	JICA	GoB	Harmonized Operational Framework
Environmental Policy and	JICA Guidelines for Environmental	• Environment Conservation	-

Aspect of Operational Framework	JICA	GoB	Harmonized Operational Framework
Regulations	and Social consideration, April 2010	Act (1995) • Environment Conservation Rules (1977) • EIA guidelines on Industrial projects	
Alternatives	Environmental impact must be assessed and examined from the earliest possible planning stage. Alternatives studies shall be made to avoid or minimize adverse impact must be examined and incorporated into the project plan	ECA (1995) and ECR (1997) do not explicitly ask for identification and assessment of alternatives.	Alternative study shall be made to minimize the project impact
Consultation	In projects, especially can have adverse effects on environment, information on projects needs to be known at early stage and stakeholders, such as local people, should be adequately consulted. The consultation result needs to be considered in projects. (Holding consultations is highly desirable, especially at scoping stage and when the draft report is being prepared)	No public disclosure is required as per ECR. Although there are descriptions recommending public participation in EIA, any detailed regulations for local consultation are not laid down.	To implement public consultation accordingly throughout the preparation and implementation stages of the Project. During preparation of the EIA report, consultations were implemented at scoping stage and when the draft report was prepared.
Disclosure of EIA report	It is needed that EIA report is disclosed to projected countries and local people, and stakeholders, such as local people, can access to the report all the time. Also, allowance for copying the report is needed. JICA discloses EIA reports 120 days prior to concluding agreement documents.	There is no regulation for the time of EIA disclosure.	Setting up the time of EIA disclosure can guarantee people to access to the report

2.8 ADB Requirements

2.8.1 ADB's Safeguard Policy Statement

In July 2009, ADB's Board of Directors approved the new Safeguard Policy Statement (SPS) governing the environmental and social safeguards of ADB's operations. The SPS builds upon ADB's previous safeguard policies on the Environment, Involuntary Resettlement, and Indigenous Peoples, and brings them into one consolidated policy framework with enhanced consistency and coherence, and more comprehensively addresses environmental and social impacts and risks. The SPS also provides a platform for participation by affected people and other stakeholders in the project design and implementation.

The SPS applies to all ADB-financed and/or ADB-administered projects and their components, regardless of the source of financing, including investment projects funded by a loan; and/or a grant; and/or other means, such as equity and/or guarantees. ADB works with borrowers and clients to put into practice the requirements of SPS.

The SPS supersedes ADB's Involuntary Resettlement Policy (1995), Policy on Indigenous Peoples (1998), and Environment Policy (2002). In accordance with the SPS, these previous policies apply to all projects and tranches of multi-tranche financing facility projects that were reviewed by ADB's management before 20 January 2010.

The objectives of ADB's safeguards are to:

- avoid adverse impacts of projects on the environment and affected people, where possible;
- minimize, mitigate, and/or compensate for adverse project impacts on the environment and affected people when avoidance is not possible; and
- assist borrowers and clients to strengthen their safeguard systems and develop the capacity to manage environmental and social risks.

ADB's SPS sets out the policy objectives, scope and triggers, and principles for three key safeguard areas:

- Environmental safeguards;
- Involuntary Resettlement safeguards; and
- Indigenous Peoples safeguards.

To help borrowers and clients and their projects achieve the desired outcomes, ADB adopts a set of specific safeguard requirements that borrowers and clients are required to meet in addressing environmental and social impacts and risks. These safeguard requirements are as follows:

- Safeguard Requirements 1: Environment (Appendix 1 of SPS);
- Safeguard Requirements 2: Involuntary Resettlement (Appendix 2 of SPS);
- Safeguard Requirements 3: Indigenous Peoples (Appendix 3 of SPS); and
- Safeguard Requirements 4: Special Requirements for Different Finance Modalities (Appendix 4 of SPS).

In addition, ADB does not finance activities on the prohibited investment activities list (Appendix 5 of SPS).Furthermore, ADB does not finance projects that do not comply with its safeguard policy statement, nor does it finance projects that do not comply with the host country's social and environmental laws and regulations, including those laws implementing host country obligations under international law.

Consultation and Disclosure requirements of ADB

ADB's *Safeguard Policy and Public Communications Policy (2011)* sets out disclosure requirements for various ADB activities, including safeguard requirement. Safeguard Requirements 2: Involuntary Resettlement (Appendix 2 of SPS); and Safeguard Requirements 3: Indigenous Peoples (Appendix 3 of SPS) sets out the need for meaningful consultation and information disclosure during project preparation and operation to the affected population and other ely stakeholders. Key requirements include:

a. Information Disclosure: The borrower/client will submit the following documents to ADB for disclosure on ADB's website as per the applicability with respect to the Project:
    - Draft EIA including draft EMP;
    - Final EIA/IEE;
    - Updated EIA/IEE and corrective active plan;
    - Environmental Monitoring Reports.
    - Resettlement Plan (RP)
    - Indigenous Peoples Plan (IPP)

b. Information disclosure to affected people or stakeholders: The borrower/client will provide relevant environmental information in a timely manner, in an accessible place and in a form and language(s) understandable to affected people and other stakeholders. For illiterate people, other suitable communication methods will be used.

c. Consultation and Participation: The borrower/client will carry out meaningful consultation with affected people and other concerned stakeholders, including civil society, and facilitate their informed participation.

d. Timing and Frequency for consultation and participation: Meaningful consultation begins early in the project preparation stage and is carried out on an ongoing basis throughout the project cycle,

2.8.2 ADB Project Categorization

The SPS, 2009 further outlines a classification system for the categorization of projects. The classification tentatively occurs at the project identification stage, during the initial screening of anticipated impacts. However, classification is an ongoing process, and the classification can be changed at any time with the concurrence of the Chief Compliance Officer (CCO), as more detailed information becomes available and a project proceeds.

Environment

A project's environment category is determined by the category of its most environmentally sensitive component, including direct, indirect, induced, and cumulative impacts. Each proposed project is scrutinized as to its type, location, scale, sensitivity and the magnitude of its potential environmental impacts. The level of detail and comprehensiveness of the EIA or IEE are commensurate with the significance of the potential impacts and risks.

A proposed project is assigned to one of the following categories depending on the significance of the potential environmental impacts and risks:

- Category A: Projects that could have significant environmental impacts. An Environmental Impact Assessment (ESIA) is required.

- Category B: Projects that could have some adverse environmental impacts, but of less significance than those for category A. An Initial Environmental Examination (IEE) is required to determine whether significant impacts warranting an EIA are likely. If an EIA is not needed, the IEE is regarded as the final environmental assessment report.
- Category C: Projects those are unlikely to have adverse environmental impacts. No EIA or IEE is required, although environmental implications are reviewed.
- Category FI: Projects that involve a credit line through a financial intermediary (FI) or an equity investment in a FI. The FI must apply an environmental management system, unless all subprojects will result in insignificant impacts.

Involuntary Resettlement

A project's involuntary resettlement category is determined by the category of its most sensitive component in terms of involuntary resettlement impacts. The involuntary resettlement impacts of an ADB-supported project are considered significant if 200 or more persons will experience major impacts, which are defined as (i) being physically displaced from housing, or (ii) losing 10% or more of their productive assets (income generating). The level of detail and comprehensiveness of the resettlement plan are commensurate with the significance of the potential impacts and risks. A proposed project is assigned to one of the following categories depending on the significance of the probable involuntary resettlement impacts:

- Category A: A proposed project is classified as category A if it is likely to have significant involuntary resettlement impacts. A resettlement plan, including assessment of social impacts, is required;
- Category B: A proposed project is classified as category B if it includes involuntary resettlement impacts that are not deemed significant. A resettlement plan, including assessment of social impacts, is required;
- Category C: A proposed project is classified as category C if it has no involuntary resettlement impacts. No further action is required; and
- Category FI: A proposed project is classified as category FI if it involves the investment of ADB funds to, or through, a financial intermediary (paragraphs 53–58).

Projects are also classified on the basis of impacts to indigenous people, however is not applicable for this Project. Based on the diversity of the work of the proposed MRT line 5 has been fallen under Category A.

3. PROJECT DESCRIPTION

3.1 Project Location

MRT Line1 and Line 5 were prioritized as the high priority projects by RSTP. The proposed MRT line 5 is located in the RAJUK area which will start from Hemayetpur of Savar upazila. MRT Line 5 is a 22 km long east-west corridor from Hemayetpur to Vatara via Dar-us-Salaam road, Mirpur road, Banani cantonment and Madani Avenue. The project area extends in both Dhaka North City Corporation (DNCC) and Dhaka South City Corporation (DSCC) and Savar Upazila starting from Hemayetpur, extended towards east and ended at Vatara. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. MRT line 5 consist of total 14 stations of which 5 will viaduct station and other 14 stations is planned underground station. The depot area has been planned to established north side of the Hemayetpur station. The location of the proposed alignment and depot area is shown in the following Figure 3-1.

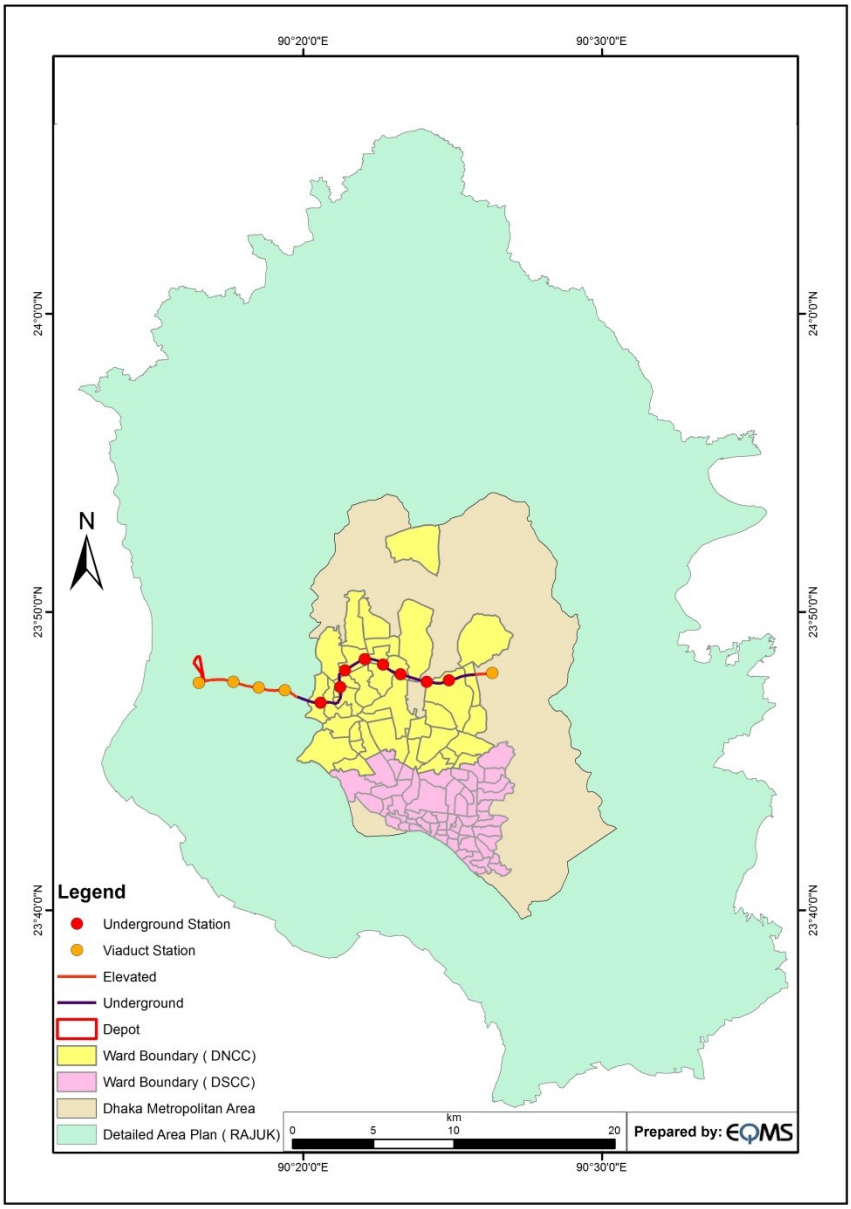


Figure 3-1: Location Map of MRT Line 5

3.2 Project Concept

The proposed MRT line 5 project will be constructed consist of both elevated and underground section. The MRT line 5 is a 22 km long east west corridor from Hemayetpur to Vatara via Dar-us-Salaam road, Mirpur road, Banani cantonment and Madani Avenue. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. MRT line 5 consist of total 14 stations of which 5 will viaduct station and other 9 stations is planned underground station.

The elevated section will start from the Hemayetput to Aminbazar staton after that the line will follow the underground section following the Gabtoli-Darus salam-Mirpur 1-Mirpur 10, Kachukhet- Kamal Ataturk road- Gulshan 2- Natun Bazar. After Natun Bazar station the MRT line 5 will be elevated till Vatara station. There are five control points of the MRT line 5 firstly RHD has a plan to construct the access control toll road from the Gabtoli-Savar-Nabinagar, intersection with Turag River, Banani DoHS, Gulshan lake, Intersection with MRT line 6 at Mirpur 10. Underground section has planned different depth from ground level considering the control point. The underground section Rail Level (RL) varies from 16.87-36.85 meter whereas the GL to RL for elevated section varies from 13.0-22.2 m.

The pile foundation of the elevated section will be 40 m depth from the existing ground level and pile diameter is applied as 1.2 meter to 1.5 meter. Superstructure type is selected as PC Box girder considering structural performance, economy and workability. The standard span of superstructure is considered as 30 m, same as used in MRT Line 6. Maximum span could be 45 m considering the surrounding road and intersections. Noise barrier wall of 1.5 m height from rail level is installed in both edge of girder. Noise barrier wall is made by precast concrete, and it is connected by anchor rebar with girder.

The underground tunnel will consist of shielded tunnels for single tracks. Typically, tunnels running directly underneath roads will be arranged horizontally in two rows side by side. However, if there are any underground obstacles, the tunnels will be built in a two tier configuration, or by separating the two lines for trains to overtake and pass. Underground section will be constructed using the shield tunneling method. The tunnel outer diameter considered as 7 m and thickness of segment is 300mm. Single track cross section shall be applied for the MRT line 5 project as for two tunnels are necessary for the MRT 5 route.

Out of 14 stations eight will be three stories flowed by four number of two stories and two number of four stories. The length of station varies from 190-220 m and width will be 18.6 m-22.8m. Station shall have escalators, elevator and stair and there is a provision for disable person for their smooth travelling.

6 cars train will be stated operation from 2028 considering the 3 min 30 sec headway and it congestion ratio will be 161%. Hence total passenger capacities of the train will 1449 persons whereas it will increase 1944 persons considering the 8 cars train operation in 2035.

3.3 Project Components

3.3.1 Route Overview

MRT Line 5 is a 22 km long east-west corridor from Hemayetpur to Vatara via Dar-us-Salaam road, Mirpur road, Banani cantonment and Madani avenue. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. Route overview of MRT Line 5 along with brief descriptions of its surroundings are summarized in **Table 3-1**.

Table 3-1: Route Overview of MRT Line 5

<table>
<tr><td colspan="2">Photo Location
 
</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>1. Entrance of Depot
There is a vacant space but brick is stacked as of April 2017.</td><td>2. Around Hemayetpur station
Two lanes road at each side. There is approx. 15 m space from road berm to buildings.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>3. Around Baliarpur station
Embankment road with two lanes at each side. Southern side is wet land.</td><td>4. Bilamalia station～Amin Bazar station
There is an electric power substation at the south side of the route.</td></tr>
<tr><td>  </td><td>  </td></tr>
<tr><td>5. Around Amin Bazar station
Two lanes road at each side. There are buildings at both south and north sides and street shops are located in 5 m space between</td><td>6. Turag river
River width is approx. 100 m between Amin Bazar station and Gabtoli stations.</td></tr>
</table>

road berm and buildings.	
	
7. Around Gabtoli station Three lanes road at each side. Some buses are stopping on the road.	8. Around Dar-us-Salam station Three lanes road at each side. Sidewalk width is 3 m, road width is 15 m and median is 0.8 m.
	
9. Mirpur1 station～Dar-us-Salam station Building located at the curve section is 7 story high.	10. Around Mirpur1 station Three lanes road at each side. Sidewalk width is 5 m, road width is 12 m and median is 1.2 m.
	
11. Around Mirpur10 station Three lanes road at each side. Sidewalk width is 6 m, road width is 11 m and median is 1.2 m. There is a cricket stadium located at north side.	12. Around Mirpur14 station Three lanes road at each side. Sidewalk width is 3 m, road width is 14 m and median is 1.1 m.
	
13. Around Kochukhet station	14. Around Banani station

Three lanes road at each side. Sidewalk width is 3 m, road width is 15 m and median is 1.1 m.	Two lanes road at each side. Sidewalk width is 2 m, road width is 10 m and median is 0.65 m. There is a private building and its parking at south side of the road. Width of the parking is 12.5 m.
	
15. Access road to Banani station of BR Sidewalk width is approx. 3 m and there are ticket booths near bus stops.	16. Around Gulshan2 station A large intersection. There are heavy traffic and there are many hotels and shopping buildings.
	
17. Notun Bazar station Two lanes road at each side. Sidewalk width is 3 m, road width is 11 m and median is 2.9 m. There are Saudi Arabia embassy annex and fire station at north side and police station at south side.	18. Notun Bazar station～Vatara station (Launching Shaft) Three lanes road at each side. Sidewalk width is 3 m, road width is 11 m and median is 2.9 m.
	
19. Vatara station One lane road at each side. Sidewalk width is 11 m, road width is 7.2 m and no median.	

Source: JICA Study Team

3.3.2 Design Standard

Design standards conform to the "Bangladesh MRT Engineering Standards" (2014.12 DTCA, JICA), and the specifications required for alignment planning are shown in **Table 3-2** below.

Table 3-2: Specifications Required for Alignment Planning

Item		Standard	Remarks
Maximum Operation Speed		100 km/h	
Maximum Design Speed		110 km/h	
Minimum Curve Radius	Main Line	200 m	Desirable 400m or more
	Along Platform	600 m	
	Siding	200 m	including Depot alignment
Maximum Gradient		35 ‰	
Minimum Gradient	Elevated section	0 ‰	
	Underground section	2 ‰	0‰ in station yard
Platform Length		170 m	for 8 cars

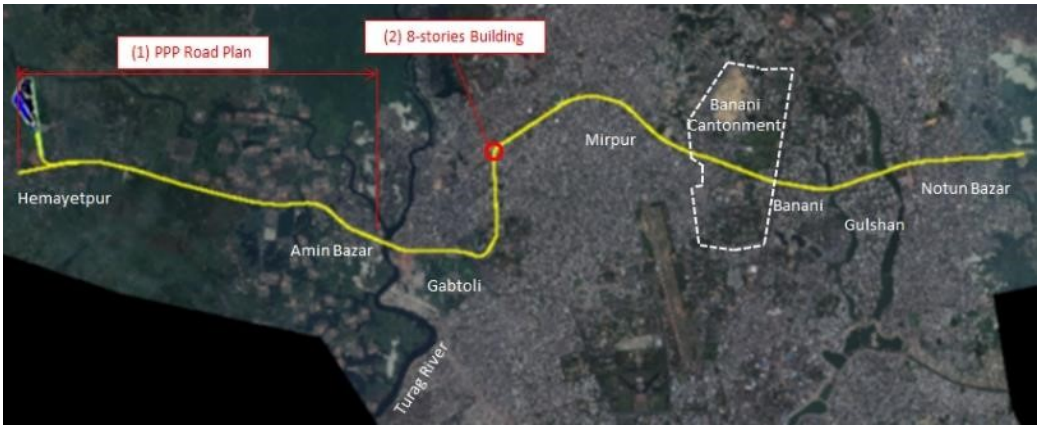
Source: JICA Study Team

3.3.3 Control Point

There are some hard points in the MRT line 5 which has been considered carefully to minimize the impact on the surface structure as well as underground obstacles.

A. Horizontal Alignment

The control points for the horizontal alignment are shown in the following Figure 3-2



Source: JICA Study Team

Figure 3-2: Control Points for Horizontal Alignment

1. Access Control Toll Road Plan

There is a RHD plan to construct an Access Control Toll Road by PPP between Hemayetpur station and Gabtoli station. The horizontal alignment in this section follows the alignment of the Access Control Road plan.

2. The 8-Story Building at the Intersection of Dar-us-Salam Road and Mazar Road

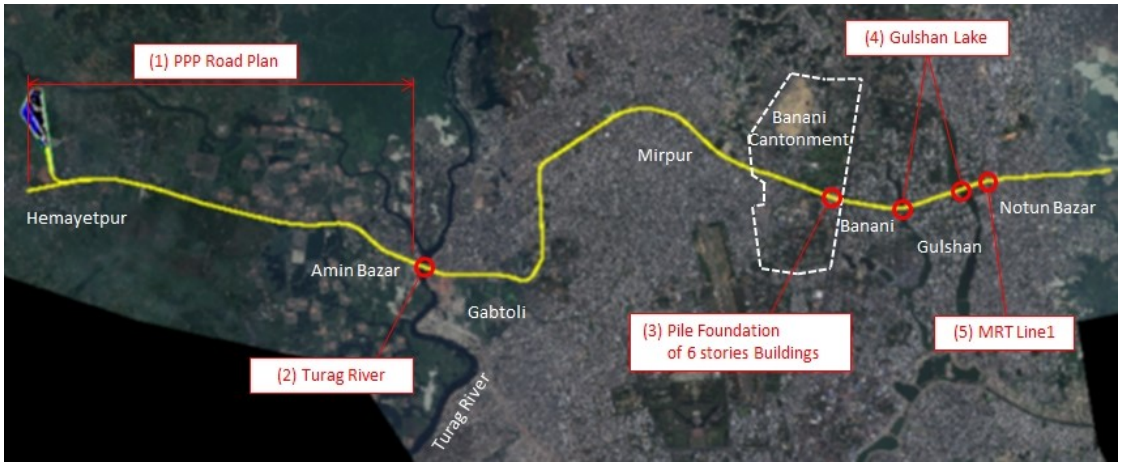
There is an 8-story building at the intersection of Dar-us-Salam Road and Mazar Road. It is supposed that there is pile foundation in this building, and the MRT Line5 should avoid the pile foundation.

Source：JICA Study Team

Figure 3-3: Eight Story Building at the Intersection of Dar-us-Salam Road and Mazar Road

B. Vertical Alignment

The control points for the vertical alignment are shown in the following **Figure 3-4**.



Source：JICA Study Team

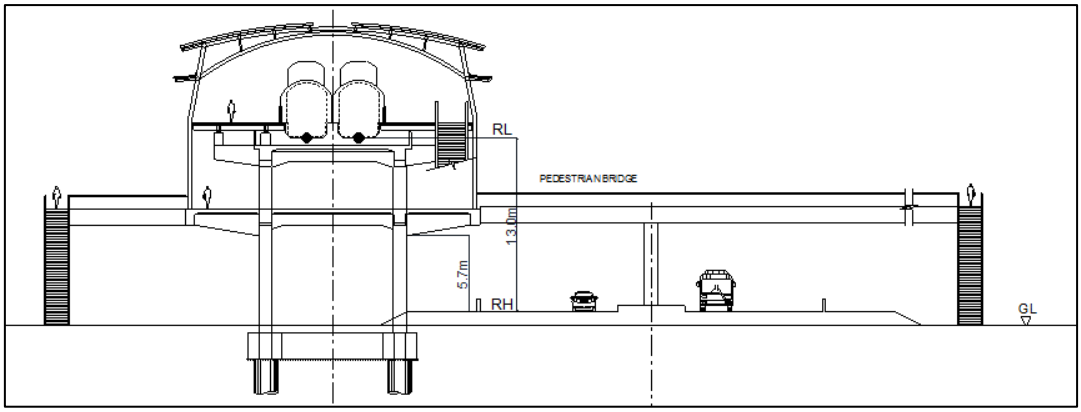
Figure 3-4: Control Points for Vertical Alignment

1. Access Control Toll Road Plan

In the parallel section with the Access Control Toll Road, although the railway structure is arranged within the ROW of the road, the station section cannot be fit within the ROW. In the station section, in order to accommodate the railway structure as much as possible within the ROW, a part of the station structure overhangs the road as shown below.

Therefore, the height of the PPP road surface is the control point for vertical alignment plan at the station. Road construction gauge and concourse floor clearance are secured from road surface height, and at least 13.0 m from road surface height to Rail Level (hereinafter: RL) is required.

Since the planned road height of the Access Control Toll Road has not been decided yet, in this Study, the road surface height of the existing road is set as the Access Control Toll Road surface height.



Source: JICA Study Team

Figure 3-5: Control Point in Parallel Section with Access Control Toll Road

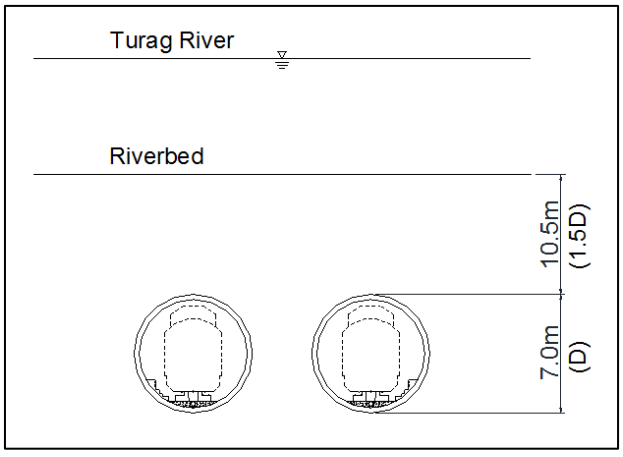
Table 3-3: Required RL at each Station

Station	Road Surface Height (altitude)	RL (altitude)
Hemayetpur	8.5 m	21.5 m
Baliarpur	9.2 m	22.2 m
Bilamalia	7.8 m	20.8 m
Amin Bazar	10.0 m	23.0 m

Source: JICA Study Team

2. Intersection with Turag River

The distance from the riverbed to the upper end of the tunnel shall be more than 1.5 D (D: tunnel outer diameter), so that 16.35 m or more will be secured from the riverbed to the RL. The level of the riverbed at the deepest part of Turag River is measured as -6.34 m in altitude, so the RL at the intersection with Turag River should be less than -22.69 m in altitude.



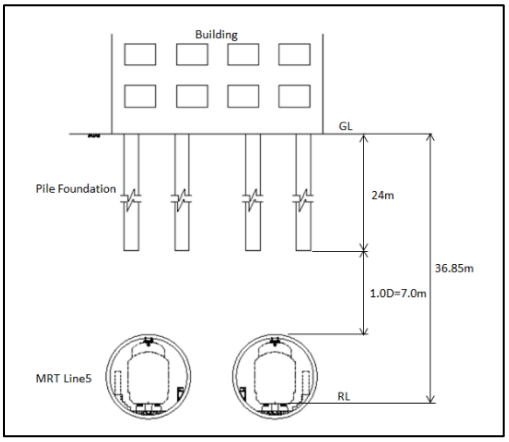
Source: JICA Study Team

Figure 3-6: Control Point at Intersection with Turag River

3. 6 stories apartment buildings of Banani Cantonment

In Banani DOHS Cantonment area, there are many buildings of 6 stories, and MRT Line 5 passes under these buildings.

According to information from DTCA/ Cantonment authority, the maximum length of the pile foundations of the apartments is about 80 feet (approx. 24 m). In order not to affect the apartment, the distance of the tunnel outer diameter 1.0D (7.0 m) from the tip of the pile foundation to the upper end of the tunnel is secured.



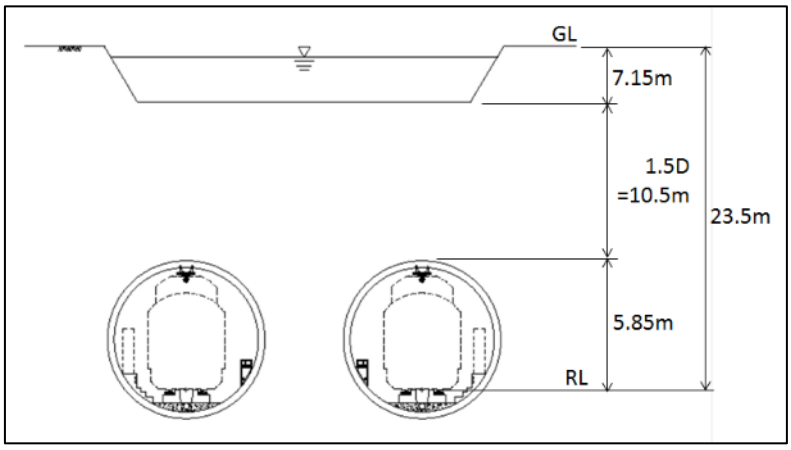
Source: JICA Study Team

Figure 3-7: Control Point at 6-Story Apartment Buildings

4. Gulshan Lake

The tunnel of MRT Line 5 passes under the Gulshan Lake. The overburden of tunnel (from the bottom of the lake to the upper end of the tunnel) is the 1.5D (10.5 m).

The depth of Gulshan Lake is 7.15 m at the deepest place according to the topographic survey.



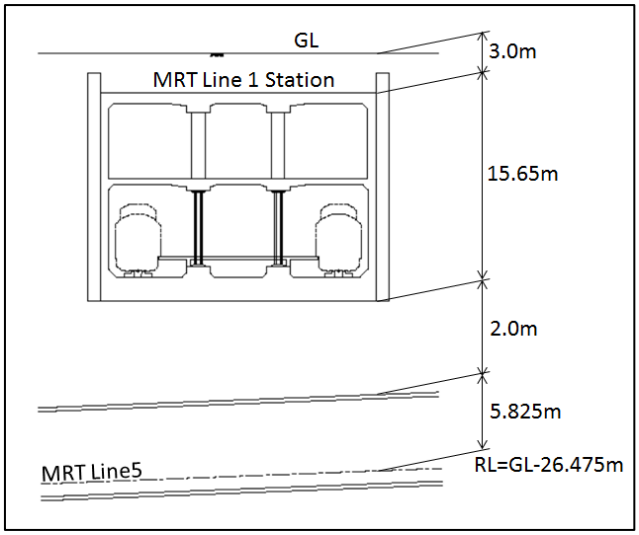
Source: JICA Study Team

Figure 3-8: Control Point at Gulshan Lake

5. Intersection with MRT Line 1

At the chainage of 17k900m of MRT Line 5, MRT Line 5 crosses MRT Line 1. In this section, MRT Line 1 is the underground railway, and MRT Line 5 passes under MRT Line 1.

Regarding the height, MRT Line 1 has the station section at the intersection, and the distance of 2.0 m is secured from the lower end of the station structure to the upper end of the tunnel. As a result, the RL of MRT Line 5 is GL-26.475 m.



Source: JICA Study Team

Figure 3-9: Control Point at Intersection with MRT Line 1

3.3.4 Alignment Planning

3.3.4.1 Horizontal Alignment Plan

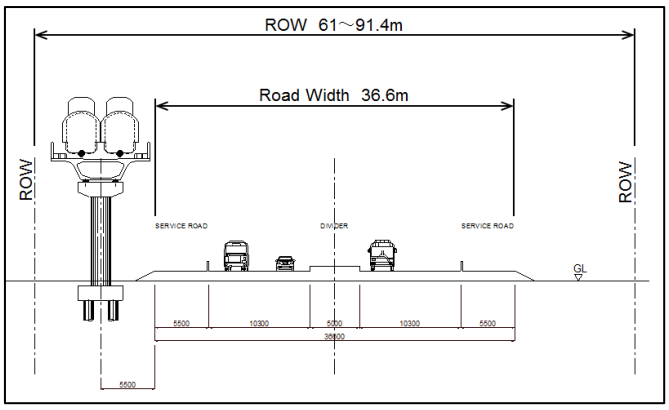
In the elevated section, land acquisition and house relocation are minimized by arranging the railway within the road right of way.

In the underground section, in case of passing the railway under the buildings, it is necessary to deepen the vertical alignment in order to avoid obstacles of the pile foundation. Deepening the vertical alignment leads to deepening the station section, and it is a factor of increasing the construction cost. Therefore, even in the underground section, the horizontal alignment should be arranged as much as possible within the road right of way.

The outline of the horizontal alignment plan is described below.

1. Between Hemayetpur station and Turag River

There is a plan of Access Control Toll Road by PPP in this section as mentioned earlier. This planned road has a width of 120 feet (approx. 36.6 m) for the portion to be used as a road and 200 to 300 feet (approx. 61 to 91.4 m) for ROW. In this section, MRT Line5 is planned as the elevated railway, and the railway elevated facility will be placed in the ROW of the planned road in parallel with the road.



Source: JICA Study Team

Figure 3-10: Typical Cross Section of the Alignment Parallel to Road

2. Between Hemayetpur station and Baliarpur station

The branch line to the depot is arranged between Hemayetpur station and Baliarpur station. In the planned Access Control Toll Road section, MRT Line 5 basically runs parallel to the south side of the road, but in order to shorten the length of the depot access line, the route of this section is located on the north side of the Access Control Toll Road. As a result, MRT Line 5 crosses over the Access Control Toll Road between Hemayetpur station and Baliarpur station.

3. Gabtoli station

Gabtoli station is the junction station of the North Route and South Route of MRT Line 5, which is the underground station with 2 island platforms serving 4 tracks. The width of this underground station is approx. 38 m. Construction of the station structure will be by the cut and cover method and in order to reduce the impact on the road traffic during construction, Gabtoli station is placed in the site of the Gabtoli bus terminal instead of under the road.

4. Between Gabtoli station and Vatara station

Between Gabtoli station and Notun Bazar station is the underground section, and between Notun Bazar station and Vatara station is the elevated section. This section is the route that passes within the road ROW along the road alignment except for Banani Cantonment area.

As for the 3 places around 8k150m, around 8k600m, and around 10k000m, the minimum curve radius of R200 m must be used for the following reasons.

- At around 8k150m

Although the route of this section passes under the gas station, the buildings are built adjacent to the gas station. It is assumed that there is the pile foundation in this building, and the minimum curve radius of R200 m is used to avoid this pile foundation.

- At around 8k600m

In this section, since the road alignment is the R200 m curve, the MRT Line 5 alignment is also R200 m curve along the road.

- At around 10k000m

In order to avoid the 8-story building at the intersection of Dar-us-Salam Road and Mazar Road, the R200 m curve must be used.

5. Banani Cantonment area

Although the horizontal alignment basically passes under the existing road, the east-west direction road is divided by Banani Cantonment in this area. Therefore, the horizontal alignment of this area connecting Kochukhet station and Banani station in the shortest.

6. Banani station

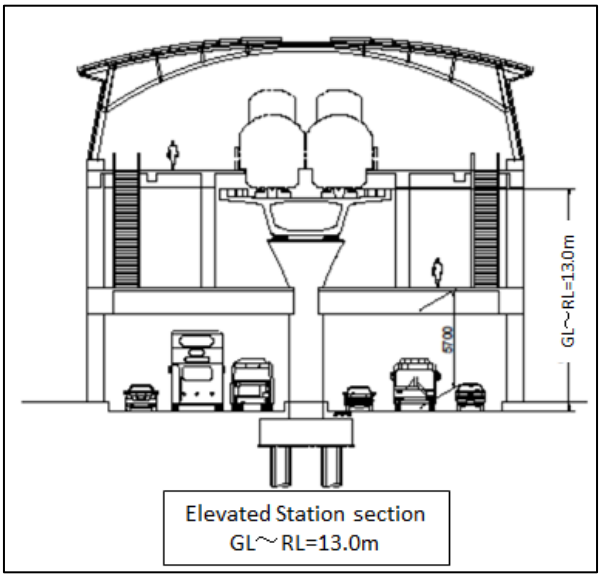
Kemal Ataturk Avenue where Banani station is located has a narrow road width of approx. 20 m and high buildings are built along the roadside. Therefore, Banani station has a station structure in which the up line and the down line are vertically arranged, so that the station structure can fit within the existing road width by narrowing the width of the station box. At Banani station, the horizontal alignment of the up line and the down line overlaps into one line before and after the station.

3.3.4.2 Vertical Alignment Plan

After the height of the station section is decided, the vertical alignment connects the stations while considering the control points. The gradient is kept as gentle as possible. In addition, the gradient at the station section is level.

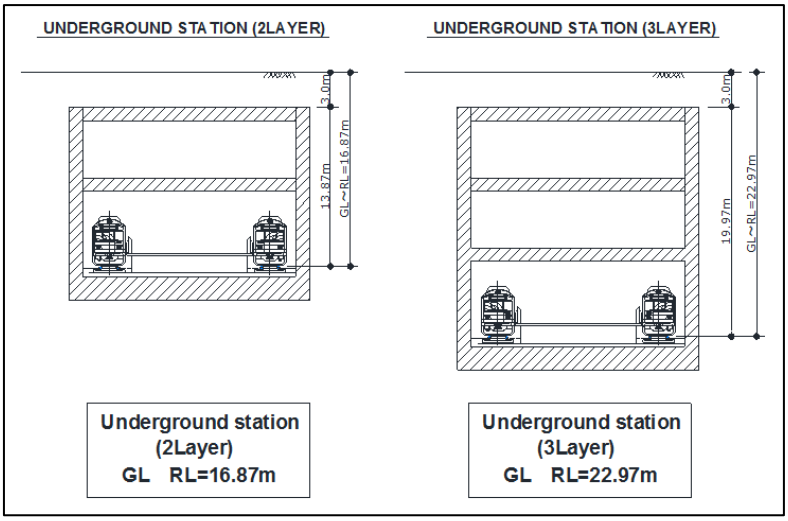
In the underground section, sag point is not provided between the stations, and the minimum gradient is set to 2‰. Thus, basically the tunnel leakage collecting point is set at the station. However, as for the intersection with Turag River and the intersection with the up line and south route after Gabtoli station, the sag is unavoidably provided between the stations.

The required height at the station section is as shown in the following **Figure 3-11** and **Figure 3-12**, and the height from GL to RL is 13.0 m or more for the elevated stations. As for underground stations, the height from GL to RL for the 2-layer underground station is 16.87 m or more, and the height from GL to RL for 3-layer underground station is 22.97 m or more.



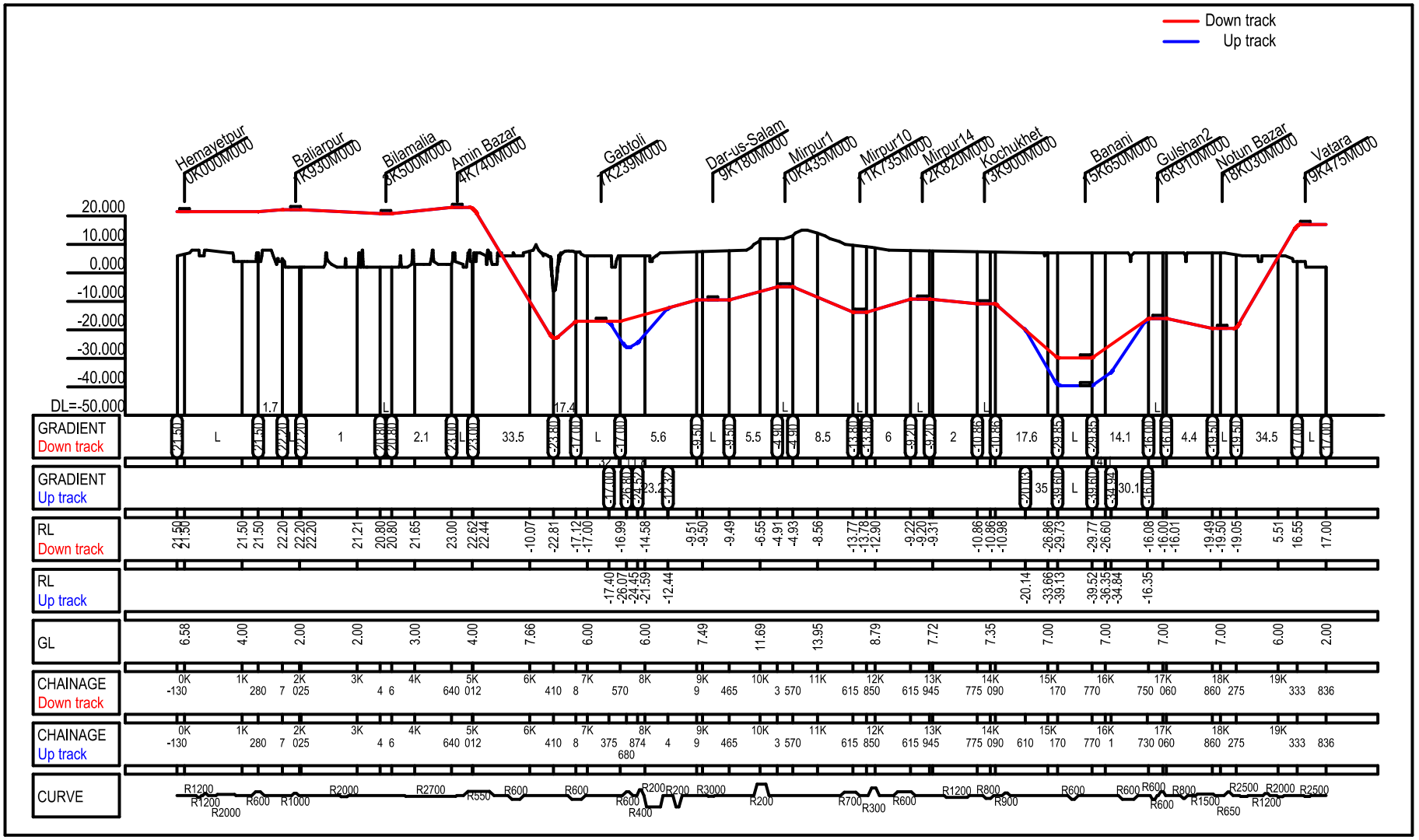
Source: JICA Study Team

Figure 3-11: Required Height at Elevated Station



Source: JICA Study Team

Figure 3-12: Required Height at Underground Station



Source: JICA Study Team

Figure 3-13: Plan and Profile of MRT Line 5

3.3.5 Station Location

The station should be placed approximately every 1 km. In consideration of horizontal alignment, vertical alignment, and connection with other lines, the station location shall be the position shown in the **Table 3-4** below.

Table 3-4: Station Location of MRT Line 5

	No.	Station	Location	Distance	Remarks
Elevated	1	Hemayetpur	0k000m		Station in straight section as close as possible to urban area in west side.
	2	Baliarpur	1k930m	1.93km	Intersection with PPP road before station, station location as far as possible on the west side considering vertical alignment at intersection.
	3	Bilamalia	3k500m	1.57km	Near the center between Bilamalia station and Amin Bazar station.
	4	Amin Bazar	4k740m	1.24km	Transition section after station. Station location is determined by the position of transition.
Underground	5	Gabtoli	7k239m	2.499km	Located at the current Gabtoli bus terminal position.
	6	Dar-US-Salam	9k180m	1.941km	Near the center between Gabtoli station and Mirpur 1 station.
	7	Mirpur 1	10k435m	1.255km	Location to avoid monument in roundabout.
	8	Mirpur 10	11k735m	1.3 km	Station location as close as possible to MRT line 6, considering the connection with MRT line 6. Curve of R300m to the east side of line 6. Station installation is impossible.
	9	Mirpur 14	12k820m	1.08 km	Near the center between Mirpur 10 station and Kochukhet station.
	10	Kochukhet	13k900m	1.08 km	Box culvert after station, station location as far as possible to east, avoiding box culvert station arrangement within Banani Cantonment is not allowed.
	11	Banani	15k650m	1.75km	Bangladesh Raiways and plan of BRT Line line 3 before station location shall be the position considering the connection with these. Station arrangement within Banani Cantonment in not allowed.
	12	Gulshan 2	16k910m	1.26 km	Considering the accessibility to commercial buildings in Gulshan2 circle, station is located in the center of the circle.
	13	Notun Bazar	18k030m	1.12 km	Station location as close as possible to MRT line 1. Considering the connection with MRT line 1 East side of MRT line 1. Considering the accessibility to market.
Elevated	14	Vatara	19k475m	1.445 km	Transition section before station location is determined by the position of transition section.

Source: JICA Study Team

3.3.6 Schematic Proposed Alignment (Plan, Longitudinal) and Track Layout

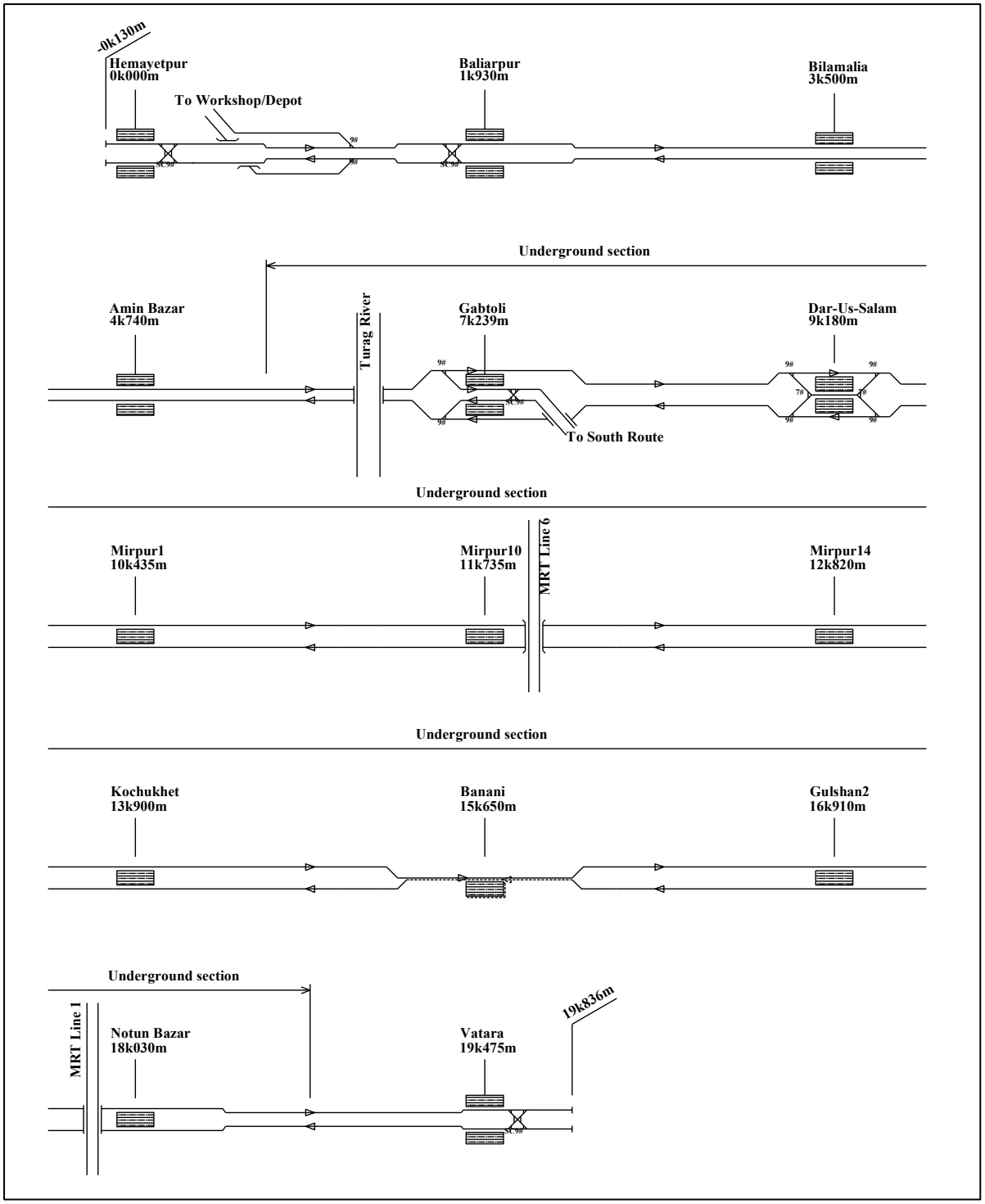
Basically, the station layout is 2 separate platforms serving 2 tracks for the elevated station, and 1 island platform serving 2 tracks for the underground station. However, the following stations will have some exceptions.

- Gabtoli station is a junction station of North Route and South Route of MRT Line 5 and it is an underground station of 2 island platforms serving 4 tracks. Station layout is “same direction operation on one platform” considering the transfer convenience of passengers. Therefore, the north route of up line and the south route are grade separated after station.
- Because Dar-us-Salam station is located near the center of the route of MRT Line 5 and the road width is wide, the track layout of 2 island platforms serving 3 tracks underground station with common passing siding is selected. By providing common passing siding, it is possible to perform turn-back operation in emergency such as stabling of broken car or accident.
- Since the road width is narrow at Banani station, the track layout is 1 platform serving 1 track, vertically arranged parallel with up and down line, in order to reduce the width of the station structure.

Also, at the terminal station Hemayetpur Station and Vatara Station, the scissors crossing for turn-back operation is installed. Hemayetpur station has a future plan for westbound extension, and at the time of extension, the turn-back operation at this station disappears and the scissors crossing is removed. And, in order to locate the station as far as possible to the west side, scissors crossing is set in front of station. On the other hand, since there is no extension plan at Vatara station in near future, turn-back operation will be carried out at Vatara station. Therefore, considering passenger convenience, scissors crossing is inserted behind the station, and the turn-back track for 1 train length is set behind the station.

In addition, the scissors crossing is inserted into the south route of Gabtoli station assuming turn-back operation.

The branch line to the depot will be set between Hemayetpur station and Baliarpur station. Considering the operation from Hemayetpur station to depot via Baliarpur station, scissors crossing for turn-back operation is inserted before Baliarpur station.



Source: JICA Study Team

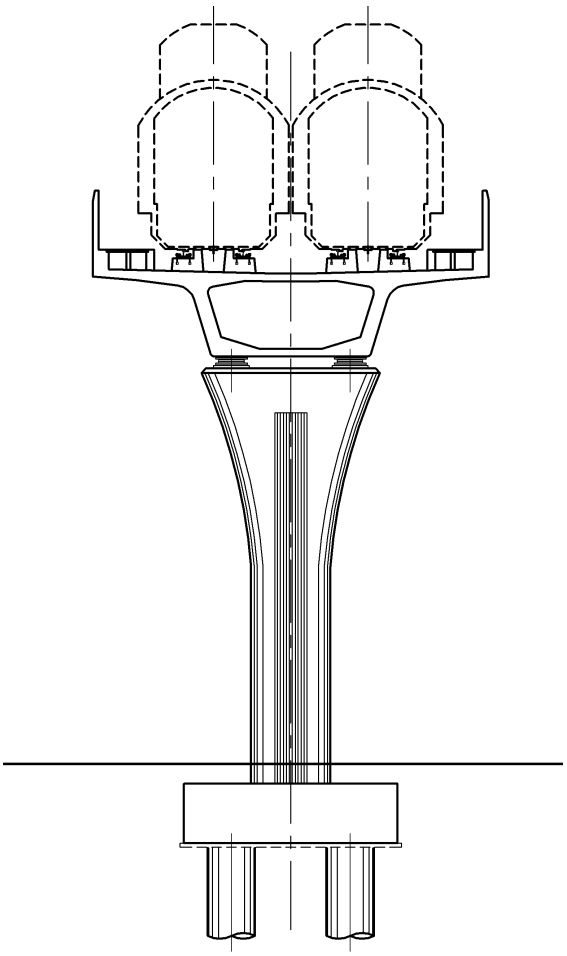
Figure 3-14: Track Layout of MRT Line 5

3.3.7 Civil Structure

3.3.7.1 Elevated Section Structures

1. Selection of Substructure

Substructure type is selected as RC pier with single column as following **Figure 3-15**. Based on the geotechnical survey, pile foundation is the most suitable considering that bearing layer is located at 40 m depth from the existing ground level. And pile diameter is applied as 1.2 m to 1.5 m, and the number of piles shall be as less as possible (that is, four numbers).



Source：JICA Study Team

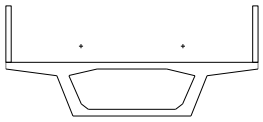
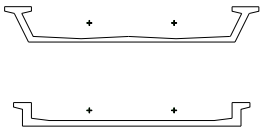
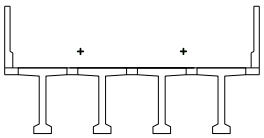
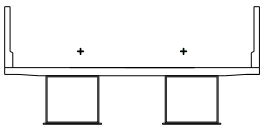
Figure 3-15: Standard Cross Section of Pier

2. Selection of Superstructure

Superstructure type is selected as PC Box girder considering structural performance, economy and workability. The standard span of superstructure is considered as 30 m, same as used in MRT Line 6. Other spans are also applied according to circumstances related to surrounding road and intersections. However, maximum span is 45 m considering workability. Comparison table for superstructure is shown in following.

Superstructure is pre-cast segmental structure with erection girder method.

Table 3-5: Comparison Table for Superstructure

	Section	Structural	Economy	Workability	Characteristic
PC Box Girder		○	○	○	✓ Curve span can be applied ✓ Economical ✓ Road occupation during construction is minimized ✓ Construction duration is minimized ✓ Easy erection of precast blocks
PC U Girder		Δ	Δ	○	✓ Study for deflection of slab is necessary ✓ Not economical ✓ Road occupation during construction is minimized ✓ Construction duration is minimized ✓ Easy erection of precast blocks
PC I Girder		Δ	○	Δ	✓ Curve span cannot be applied ✓ Economical ✓ Work space under girder is required for erection by truck. ✓ Form work and concrete work are required for cross beam and slab
Steel Box Girder		Δ	×	Δ	✓ Concerning for corrosion ✓ Not economical ✓ Work space under girder is required for erection by truck. ✓ Form work and concrete work are required for cross beam and slab

Source: JICA Study Team

Cable ducts (both sides), noise barrier wall, drainage (center of the girder) are installed on the girder surface of the superstructure in addition to the track structure. Formation width is 10 m for both curve span and straight span.

Noise barrier wall of 1.5 m height from rail level is installed in both edge of girder. Noise barrier wall is made by precast concrete, and it is connected by anchor rebar with girder. By adopting the precast structure, it is easy to control the quality, and it is possible to unify the appearance, and construction period can be minimized.

Source: JICA Study Team

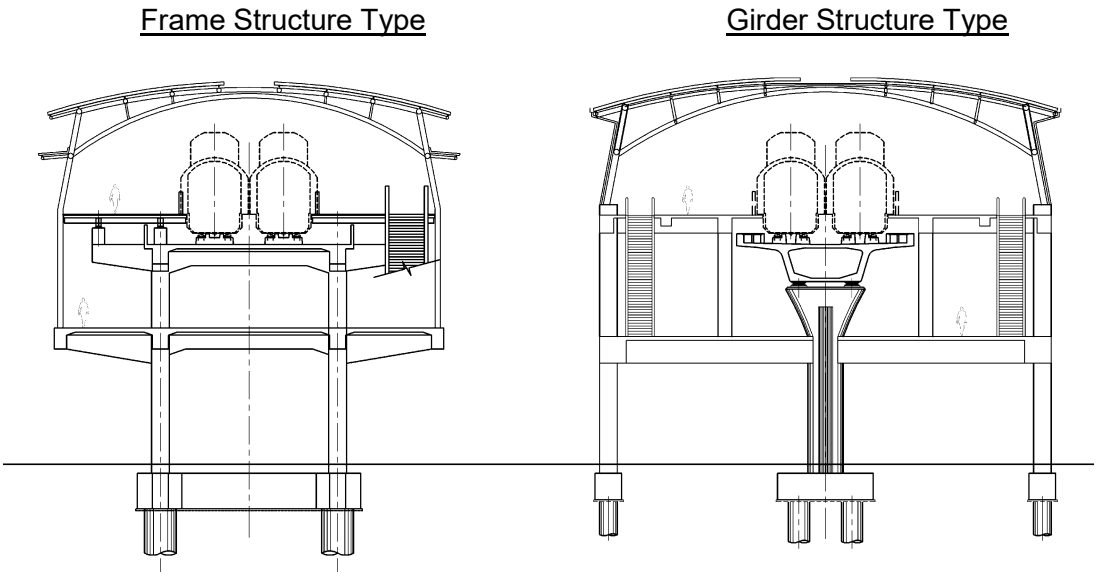
Figure 3-16: Precast Noise Barrier

3. Selection of Elevated Station Structure

Generally, the elevated station structure type can be divided into a frame structure type and a girder structure type, but application is decided according to the situation under the station and construction conditions.

For the western section (Hemayetpur station – Amin Bazar station), the station is built at one side of the current road, and no road is located under the station. For that reason, frame structure is adopted since it is economical.

On the other hand, eastern section (Vatara station) is constructed at the center of road, similar to MRT Line 6. For this reason, main substructure is constructed on road divider, and adopted girder type structure which overhangs the concourse.



(Western Section: Hemayetpur station to Amin Bazar station) (Eastern Section: Vatara station)

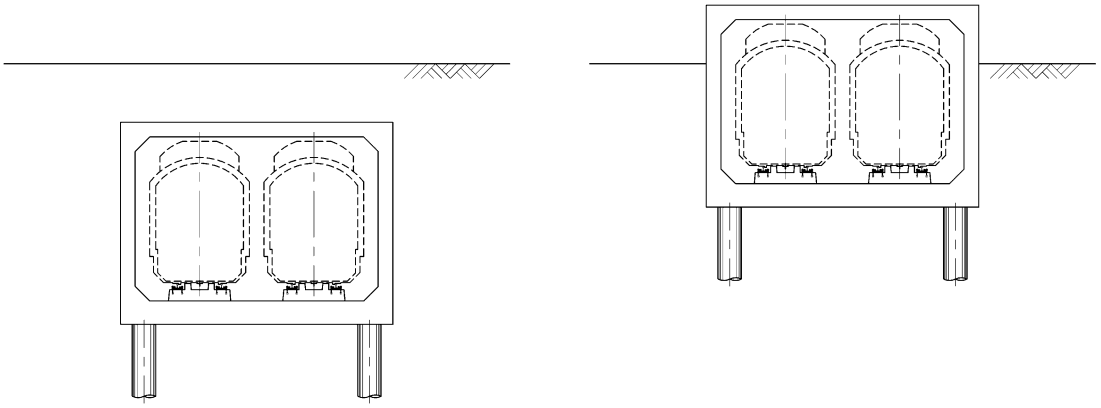
Source: JICA Study Team

Figure 3-17: Cross Section of Elevated Station

4. Transition Section Structure

The transitional section from the elevated section to the underground section is composed of a box culvert and a U-shaped retaining wall.

a) Box Culvert (Cut and Cover) Section



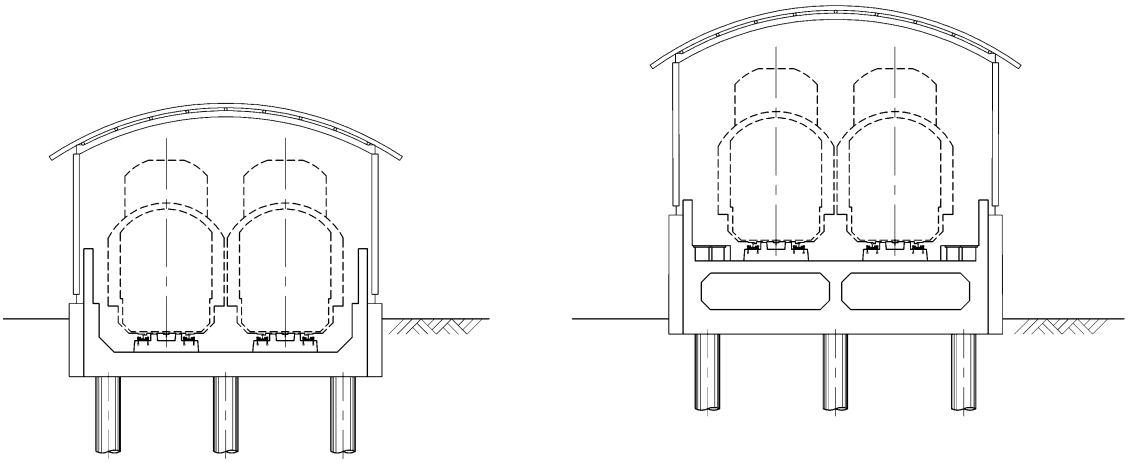
(Underground Section) (Half Underground Section)

Source: JICA Study Team

Figure 3-18: Cross Section of Box Culvert

Box culvert structure is adopted from end of shield tunnel. The box culvert section is applied until height of edge of top slab is maximum flood level plus 300 mm (margin).

b) U Shape Retaining Wall and Half Underground Retaining Wall Section



(U Shape Retaining Wall Section) (Half Underground Retaining Wall Section)

Source: JICA Study Team

Figure 3-19: Cross Section of Retaining Wall

Since the top part of U shape retaining wall is opened, a roof is provided to prevent rainwater entering inside of tunnel. It is applied to section until distance is 4 m from rail level to ground level. After this section, normal viaduct section is adopted.

c) Flood Measures

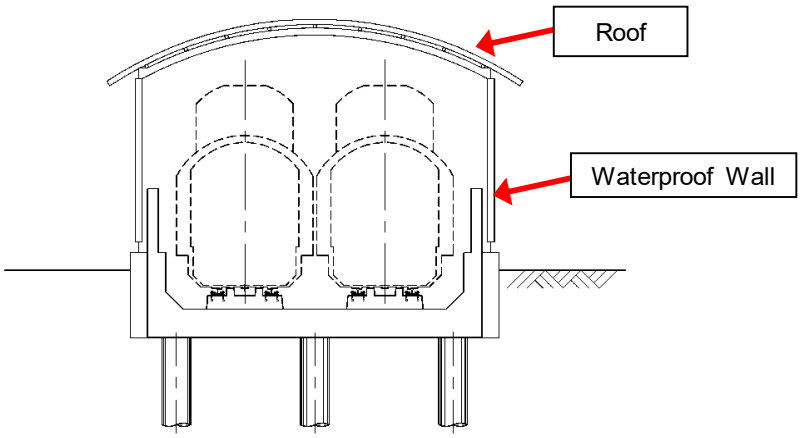
The transition section has a possibility to cause inundation damage to underground tunnels and underground stations. Therefore, it is necessary to take appropriate flood control measures during floods and torrential rains.

Countermeasures against flooding are the following items.

- Provision of waterproof wall considering the flood level against 100-year probability rainfall
- Provision of roof
- Provision of waterproof door at entrance of tunnel
- Provision of drain pump

(Waterproof Wall)

(Waterprrof Door at Entrance)



Source: JICA Study Team based on Tokyo Metro

Figure 3-20: Flood Measures in Transition Section

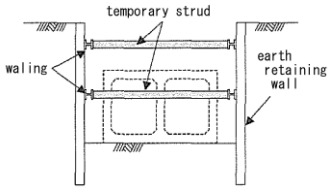
3.3.7.2 Underground Section Structure

1. Tunnel Plan

1) Tunneling Methods

Various methods can be applied for tunnel construction under roads in the urban area, namely, shield tunneling method, cut and cover method and mountain tunneling method. These methods are studied for this project. **Table 3-6** shows the summary of each tunneling method and the applicability of the methods to Line 5.

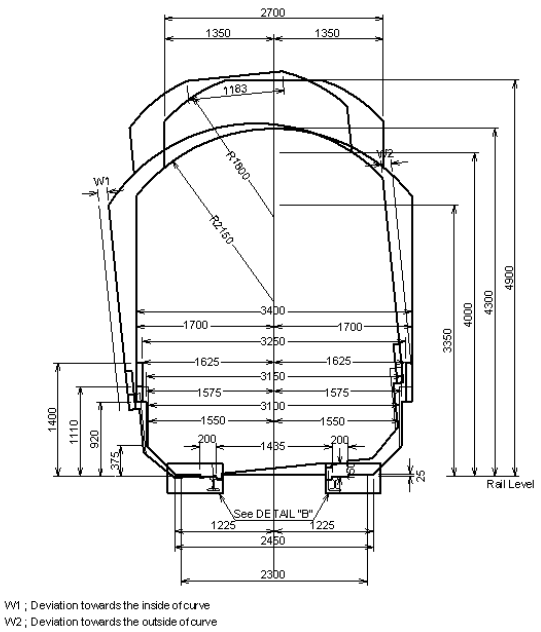
Table 3-6: Comparison of Tunneling Methods

	Shield Tunneling	Cut and Cover Method	Mountain Tunneling Method
Summary	Shield machine is driving while securing the stabilization of the face against earth and water pressure with muddy soil or slurry. Segments are assembled to retain the ground and the tunnel is constructed.	The ground is excavated from the surface to the predetermined depth and then the structures are constructed. The ground on top of the structures is backfilled to recover the surface.	The excavation is proceeded by effectively utilizing arch action of the ground around the excavation area while securing the stability of the ground with shotcrete, rock bolts, steel support and so on.
Schematic view			
Applicable Soil	Generally, this method can be applied to the soil conditions from very soft alluvium to diluvium and soft rock. It is relatively easy to adopt to the change of soil condition.	Earth retaining method and auxiliary method are adopted in accordance with specific soil condition.	Generally, this method is adopted for soft rock and hard rock.
Adaptability to Line 5	This method is suitable for the existing soil conditions and the impact on the current traffic can be minimized.	The planned route for construction is located under the heavy-trafficked roads and the impact on the current traffic is very large. It is not realistic to adopt this method.	This method can't be adapted since the soil is alluvium and the excavation ground cannot be stabilized.
Judgment	○ (good)	× (not good)	× (not good)

Source: JICA Study Team

2) Construction Gauge for Vehicle

The inner diameter of the tunnel shall be determined based on the construction gauge shown below.

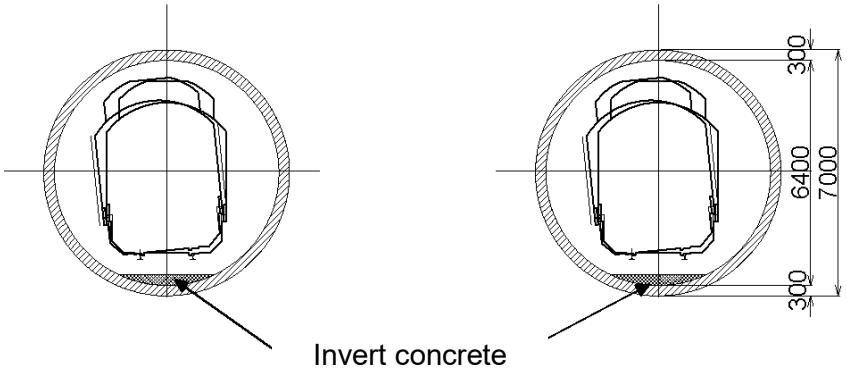


Source: JICA Study Team

Figure 3-21: Construction Gauge for Vehicle

3) Type of Tunnels

Type of tunnels is categorized into single-track cross-section and double-track cross-section. In this project, single-track cross-section shall be applied.



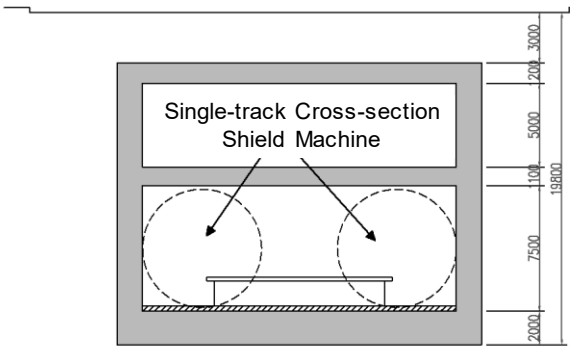
Source: JICA Study Team

Figure 3-22: Single-track Cross Section

① Shape of the stations

The tunnel is constructed by reaching the shield machine to the station after the construction of the station framework. The machine is transported to the other side of the station and the machine re-starts tunnel construction. As a result, the shape of the station is large in case of the double-track cross-section tunnel since the height of inner space through which the shield machine is transported must be secured on the platform floor. The type of the station for each cross-section is shown in Figure 3-23.

【 Type of the Station for Single-Track



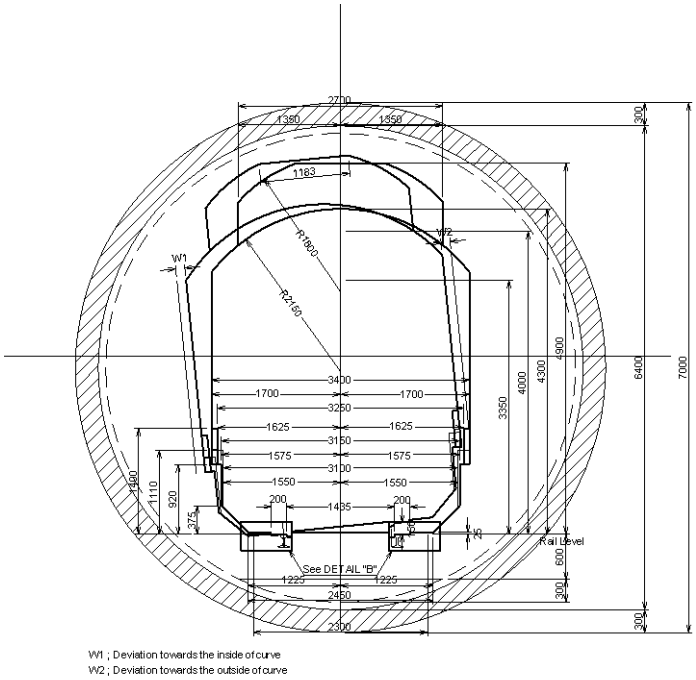
Source: JICA Study Team

Figure 3-23: Cross Section of Station Box for Single-track Tunnels

4) Tunnel Cross-section

a) Inner Diameter Cross-section

Inner Diameter of the tunnel is determined by securing the construction gauge for vehicles and the space to install facilities including the space for maintenance corridor and by considering the construction errors. Since MRT Line 5 runs under a quiet residential area in Cantonment District, anti-vibration track will be applied and 600 mm between RL and FL (Formation Level) and 300 mm from the FL to the bottom surface are secured. In addition, the inner diameter of the tunnel is φ6400 mm considering the construction gauge for vehicles and 100 mm of construction error. These numbers are not fixed yet as the location of facilities inside the tunnel not determined in details at this point of the study. In the detailed design, the scale and the location of the facilities inside the tunnel as well as the tunnel cross-section shall be reviewed.



Source: JICA Study Team

Figure 3-24: Cross-section of Tunnel

b) Segments

Types of Segments are categorized into RC segment, Composite segment, Cast iron segment and Steel Segment and each segment has different characteristics. Since there are no special parts, such as heavily loaded part or sharp curve part, for the tunnel of MRT Line 5, RC segment will be applied, which is most economical.

Table 3-7: Comparison of Tunnel Segments by Type

Type	Characteristics
RC Segment	Highly Economical. Possible to handle various load conditions by adjusting the volume of reinforcing bars. Commonly adopted as the segment for the standard part.
Composite Segment	Used partially at places where the thickness of the segment has limitation and the heavy load is expected; the type of segment is highly rigid and the thickness of the lining can be thinner.
Cast Iron Segment	Used partially at places where the strong bearing force is required, such as at heavily loaded part or sharp curve part, since the segment is highly rigid.
Steel Segment	Used at the sharp curve or at where the segment is cut open and the welding is required, since it is highly rigid and welding is possible.

Source: JICA Study Team

c) Thickness of the segment

It is desired to make the thickness of RC segment larger than 4% of the tunnel outer diameter based on the performance proven in the past, and the thickness is determined based on this. Therefore,

$$t = (6400 + 2t) \times 0.04 \Rightarrow t = 280 \text{ mm}$$

The segment thickness is rounded up to 300 mm considering safety factor.

5) Type and method of Shield Machine

There are two types of shield machines; one is closed type shield and the other is open type shield. The open type shield can be used in the condition where there is no water in the ground and the face can be independently stable. However, although there is no water in the ground, the soil for MRT Line 5 is relatively soft according to the results of Geotechnical Investigation (N value of 20~30) and it is difficult for the face to be independently stable. Therefore, in this study, closed type machines like Earth Pressure Balanced (hereinafter: EPB) shield machine and Slurry Shield machine are to be considered.

a) Selection of Shield Machine Type

Earth Pressure Shield Machine is to be applied for MRT Line 5 due to the following reasons:

- Currently, there is no water at the depth of the ground planned for tunnelling. Slurry shield machine, which stabilizes the face using the slurry pressure, can lose balance of the face largely because of missing water. Losing balance of the face could lead to catastrophes such as settlement of the ground, cutting the underground installation for life lines and making the surrounding building tilt.
- The tunnel for MRT Line 5 will be constructed under the major congested road and it is difficult to acquire the site for launching the shield machine along the road. Therefore, it

is necessary to plan the launching site in suburb and driving the machine to the center of the city. This means that it can be assumed that the excavation distance per shield machine will be over 6km. Under this condition, if the excavated soil is transported using the fluid transporting pump in case of slurry shield machine, it increases the risk of clogging the discharge pipe and it is difficult to detect the location of clogging as the pipe is extended over long distance. Once the pipe is clogged, the excavation might have to stop for a long time and that could cause extension of the construction period.

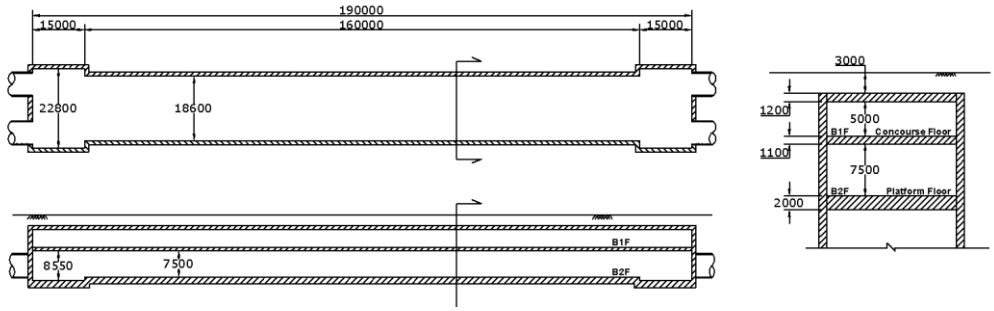
- Excavation using slurry shield machine requires slurry treatment facility and the facility must be imported from outside of the country. Therefore, the cost of transportation will be higher than that of Earth Pressure Shield machine.

2. Station Structure Planning

1) Study on Station Structure

Structure of an underground station is basically to be determined based on the tunnel longitudinal alignment planned considering control points on the planned route. At the station where there are no control points on the longitudinal alignment, the underground station structure is to be determined considering the conditions such as the station structure and facility locations.

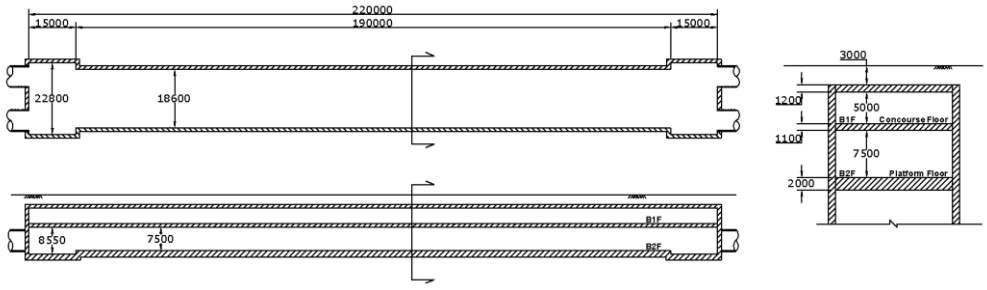
The ideal structure of the station is two-story station with Concourse floor and Platform floor, which has the minimum length of the station determined based on the length of the platform (Refer to Figure 3-25). However, since this structure cannot secure the required floor area as number of mechanical equipment to be installed in the underground station is large.



Source: JICA Study Team

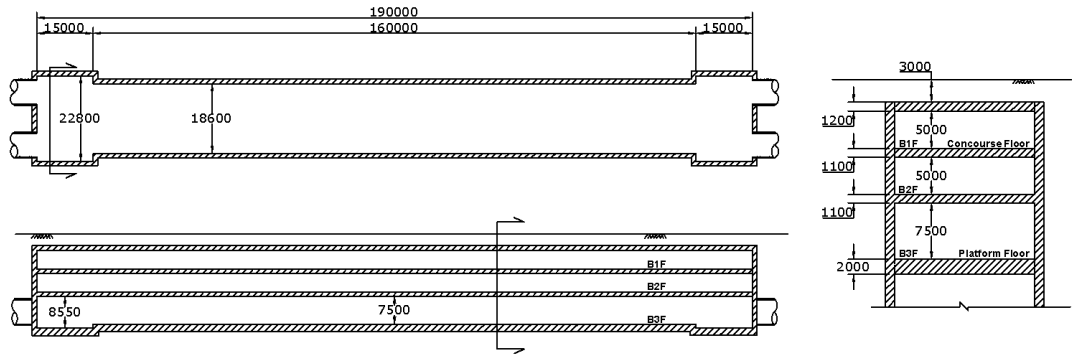
Figure 3-25: Ideal Shape of a Station (Two-story Structure L=190 m)

Therefore, to secure the required floor area, either two-story with longer station structure as shown in Figure 3-26 or three-story with extra floor as shown in Figure 3-27 shall be selected.



Source: JICA Study Team

Figure 3-26: Structure of a Station (Two-story Structure L=220 m)



Source: JICA Study Team

Figure 3-27: Shape of a Station (Three-story Structure L=190 m)

Table 3-8: Number of Floors for Each Station and its Reasons

No	Station	No. of Floor	Rationales
1	Gabtoli	3	The tunnel is planned to run under nearby Turag River and the depth of the tunnel is large if more than 1.5D of overburden from the river bed has to be secured. Therefore, this station is three-story structure in accordance with the longitudinal alignment.
2	Dar-us-Salam	2	It is planned to have two platforms and three tracks including a passing track at this station, and cross over road on both sides of the tracks will be installed. (Refer 4.1.6) Because of this, plane shape of the station will be large in the direction of the track and width. Therefore, even though it is two-story station, sufficient space for mechanical equipment can be secured. In addition, since there is not control points nearby this station, two-story structure is applied for this station.
3	Mirpur 1	2	Even if the station is extended for 15 m on both side of the station, two-story structure can be applied to this station. Therefore, considering convenience of passengers, two-story structure is applied to this station.
4	Mirpur 10	3	This station is the connecting station with MRT Line 6. Distance between platforms in the horizontal direction should be short considering the transfer. It is considered that two-story structure cannot be applied since the distance in the horizontal direction is long because of the mechanical equipment on both end of the station. Therefore, the three-story structure is applied to this station.
5	Mirpur 14	2	Even if the station is extended for 15 m on both side of the station, two-story structure can be applied to this station. Therefore, considering convenience of passengers, two-story structure is applied to this station.
6	Kochukhet	2	Even if the station is extended for 15 m on both side of the station, two-story structure can be applied to this station. Therefore, considering convenience of

No	Station	No. of Floor	Rationales
			passengers, two-story structure is applied to this station.
7	Banani	4	The location of this station is deepened as the tunnel runs under the foundation piles below the residential area of Cantonment. In addition, the road at where the station is located is narrow and if two tunnels are running in vertical parallel, the station should be of four-story (B3F and B4F are platform floors) structure.
8	Gulshan 2	3	The tunnel runs under Banani Lake and Gulshan Lake which are located on the both end of this station. Because of these lakes, the location of the station is deep in underground and three-story structure is applied for this station.
9	Notun Bazar	3	Right before connecting to this station, the tunnel runs under the two-story station for MRT Line 1. Therefore, the three-story structure is applied to this station.

Source: JICA Study Team

3.3.8 Station Architectural Design

1. Condition of Station Planning

Passenger stations are planned considering demand forecast, car numbers, alignment, civil structure, mechanical and electrical facilities, O&M planning, city planning and intermodal access.

2. Station Size

Station size is basically defined according to the following criteria.

- Concourse floor length is designed in consideration of accumulated dimension of minimum concourse length + station office + E/M rooms + station and tunnel ventilation rooms.
- Platform length is designed in consideration of number of future train sets (8 cars) +5m clear spaces at both ends of the platform.
- Platform width is an accumulation of minimum stairway width + Escalator + wall + reasonable width between stairway walls to Platform Screen Door (hereinafter: PSD) (Minimum 1.5m)

Station size such as platforms, concourse, stairs, and ticket gate numbers are basically defined to keep passengers' safety, comfort and serviceability at peak hour. In MRT Line 5, PSD are planned to be installed in every station.

3. Ticket Gates and Security Check Gates Planning

There are four main access routes from the street level to the B1 concourse level designated at both sides of public area (layout is shown in section 4.2.4 8). There are two ticket gates at both sides of paid concourse which is located at center of the station. In addition to normal ticket gates, security check gates will be installed at entrance. Entrance and exit are clearly separated. Number of ticket gates will be calculated based on demand forecast, and it shall be later verified by final demand forecast for each station. In this study, width of ticket gates is planned based on MRT 6 station plan.

Security check gate has to have area of 2.5 m×3.5 m, to arrange check gate itself plus security staff table, baggage check table. Basically 2 check gates should be provided at each entrance. There should be wide space not only in front of ticket gates, but also at security check gates as queueing in front of check gates are expected.

4. Station Office and Ticket Selling

Station office area is planned based on MRT Line 6 station plan. There are control room, station office, station master room, security guards room, maintenance room, staff mess, prayer room, first aid room, staff toilet, and storage etc.

Size of the area is estimated to be 450 m2 including corridors.

5. Public Toilet

Passenger toilet shall be provided in paid concourse in every station. Men's toilet, Women's toilet and multipurpose toilet for physically challenged person will be provided.

6. Elevators and Escalators

Escalators shall be provided in every station from the ground level to the concourse level, one at the north side and another one at the south side of the street. At least one set of up-down escalators shall be provided from concourse level to platform level.

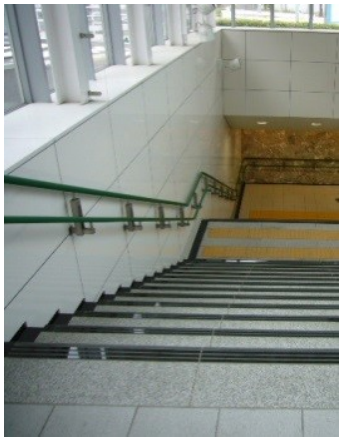
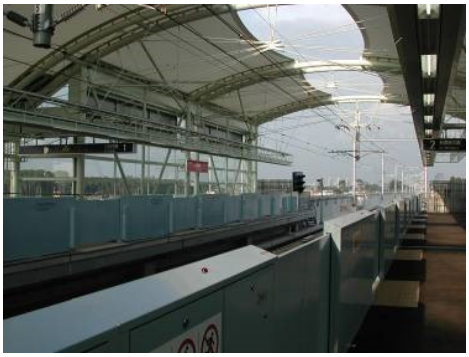
At least one elevator shall be provided from ground level to concourse level and concourse level to platform level for physically challenged person.

As above mentioned is a basic policy, for stations with large numbers of passengers and for transfer stations, more escalators and elevators will be provided. Number of escalators and elevators will be determined by the passenger demand.

7. Barrier Free/ Universal Design

Stations, as part of public transportation system, need to be more disabled- friendly by means of installing facilities that will provide easier access to passengers with physical and visual disabilities. Disable friendly design shall basically be performed in accordance with Bangladesh code; and the design can be further improved by applying advanced design concept, referring "Barrier free guideline (Passenger facilities edition)" by Ministry of Land, Infrastructure, Transportation, and Tourism of Japan. Related features are shown in figure below.

	
Automatic Escalator 3 Flat Steps	Guiding/ Warning Blocks

	
2 Levels Handrail	See-Through Elevator
	
Platform Screen Door	Low Counter at Ticket Gate
	
2 Levels Bench	Multi-Purpose Toilet

Source: JICA Study Team

Figure 3-28: Barrier Free Design Features

3.3.9 Train Operation Plan

3.3.9.1 Train Operation Policy

The route characteristics of MRT Line 5 is that there are many transit stations with under construction and planned MRT, BRT and BR lines. Table 3-9 shows the number of daily passenger and transit passenger of MRT Line 5. More than forty percent passengers are transit passenger in 2028 and 2035. Therefore, it is very important to consider the transit passengers for train operation.

Table 3-9: The Number of Daily Passenger and Transit Passenger

Transit stations	2028			2035		
	Daily passenger (person)	Transit passenger (person)	Transit passenger ratio (%)	Daily passenger (person)	Transit passenger (person)	Transit passenger ratio (%)
Natun Bazar station (MRT Line 1)	186,000	101,300	54%	171,000	92,400	54%
Gabtoli station (MRT Line 2)	-	-		221,000	97,300	44%
Mirpur10station (MRT Line 6)	206,000	98,200	47%	206,000	104,200	51%

Source: JICA Study Team

3.3.9.2 Passenger Demand and Transport Capacity

Traffic demand forecast is updated in the Study based on the RSTP analysis. OD table of the target study area in RSTP is created in 2025 and 2035 and MRT passenger demand was forecast. MRT Line 5 is plan to open in 2028 and OD table in 2028 has not been created, therefore the demand in 2028 is estimated by increasing the trend between 2025 and 2035.

Passenger demand in 2058 is also necessary because the project life of MRT Line 5 is 30 years. Therefore, it is assumed that annual growth rate is 1 % from 2035 to 2058. Total daily board and alight passengers in 2028, 2035 and 2058 are summarized in Table 3-10.

Table 3-10: The Number of Passengers of MRT Line 5

Station		2028				2035				2058			
		Boading	Alighting	Westbound	Eastbound	Boading	Alighting	Westbound	Eastbound	Boading	Alighting	Westbound	Eastbound
N1	Hemayetpur	206,000	201,000			199,000	203,000			243000	248000		
				201,000	206,000			203,000	199,000			243000	243000
N2	Baliarpur	25,000	24,000			31,000	67,000			38000	82000		
				216,000	221,000			235,000	193,000			287000	235000
N3	Modhumoti	22,000	22,000			76,000	20,000			93000	24000		
				230,000	236,000			196,000	21,000			239000	256000
N4	Amin Bazar	48,000	46,000			28,000	20,000			34000	24000		
				231,000	239,000			195,000	216,000			238000	264000
N5	Gabtoli	74,000	93,000			281,000	304,000			343000	371000		
				191,000	180,000			221,000	220,000			270000	268000
N6	Dar-us-Salam	27,000	30,000			51,000	47,000			62000	57000		
				208,000	195,000			136,000	125,000			166000	153000
N7	Mirpur1	73,000	64,000			91,000	83,000			111000	101000		
				226,000	222,000			195,000	193,000			238000	235000
N8	Mirpur10	206,000	163,000			163,000	149,000			199000	182000		
				222,000	262,000			206,000	219,000			251000	267000
N9	Mirpur14	10,000	9,000			11,000	14,000			13000	17000		
				226,000	266,000			207,000	218,000			253000	266000
N10	Kochukhet	1,000	1,000			21,000	33,000			26000	40000		
				226,000	266,000			195,000	193,000			238000	235000
N11	Banani	52,000	82,000			52,000	62,000			63000	76000		
				216,000	226,000			206,000	194,000			251000	237000
N12	Gulshan2	85,000	94,000			67,000	66,000			82000	81000		
				215,000	216,000			220,000	209,000			268000	255000
N13	Notun Bazar	186,000	203,000			171,000	150,000			209000	183000		
				214,000	199,000			201,000	211,000			245000	257000
N14	Vatara	214,000	199,000			141,000	153,000			172000	187000		
								137,000	137,000			167000	167000
E4	E4					141,000	153,000			172000	187000		
								137,000	137,000			167000	167000
E3	E3					18,000	18,000			22000	22000		
								124,000	124,000			151000	151000
E2	E2					35,000	36,000			43000	44000		
								124,000	123,000			151000	150000
E1	E1					124,000	123,000			151000	150000		

Source： JICA Study Team

3.3.9.3 Transport Capacity in a Train Set

An end car and a middle car have a different capacity according to the rolling stock plan. Passenger capacity of congestion ratio 100% is as follows;

- An end car: 153 passengers
- A middle car: 165 passengers

The transport capacity of each train set and congestion ratio in a train set is summarized in Table 3-11. Although transport capacity is increased, if the congestion ratio is accepted up to 180%, operation headway is to set for approx. congestion ratio of 150% to follow the operation policy.

Table 3-11: Transport Capacity of Train Sets for different Congestion Ratios

	Congestion ratio		
	100%	150%	180%
4-car	636	954	1,144
6-car	960	1,449	1,738
8-car	1,296	1,944	2,332
Unit: Person		Source: JICA Study Team	

3.3.9.4 Operation Headway

Table 3-12 summarizes the PHPDT and its section calculated in Table 3-13). Peak time is considered during 8:00 – 9:00 for all years and lines.

Table 3-12: PHPDT and Its Section

Year	PHPDT	Section
2025	27,930	Mirpur14 station – Kochukhet station
2035 North line	28,600	Gabtoli Station -Dar-us-Salam Station
2035 South line	28,730	S2 Station -S3 Station
2055 North line	34,840	Gabtoli Station -Dar-us-Salam Station
2055 South line	35,100	S2 Station -S3 Station

Source: JICA Study Team

Operation headway shall be determined based on the transport capacity mentioned inTable 3-11 in order to carry all the passengers. Transportation capacity per hour is summarized in Table 3-13 by operation headway and congestion ratio.

Table 3-13: Hourly Transport Capacity among Congestion, Train Set and Headway

Headway (min)	100%			150%			180%		
	4-car	6-car	8-car	4-car	6-car	8-car	4-car	6-car	8-car
5.0	7,632	11,592	15,552	11,448	17,388	23,328	13,737	20,865	27,993
4.5	8,268	12,558	16,848	12,402	18,837	25,272	14,882	22,604	30,326
4.0	9,540	14,490	19,440	14,310	21,735	29,160	17,172	26,082	34,992
3.5	10,812	16,422	22,032	16,218	24,633	33,048	19,461	29,559	39,657
3.0	12,720	19,320	25,920	19,080	28,980	38,880	22,896	34,776	46,656
2.5	15,264	23,184	31,104	22,896	34,776	46,656	27,475	41,731	55,987

Unit: Person

Source: JICA Study Team

The congestion ratio will 180% to meet the PHPDT demand by 4-car train set in 2028. On the other hand, 3 min. operation can be realized by 6-car train set and 4 min. operation can be realized by 8-car in a train set.

3 min. 30 sec. headway operation is required for 6-car train set and its congestion ratio will be 161%. It is mostly acceptable for passenger comfortability, although the congestion ratio slightly higher than the train operation policy set.

Comfortability can be increased by operating more frequently, however initial cost will be high because the required number of rolling stock is increased accordingly. Considering the operation headway, comfortability and initial cost, train operation in 2028 shall be 3 min. 30 sec. headway by 6-car train.

It is possible to operate 3 min. headway by 6-car train set to carry PHPDT in 2035 with same strategy of 2028.

It is not possible to carry PHPDT in 2058 by 6 car train set even in 2 min. 30 sec. headway, thus it is planned to operate in 3 min. headway by 8-car train set in 2058. Train operation headway in 2058 is same as that of 2035 because demand is estimated by annual growth rate and it is possible to carry all passenger by 8-car train set. Another 2-car train set shall

be procured in 2038 according to the analysis of annual growth rate from 2035 to 2058.

3.3.9.5 Travel Time

Travel time is calculated by considering 1) Rolling stock specification, 2) Speed limit, 3) Stopping time at station and 4) Turnback time of terminal stations. Operation simulation is done by these conditions.

As the result of operation simulation considering the abovementioned condition in the feasibility study report, total operation time for one-way trip takes 32 min. 30 sec. Scheduled speed is calculated as 41 km/h since total length is 22.2 km.

3.3.9.6 Required Number of Rolling Stock

Required number of rolling stock is calculated by operation headway and scheduled speed as summarized in Table 3-14. A total of 30 train sets of 6-car in 2028, 42 train sets of 6-car in 2035 and 42 train sets of 8-car in 2058 are required to deal with the passenger demand. Extra 3 train sets as spare are included in each of those target years.

In addition, it shall be considered to stable MRT Line 5 south line rolling stock also at depot. Required number of rolling stock of MRT Line 5 south line is also calculated preliminary by the route length and scheduled speed of MRT Line 5 north line.

Table 3-14: Required Number of Rolling Stock in each Year

	2028	2035		2058	
	Phase1	Phase1+ Extension (east side)	Extension (South line)	Phase1+ Extension (east side)	Extension (South line)
PHPDT	26,460	28,600	28,730	34,840	35,100
Length (km)	22.2	28.6	17.3	28.6	17.3
Train set (car)	6	6	6	8	8
Headway	3min. 30sec.	3min. 0sec.	3min. 0sec.	3min. 0sec.	3min. 0sec.
Required No. of train set	27	39	25	39	25
Spare	3	3	1	3	1
Total No. of train set (train set)	30	42	26	42	26
Total No. of cars (car)	180	252	156	336	208

Source: JICA Study Team

3.3.10 Rolling Stock

As MRT is a high-speed public transportation system transporting many passengers, safety assurance is essential. The equipment and facilities of rolling stock with high reliability are required to prevent the train derailment and collision accidents. Rolling stock should be safe, comfortable and long-life system to transport the passengers on Dhaka MRT system throughout the specified design life.

A six-car train will be manufactured to meet the initial traffic forecast demand for Line 6 of the Dhaka Mass Rapid Transit System. This train will be easily expanded to an eight car train when the traffic demand calls for the additional capacity. The specifications of the rolling stock of MRT line 5 shall transform the existing systems to an architecture that is common with Dhaka Line 6 as much as possible. Rolling Stock Specification has shown in the following **Table 3-15**.

Table 3-15: Rolling Stock Specifications

Item	Description	Specification
Line Profile	Truck Gauge	1,435mm
	Minimum curve radius on a main track	160 m
	Steepest gradient in a running area of Rolling Stock	35/1000
	Design speed	110 km/h
	Maximum train operating speed At the elevated section and At the underground section	 100 km/h 90km/h
	The train loading for civil structure	16 tons/Axle
Car body dimension	Body Length of Middle car	19,500 mm
	Body Length of End car	19,800 mm
	Body Width	2,950 mm
	Body roof Height above Rail Level	3,650 mm
	Air-conditioner height above Rail Level	4,100 mm
	Floor height (above rail level)	1,150 mm
	Maximum Gap between Platform edge and Car body entrance floor	70 mm
	Longitudinal compressive load at coupling point	490kN (50t)
	Car body material	Stainless steel or aluminium alloy
Setting Arrangement	Longitudinal	-
Passenger Comfort	Passenger entrance doors	
	Number of Passenger Doors per Car Side	4
	Width of Passenger Door	1,300 mm

Item	Description	Specification
	Height of Passenger Door	1,850 mm
	Gangways	
	Gangway size between coaches	Appr. 900 mm width
	Gangway size at the end of the Tc cars	Appr. 650 mm width
	Dropping Window	
	Full opening area	1350 mm
	Passenger seats	Longitudinal 3 seats and 7 seats
	Dimension	430 mm width and 550 mm depth
Bogie	Gauge	1,435 mm
	Distance between two bogies	13,800 mm
	Bogie wheel Base	2,100 mm
	Wheel Diameter	860 mm (New), 780 mm (Fully Worn)
Formation	Beginning (6-car)	Tc - M - T- M - M - Tc
	Future (8-car)	Tc - M - T - M- T- M - M – Tc
Passenger Capacity (Pax = passengers)	End car	153 Pax
	Middle car	165 Pax
	6 car formation 3M3T seated with 160% congestion rate	1546 Pax
	8 car formation 4M4T seated with 160% congestion rate	2074 Pax
Train Performance	Acceleration	0.92 m/s2
	Deceleration (Service Brake)	0.97 m/s2
	Deceleration (Emergency Brake)	>1.25 m/s
Catenary Voltage (VDC)	Rated	1,500 V
	Range	900 – 1,800 V
Pantograph	Single Arm raised by Spring and lowered by Air	
	Rated Current (Approximate)	1,500 A
	Working range at elevated section	4300 mm to 5200 mm
	Working range at underground section	4300 mm to 4900 mm
Power	Peak per Train (Approximate)	6.0 MW

Item	Description	Specification
Requirements	Average per Train (Approximate)	4.2 MW
Maximum Current	-	4000 Amp
Traction Motor	3-Phase Induction Motor 140 – 200 KW (Estimated)	-
	Maximum Rated Voltage	1,100 V
	Battery Charging Circuit	110 VDC
Lighting	Level in Saloon	>200 Lux
	Level in Driving Cab	>100 Lux
Air Conditioning	Self-Contained Package Type	-
	Saloon Interior Temperature	24˚C
	Saloon Interior Relative Humidity	60%
Ventilation	Fan Capacity	13m^3 /min
Air Compressor	Three phase 380 VAC motor driven unit	-
	Capacity (estimated)	2,000 liters/min
Train Information System	On Board Information for the Train Driver and On-Board diagnostics for Maintenance	-

Source: JICA Study Team

3.3.11 Depot

3.3.11.1 Depot location

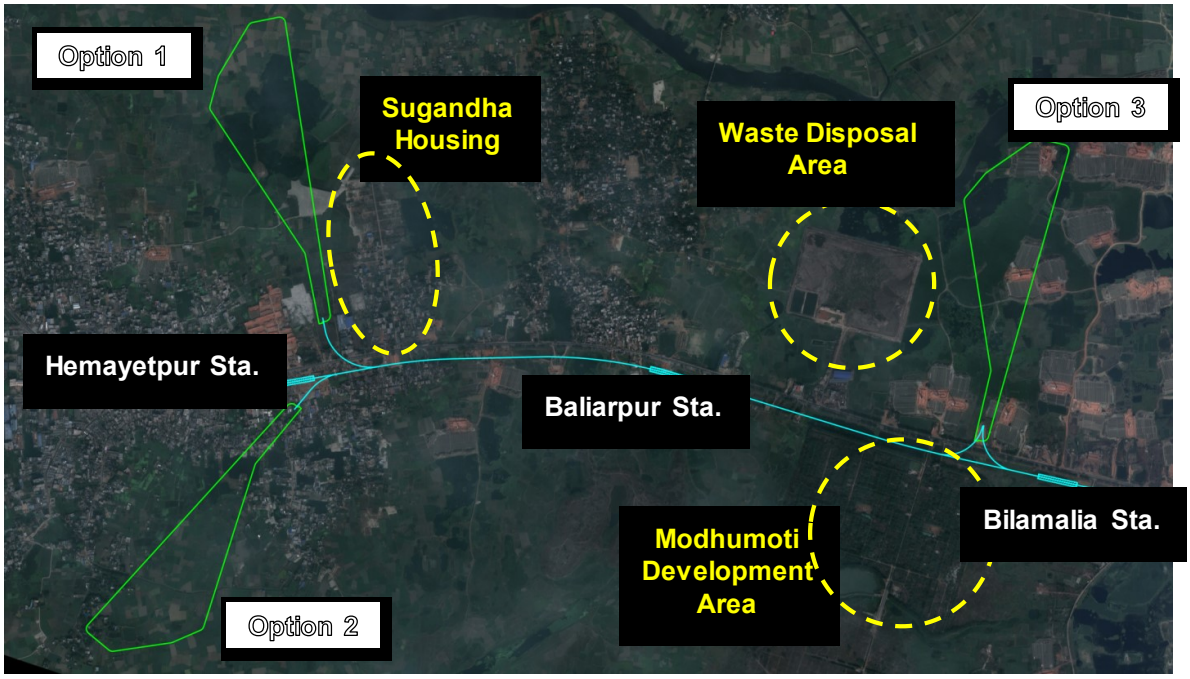
Primarily the proposed depot of MRT line 5 has been selected in the North side of Hemayetpur station. Three candidate depot locations were selected between Hemayetpur and Gabtoli in RSTP Supplement Study for MRT Line 5. The locations are shown in Figure 3-29. As a viewpoint of resettlement, flood damage and land use, Option 1 was selected as the best option. Candidate sites overview and evaluation is shown in Table 3-16.

Table 3-16: Selection of Candidate Depot Location

	Option 1	Option 2	Option 3
Location	North side of Hemayetpur station	South side of Hemayetpur station	West side of Bilamalia station
Overview	This option has an advantage to connect the approach line to Hemayetpur station. Embankment will be required because ground level is approx. 5 m lower at 200 m far area from the road.	This option has an advantage to connect the approach line to Hemayetpur station. However, housing will be obstacle because approach line crosses the housing.	Approach line diverts from the main line at 250 m far from Bilamalia station. Embankment and soil improvement with remove of soft Alluvium will be required because depot area is low ground.
RAJIK Land	Partially within	Growth management	Completely within

	Option 1	Option 2	Option 3
Use Plan (2015)	conservation area	area	conservation area
Flood damage	Flood impact is less, possible to get approval	No flood impact	Flood impact is high, difficult to get approval
Condition as of May 2016 (The beginning of Monsoon)	No water	Not confirmed	Totally flooded
Condition as of April 2017*	No water. It is vacant area but brick is stacked.	There are housings along the road. Not confirmed behind the road.	Totally flooded
Land ownership	Individual with one large owner (7 ha)	Individual ownership	Individual ownership
Current land use	Vacant site and farm land	Farm land and housing	Vacant area, farm land and wet land
Resettlement	No	Yes	No
Evaluation	Good	Fair	Not recommended

Source: JICA Study Team based on RSTP Supplemental Study for MRT Line 5



Source: JICA Study Team

Figure 3-29: Alternative location of Depot for MRT line 5

Among the three alternative locations of depot, the feasibility study team decided to establish the vehicle depot at the location of option-1 considering the less inhabitants, flood damage and land use compare to the option 2 and 3.

3.3.11.2 Capacity

The number of train set for MRT Line 5 is shown in Table 3-17.

Table 3-17: The Number of Train Set

		2028	2035	2058
North line	6-car train set	30 train set	42 train set	
	8-car train set			42 train set
South line	6-car train set		26 train set	
	8-car train set			26 train set
Total	6-car train set	30 train set	68 train set	
	8-car train set			68 train set

Source: JICA Study team

Depot size is planned to stable 68 train sets of 8-car based on the train operation plan.

3.3.11.3 Methodology of Rolling Stock Inspection Plan

The size of inspection facility and the number of inspection track are determined by the type of rolling stock inspection and its cycle.

The rolling stock inspection of MRT Line 5 can follow the MRT Line 6 method. However, MRT Line 6 is now under construction stage, so the climate condition, working environment, inspection type and its cycle in line with technician skill has not been confirmed yet.

Because of this, rolling stock inspection of Delhi Metro in India is referred as precedent of MRT project in South Asia in this study.

Table 3-18 is the excerpt of the report of the Sub-Committee on Operation and Maintenance System for Metro Railways organized by Government of India Ministry of Urban Development.

Table 3-18: Maintenance Schedule for Rolling Stock adopted at DMRC

				Manpower Required for 4 Car Train		
Sl.	Activity	Interval		Downtime	Required Manpower	Required Man-Hour
1	Daily Check	-		30 minutes	02	01
2	A Service Check	5,000km,	(15days)	02 hours	04	08
3	B1 Service Check	15,000km,	(45days)	08 hours	07	56
4	B2 Service Check	30,000km,	(90days)	08 hours	07	56
5	B4 Service Check	60,000km,	(180days)	08 hours	12	96
6	B8 Service Check	120,000km,	(360days)	16 hours	13	208
7	B16 Service Check	240,000km,	(720days)	16 hours	13	208
8	C1 Overhaul	420,000km,	(3.5years)	-	-	3065
9	C2 Overhaul	840,000km,	(7.0years)	-	-	7910

				Manpower Required for 4 Car Train		
Sl.	Activity	Interval		Downtime	Required Manpower	Required Man-Hour
10	C3 Overhaul	1,560,000 km,	(10.5years)	-	-	
11	C5 Overhaul	2,250,000 km,	(15years)	-	-	
12	Daily Internal Cleaning (turn-around in platform)	Every turn around		Activity not performed		
13	Daily Internal Cleaning (Stabling Yard)	Daily		1	1	1
14	Internal light Cleaning	Weekly		-	-	-
15	Monthly Heavy Cleaning (Exterior & Interior + Roof)	Monthly		6	8	48
16	External Washing (Window cleaning)	Daily (Automatic Train Wash Plant)		2	2	4
17	Pest and Rodent Control	Bi-monthly		01 hours	02	02
18	Air dust cleaning	Half yearly		-	-	-

Source: Report of the Sub-Committee on Operations and Maintenance Systems for Metro Railways (Government of India Ministry of Urban Development, November 2013)

Based on the above condition, the number of inspection of MRT Line 5 depot is calculated. Prerequisites are as follows;

- Future stabling number of rolling stock is 68 train sets of 8-car
- Operation hour is 8 hours per day
- Manpower is doubled because above mentioned example is for 4-car train set, but MRT Line 5 will have 8-car train set.

Table 3-19: Calculation of the Required Number of Inspection Line of MRT Line 5

S/No	Activity	Interval	Category	Location	Number of required tracks
1	Daily Check	Daily	Start-up test	Stabling yard	For 68 trains
2	A Service Check	15 days	Light Inspection	Light maintenance tracks	Required time:1 day/train Number of required tracks: (68-3)x(1/15) =5 tracks
3	B1 Service Check	45 days			
4	B2 Service Check	90 days			
5	B4 Service Check	180 days			Required time: 2 day/train Number of required tracks: (68-2) x (2/180) =1 track
6	B8 Service Check	360 days			
7	B16 Service Check	720 days			
8	C1 Overhaul	3.5 years	Overhaul	Heavy maintenance tracks	Require time:1 month/train Number of required tracks: 68 trains/42 months =2 tracks
9	C2 Overhaul	7.0 years			
10	C3 Overhaul	10.5 years			
11	C5 Overhaul	15 years			
12	Daily Internal Cleaning	n/a	n/a	Turn back station	
13	Daily Internal Cleaning	Daily	Light Cleaning	Stabling yard	For 68 trains

S/No	Activity	Interval	Category	Location	Number of required tracks
14	Internal light Cleaning	Weekly			
15	Monthly Heavy Cleaning	Monthly	Heavy Cleaning	Train wash line	Require time: 1 day/train Number of required tracks: (68-2) / 30 = 3 tracks (1 AWP)
16	External Washing	Daily	Automatic wash plant (AWP)		
17	Pest and Rodent Control	Bi-monthly	Included in A Service Check		
18	Air dust cleaning	Half yearly	Included in B4 Service Check		

Source: JICA Study team

Depot facility of MRT Line 5 is summarized in Table 3-20 based on the above calculation result.

Table 3-20: Depot Facilities of MRT Line 5

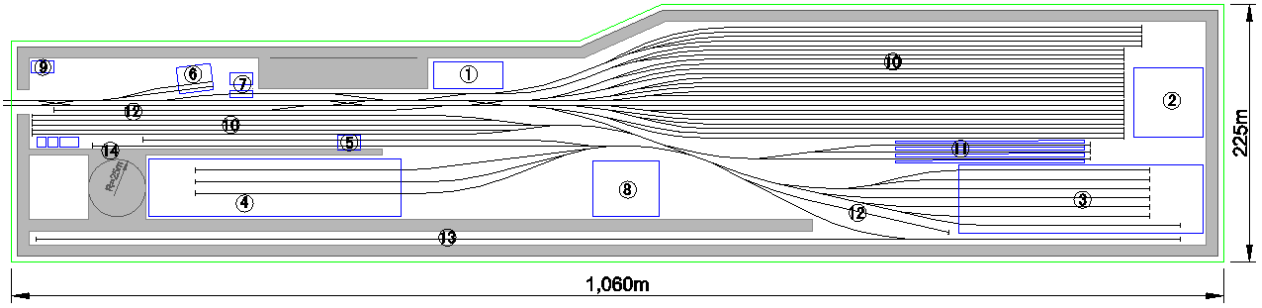
	Track Name	No. of lines	Description
1	Light Maintenance Track	6 lines	It is located at Light Maintenance Area at workshop
2	Heavy Maintenance Track	3 lines	It is located at Heavy Maintenance Area at workshop. In addition to two lines for overhaul, another line is installed for unscheduled maintenance and failure inspection.
3	Train wash track	3 lines	Three lines are located for hand wash. An automatic train wash plant is installed at the easy wash area for rolling stock entrance.
4	Air blowing track	1 line	It is located at Light Maintenance Area at workshop. Blow down plant is installed.
5	Wheel lathe track	2 lines	Wheel lathe track has a building for under floor wheel lathe. Overhead catenary is not installed at one of two tracks. It is for unloading dock of rolling stock.
6	Test track	1 line	Test track is a straight line of 1 km long.
7	Stabling track for maintenance vehicle		Maintenance vehicle is installed. Shed is equipped.
8	Stabling track		8 train sets out of total 68 train sets are stabled on the Light Maintenance track, Heavy Maintenance track, train wash track, air blow track and wheel lathe track. Stabling track is installed for stabling the remaining 60 train sets.

Source: JICA Study team

3.3.11.4 Layout

Stabling track secures two columns in series of 8-car train set per track. Depot height is raised by 3 m from ground level to prevent the flood and the ground surface shall be flat without any slope.

5 m width space is secured for slope protection at the outer road. As a result, the size of the depot is calculated as 1,060 m long, 225 m width and 22 Ha. Depot layout on embankment is shown in Figure 3-30.



①	Administration Building	⑧	Warehouse
②	Traction Substation	⑨	Guard house
③	Light Maintenance shop	⑩	Stabling yard
④	Workshop (Heavy maintenance)	⑪	Hand wash line
⑤	Under floor wheel lathe	⑫	Shunting track
⑥	Maintenance Vehicle shed	⑬	Test Track (L=1,000m)
⑦	Train wash plant	⑭	Train Delivery Area

Source: JICA Study Team

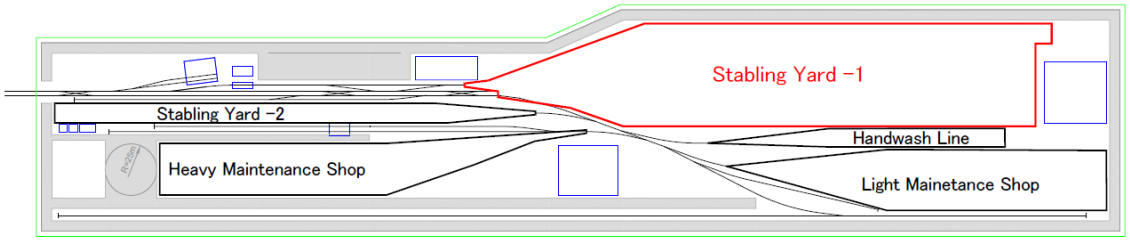
Figure 3-30: Depot Layout of Embankment

3.3.11.5 Structure Type

There are several examples to utilize the upper/ over or under space of depot for property development and/or public space such as a park by constructing a viaduct or underground depot. Issues and evaluation of three-dimensional usage for MRT Line 5 depot are described below.

1) General Conditions

- 22 Ha land is necessary to construct the stabling facility, inspection facility and other related facilities by embankment structure.
- As a viewpoint of the depot function, it is desirable to stable on the same flat ground plane. If depot is three-dimension structure, slope/ ramp is to be installed to adjust the differences of the level. In such case, movement distance is much longer and movement speed is slower, thus work efficiency will be low.
- Considerable three-dimension structures for depot are 1) Embankment only, 2) Underground only, 3) Embankment + Utilization of Overhead and 4) Viaduct + Utilization of Underneath of viaduct area. Land size of 22 Ha is minimum area for embankment depot and required area will be increased depending on the structure type. Total underground structure, total viaduct structure or artificial ground are not realistic due to the extremely high cost, thus only 4.7 Ha stabling yard is considered for alternate analysis in the study. This portion can stable the 50 train sets of 8-car in 25 lines.



Source: JICA Study Team

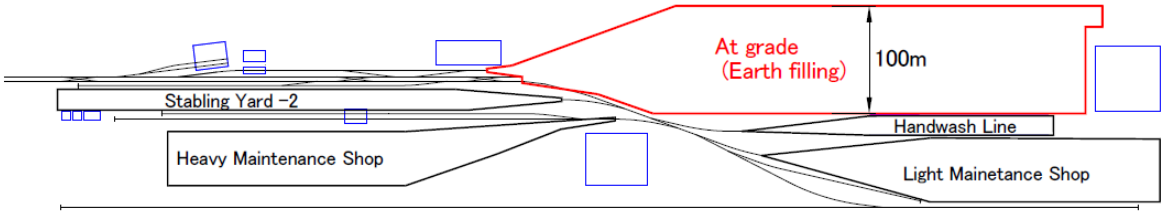
Figure 3-31: Stabling Yard

- In the case of 2) underground only and 3) Embankment + Utilization of Overhead, width of stabling yard becomes 15 m ~ 20m wider than 1) Embankment case because piers which support the artificial ground has to be built.

2) Analysis of Stabling Yard based on Structure Type

a) Embankment Structure

This is the best option of all four cases from viewpoint of train cleaning, stabling, efficiency of inspection and workability because depot is located at level. Required area is the minimum in all four cases.



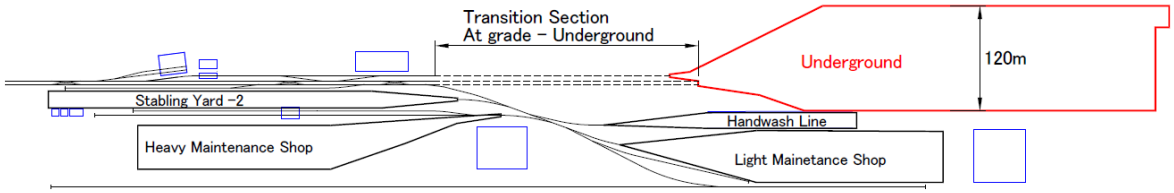
Source: JICA Study Team

Figure 3-32: Embankment Structure

b) Underground Structure

Overhead area of the artificial ground can be utilized for parking lot, park and housing by covering the underground stabling yard by artificial ground. It is necessary to install the transition section of 300 m to the underground stabling yard. The width of underground stabling yard is 15 m ~ 20 m wider than that of embankment one. As a viewpoint of the operation, although it has an advantage because trains can be protected from the sunlight, wind and rain, operation cost will be high because the light is always on and mechanical ventilation is required.

The most concerning issue is flooding. Entrance of the rain water to the stabling yard must be protected and pump shall be installed at the proper place.



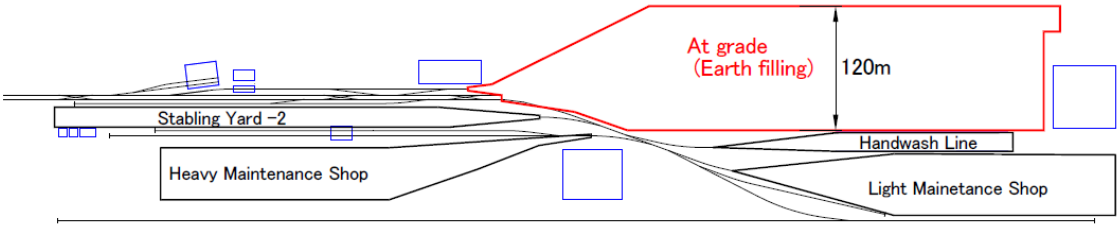
Source: JICA Study Team

Figure 3-33: Underground Structure

c) Embankment + Utilization of Overhead

Basically, depot is embankment structure built at same level and a part of the stabling yard is covered with a roof and by the artificial ground to utilize the overhead area. Width of the stabling yard of this type is 15 m ~ 20 m wider than embankment type.

As a viewpoint of the operation, although it has advantage because trains can be protected from the sunlight, wind and rain, operation cost will be high because the light is always on and mechanical ventilation is required.



Source: JICA Study Team

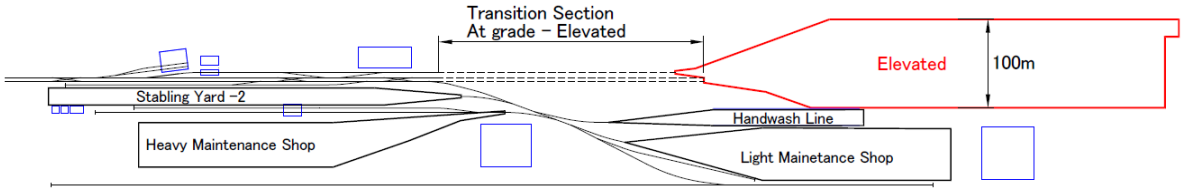
Figure 3-34: Embankment + Utilization of the Overhead Structure

d) Viaduct + Utilization of Underneath of Viaduct area

Stabling yard is constructed over a viaduct and space under the viaduct is utilized for any purpose. It is necessary to install the transition section of 300 m to the viaduct stabling yard.

The length of the stabling yard is same as embankment structure. The available space of approx. 6 m height and 4.7 Ha between the ground level of the embankment of depot and the roof is utilized for parking lot, for example.

As a viewpoint of the operation, compare to the embankment structure, it has the disadvantage that maintenance staff and driver has to access the viaduct structure.



Source: JICA Study Team

Figure 3-35: Viaduct + Utilization of the Underneath Structure

3) Evaluation

Embankment structure is the best option because of the functionality of depot. Next recommendation option is embankment + Utilization of Overhead because of the minimum revision of the layout from the embankment structure.

Underground structure is not recommended because of the high initial and O&M cost and the risk of flood. In addition, development advantage of viaduct + Utilization of Underneath Viaduct option is limited to parking lot usage.

Under above consideration, Embankment structure or Embankment + Utilization of Overhead structure is recommended.

Table 3-21: Comparison among Structures Type

	Embankment (Typical)	Underground	Embankment + Utilization of Overhead	Viaduct + Utilization of Underneath Viaduct
Construction cost	Fair	Highest	High	High
Operation cost of depot	Fair	Highest	A bit High	A bit High

	Embankment (Typical)	Underground	Embankment + Utilization of Overhead	Viaduct + Utilization of Underneath Viaduct
Functionality as depot	Fair	Less	A bit Less	Less
Potential of Property Development	N/A	Better	Better	Partially
Evaluation	Best	Fair	Better	Fair

Source: JICA Study Team

3.4 Project Activities

The MRT line 5 will be constructed in three phase's e.g. Pre-construction, Construction and operation phase. The major activities involving in these phases are listed below:

Pre-construction Phase

- Selection of final route alignment.
- Planning and Utility Diversion specially in the open cut area and viaduct section if there any utility line
- Land acquisition for the depot area as well as road side area where underground station will be constructed by open cut method
- Preparation of construction site

Construction Phase

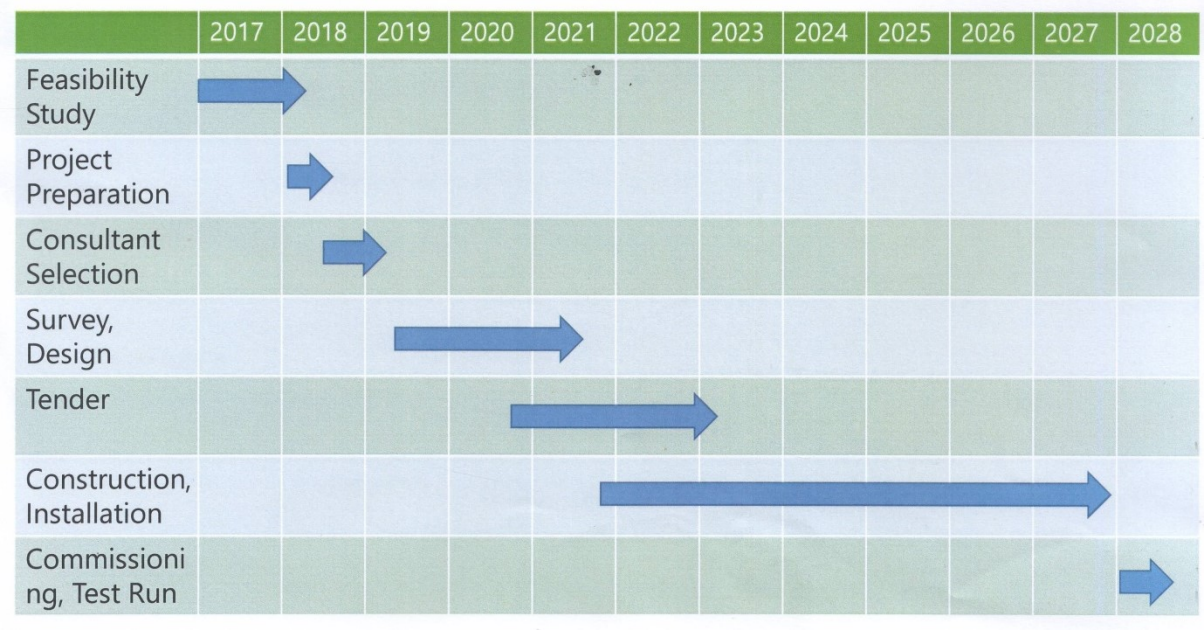
- Depot construction
- Tunneling after Aminbazar station to Natun Bazar Station
- Elevated line construction from Hemayetpur to Amin Bazar Station and after the Natun Bazar to Vatara Station
- Station Construction (9 underground stations construction by open cut method and 5 elevated station construction
- Manufacturing of girder for elevated section and RC segment for underground tunnel in the construction yard

Operation Phase

- Test run of the MRT line 5
- Commercial operation
- Maintenance of the station
- Washing and repairing of the train in the depot
- Automatic ticketing system maintenance
- Maintenance the continuous power supply system
- Implement the environmental management plan

3.5 Project Schedule

It has been expected that construction of the MRT line 5 will be started from end of 2021 and completed end of 2027. The MRT line 5 will start commercial operation by July 2028. The following **Figure 3-36** shows the tentative schedule of the MRT line 5.



Source: JICA Study Team

Figure 3-36: Time Schedule of MRT Line 5

3.6 Resources and Utilities Demand

The project needs to acquire 26.85 hectare of private land, mainly for the depot area. Electricity requirement during operation stage has been estimated as 219,508MWh/year in 2028. Others resources and utility demand has not been estimated in present stage. Details will be estimated during the operation stage.

3.6.1 Raw Material Requirement

Huge quantity of cement, aggregate, iron bar, ballast, wood will be required during the construction stage. The quantity of raw materials will be estimated during the detail design stage.

3.7 Cost Estimation

The grand total project cost has been estimated 299 billion BDT.

3.8 Alternative Analysis

3.8.1 No Action Option

No action plan is a case that MRT Line 5 is not implemented, In DMA, chronic traffic congestion has become significant problem. Expected population increase and economic growth will cause expansion of traffic congestion, deterioration of environment and economic loss.

In case that MRT Line1 and Line5 are not implemented, no land acquisition and involuntary resettlement are expected. However sustainable growth of local industry will be hampered. The environment of the area will deteriorate further by the traffic congestion and air pollution.

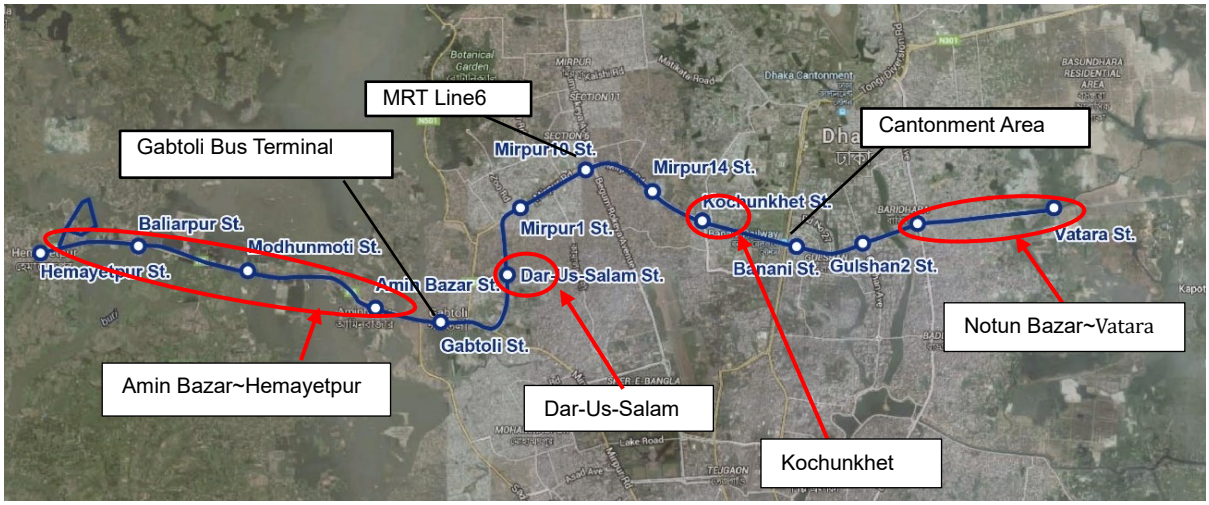
3.8.2 Comparison of Structure Types

The study team studied following three structures which have different underground sections. (See Figure 3-38)

(1) Section between Kochunkhet and Notun Bazar
(2) Section between Dar-Us-Salam and Notun Bazar
(3) Section between Gabtoli and Notun Bazar

Since the project is a railway which passes through the urban area of Dhaka city, major criteria are avoidance or minimization of living environment of local resident, pollution control and social environment including land acquisition and involuntary resettlement.

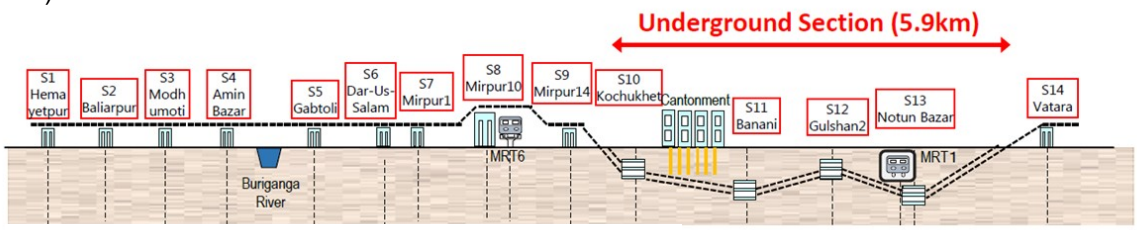
Long viaduct options cause significant land acquisition, involuntary resettlement and landscape because length of viaduct section in the centre of the city is longer. (3) option is superior to the other options on the air pollution, noise and vibration. Although (3) occurs most excavation soil than the other options, (3) option can minimize negative impacts to the environment and health. Therefore (3) option is recommended on pollution control. (See Table 3-22)



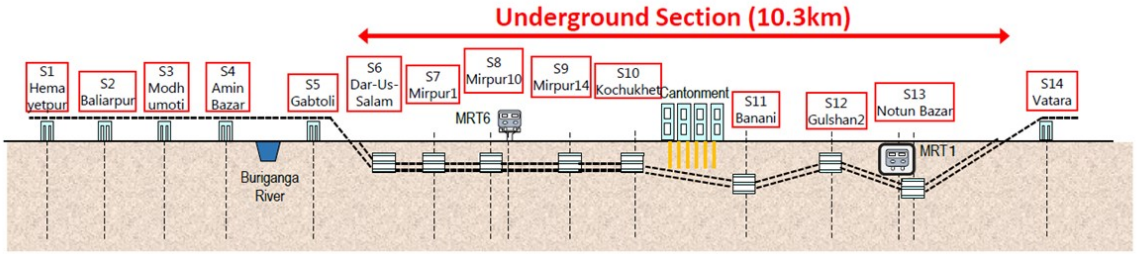
Source: JICA Study Team

Figure 3-37: Location of Underground Section of Alternative Routes

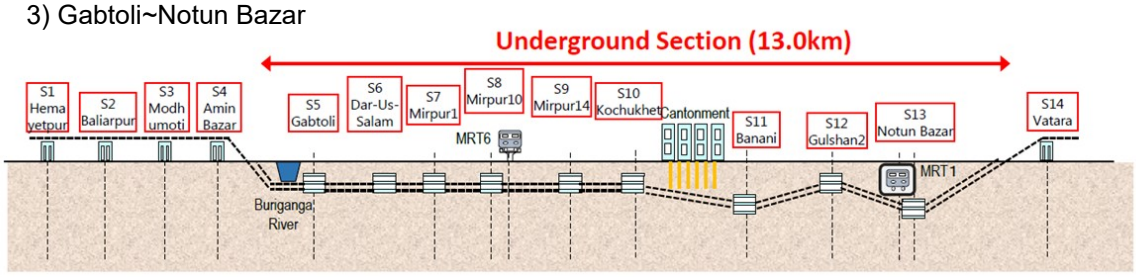
1) Kochunkhet~Notun Bazar



2) Dar-Us-Salam~Notun Bazar



3) Gabtoli~Notun Bazar



Source: JICA Study Team

Figure 3-38: Underground Section of Alternative Route

Table 3-22: Comparisons of Underground Sections of MRT Line 5

Options / Items	1) Section between Kochunkhet and Notun Bazar	2) Section between Dar-Us-Salam and Notun Bazar	3) Section between Gabtoli and Notun Bazar
Construction/Project			
Length	19.7km (Viaduct 13.8km, Underground 5.9km)	19.7km (Viaduct 9.4km, Underground 10.3km)	19.7km (Viaduct 6.7km, Underground 13.0km)
Stations	14 (Viaduct 10, Underground 4)	14 (Viaduct 6, Underground 8)	14 (Viaduct 5, Underground 9)
Construction Cost	280 billion Yen	330 billion Yen	360 billion Yen
Feature of Structure	△: Length of underground section is shortest. The viaduct at the intersection with MRT Line 6 needs high rise structure exceeding 30m.	○: The centre of Dhaka except Gabtoli takes a tunnel structure. Suburb takes a viaduct structure.	◎: The centre of Dhaka takes a tunnel structure. Suburb takes a viaduct structure.
Difficulty of Construction	△: The section of underground needs construction spaces at stations alone. Viaduct section is long and needs a lot of construction	○: The section of underground needs construction spaces at stations alone. Because Gabtoli and the vicinity is crowded, construction of	◎: The section of underground needs construction spaces at stations alone. On the viaduct section, construction spaces are

Options / Items	1) Section between Kochunkhet and Notun Bazar	2) Section between Dar-Us-Salam and Notun Bazar	3) Section between Gabtoli and Notun Bazar
	space.	viaduct is difficult.	kept easily because it is located on suburb.
Traffic	△: During construction, negative impacts to traffic is most because road lanes by viaduct construction are regulated widely.	○: Lane control by construction of viaduct causes traffic congestion around Gabtoli.	◎: Construction of viaduct needs lane control. However, negative impacts to traffic is small because the area of construction is located on suburb.
Damage to the project by inundation	◎: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required. This option has least negative impacts comparing the other options.	○: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required.	○: No inundation on viaduct structures expected. Because there is a possibility of inundation from an entrance and exit, appropriate measures are required.
Liquefaction by earthquake	△: Less damage by liquefaction is expected on underground structures. Liquefaction may damage footings of viaduct installed on long section.	○: Less damage by liquefaction is expected on underground structures. Liquefaction may damage footings of viaduct.	○: Less damage by liquefaction is expected on underground structures. Liquefaction may damage footings of viaduct.
Social Environment			
Land Acquisition and Involuntary Resettlement	△: On the underground section, land acquisition and involuntary resettlement are expected at the entrance and exit of stations and construction site. Moreover, on the centre of Dhaka, land acquisition and involuntary resettlement is expected at stations and viaduct. Therefore negative impacts is most among three options.	◎: On the underground section, land acquisition and involuntary resettlement are expected at the entrance and exit of stations and construction site. Land acquisition on viaduct sections is easy because the area is within ROW of RHD.	◎: On the underground section, land acquisition and involuntary resettlement are expected at the entrance and exit of stations and construction site. Land acquisition on viaduct sections is easy because the area is within ROW of RHD.
Dividing of local community	◎: Underground structure does not divide local communities.	◎: Underground and viaduct structures do not divide local communities.	◎: Underground and viaduct structures do not divide local communities.
Landscape	△: Negative impacts to landscape is most among the options because viaducts are installed on density areas.	◎: There is no impact to landscape because structure in the centre of Dhaka is underground. Although viaduct sections may affect landscape, it	◎: There is no impact to landscape because structure in the centre of Dhaka is underground. Although viaduct sections may affect landscape, it

Options / Items	1) Section between Kochunkhet and Notun Bazar	2) Section between Dar-Us-Salam and Notun Bazar	3) Section between Gabtoli and Notun Bazar
		will be insignificant because the areas are not density areas.	will be insignificant because the areas are not density areas.
Safety	○: Because there is no railroad crossing, traffic accident is not expected. A Fire of a station building is expected.	○: Because there is no railroad crossing, traffic accident is not expected. A seismic disaster of viaduct is expected.	○: Because there is no railroad crossing, traffic accident is not expected. A seismic disaster of viaduct and a fire of a station building are expected.
Pollution Control			
Air Pollution	△: Negative impacts to air pollution is most among three options because construction area is very wide.	◎: Negative impacts to air pollution is less than (1) because viaducts are constructed on suburb.	◎: Negative impacts to air pollution is less than (1) because viaducts are constructed on suburb.
Noise and Vibration	△: Construction noise of stations and viaducts is expected. Negative impacts are wider than the other options. Railway operation causes noise along viaduct sections.	○: Although construction noise of stations and viaducts is expected, negative impacts are small. Although railway operation causes noise along viaduct sections, negative impacts are limited.	○: Although construction noise of stations and viaducts is expected, negative impacts are small. Although railway operation causes noise along viaduct sections, negative impacts are limited.
Groundwater	○: Negative impacts to underground water are expected. However it is expected that negative impacts are small because the length of underground section is shorter than the other options.	△: Negative impacts to underground water are most among three options because the length of underground sections is long.	△: Negative impacts to underground water are significant because the length of underground sections is long.
Waste	◎: Volume of excavation soil is least.	△: Volume of excavation soil is large.	△: Volume of excavation soil is most.
Total Evaluation	△: Construction cost is cheap. Impacts on inundation area is less. On the other hand, negative impacts to resettlement and the environment is large. Traffic condition and Volume of excavation soil is least. Traffic congestion during construction and seismic safety should be considered.	○: This option almost follows (3) option. However congestion around Gabtoli during viaduct construction should be considered.	◎: Underground structure on the centre of Dhaka and viaduct structure on suburb maximise merits, this option is most suitable for the project.

Note ◎: most suitable ○: suitable △: required more considerations; Source: JICA Study Team

3.8.3 Comparisons of Alternative Routes on Cantonment Area

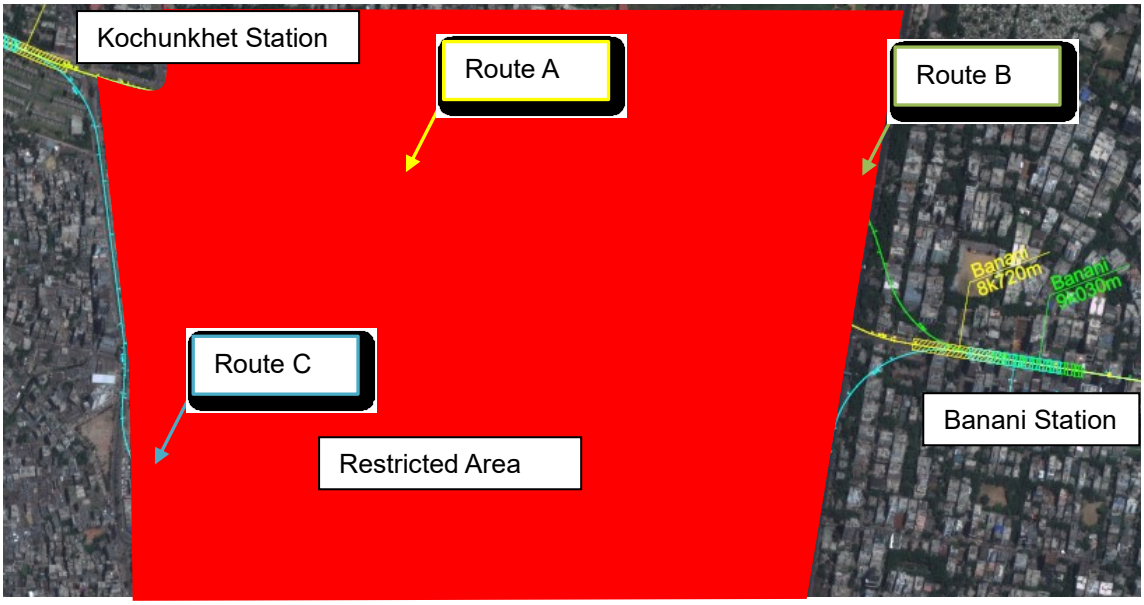
There is a restricted aria (cantonment area) between Banani Station and Kochunkhet Station on the route of MRT Line5. Three route options were examined on this section. The route options include viaduct plan and underground plan.

Route A is the shortest route connecting Banani Station and Kochunkhet Station. The rout e A secures running performance, however, interferes a lot of building in the area. Therefore it is hard to adopt viaduct plan.

Route B which mitigates interference with the buildings comparing the route A has minor curves.

Route C does not interfere with the buildings. However, since the route have more curves than other routes and longer alignment, running performance and comfort is inferior to the other routes.

From stated above, the route B as viaduct plan is recommended because the route B has less interference with the buildings than the other plans and better running performance. The route A as underground plan is recommended because the route A has no interference with the buildings and better running performance. Finally the study team recommended the underground route A considering magnitude of involuntary resettlement.



Source: JICA Study Team

Figure 3-39: Comparisons of Alternative Routes on Cantonment Area

4. ENVIRONMENTAL BASELINE

4.1 Introduction

This section includes the existing environmental baseline status of MRT line 5 Project study area, covering both the natural and social environments. The analysis was completed through the use of a combination of secondary data sources in addition to extensive on-ground reconnaissance and baseline studies to establish an understanding of the environmental and socio-economic baseline of the Project area. The likely impacts on the environment based on the actual and foreseeable events/project activities. Data for this chapter were collected from:

- **Secondary Sources:** This included data from literature reviews, maps and monitoring reports;
- **Primary Sources:** This included gathering information from field surveys, laboratory analysis and public consultations in the project area.

The baseline condition of environmental quality in the locality of project site serves as the basis for identification, prediction and evaluation of impacts. The baseline environmental quality is assessed through field studies within the impact zone for various components of the environment like air, noise, water and socio-economic etc.

Data was collected from secondary sources for the macro-environmental setting like climate (temperature, rainfall and humidity), physiography, geology etc. Firsthand information have been collected to record the micro-environmental features within and adjacent to the project area. Collection of primary information includes extrapolating environmental features on proposed project design, location and measurement of socio-cultural features adjoining proposed project area. Ambient air, noise and water quality samples were collected in terms of environment quality to prepare a baseline database. Consultation was another source of information to explain local environmental conditions, impacts and suggestions etc.

The following section describes the baseline environment into four broad categories:

- **Physical Environment:** Geology and Soil, Topology, Land-use, Meteorology and Hydrology;
- **Biological Environment:** factors related to life such as habitats, aquatic life, fisheries, terrestrial habitats and flora and fauna;
- **Environmental Quality**: Air, Water & Noise Quality; and
- **Socio-economic Environment:** anthropological factors like demography, income and infrastructure.

4.2 Geology and Soil

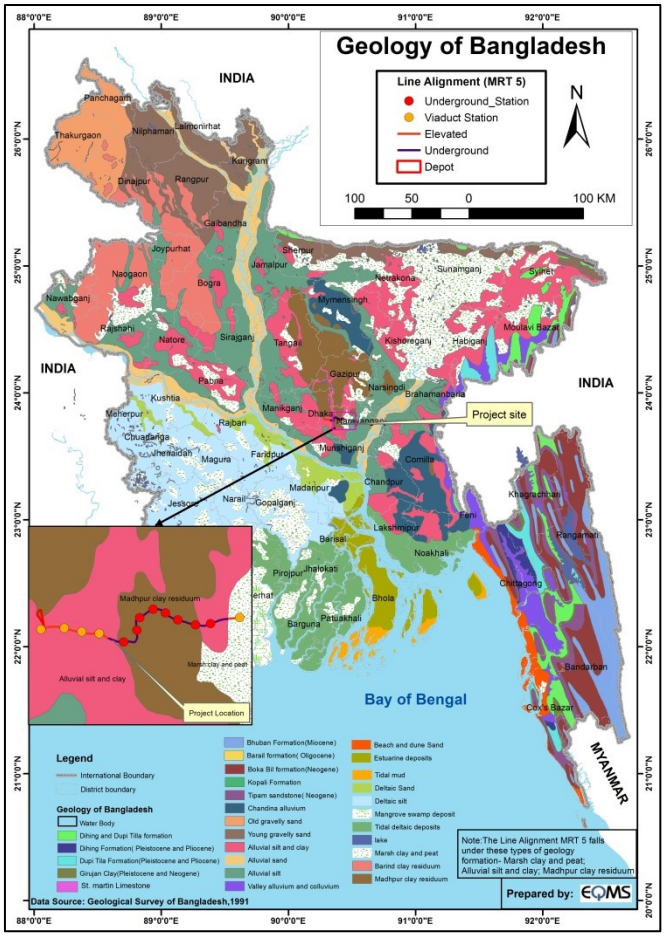
Dhaka lies in the extreme south of the Madhupur Tract, which is situated in the central-eastern part of Bangladesh. The planning area is covered mainly by the Pleistocene Madhupur Clay, a yellowish brown to the highly oxidized reddish brown silty clay; and by Holocene sediments to the south, west and east made up of alluvial silt and clay and marshy clay and peat.

The moisture content and liquid limit results obtained for the Madhupur clay show that it is normally consolidated to slightly over-consolidated, perhaps due to groundwater pumping. The clay has intermediate to high plasticity, and is overlain by the Dupi Tila formation of medium to coarse sand. The incised channels and depressions within the city are floored by

recent alluvial flood plain deposits. Geomorphic units identified by Kamal and Midorikawa (2006) for surface features are given in Table 4-1.

Table 4-1: Geomorphic Units Identified for Dhaka Terrace[1]

Higher Pleistocene Terrace (HPT)	Moderately Higher Pleistocene Terrace (MHPT)
Moderately Erosional Pleistocene Terrace (MEPT)	Highly Erosional Pleistocene Terrace (HEPT)
Erosional Terrace Edge (ETE)	Old Natural Levee (ONL)
Younger Natural Levee (YNL)	Old Inactive Floodplain (OIF)
Point Bar (PB)	Younger Floodplain (YF)
Deep Marshy land (DML)	Shallow Marshy Land (SML)
Deep Alluvial Valley (DAV)	Moderately Deep Alluvial Valley (MDAV)
Shallow Alluvial Valley (SAV)	Inundated Abundant Channel (IAC)
Abundant River Bed (ARB)	River System (RS)



Source: Geology of Bangladesh

Figure 4-1: MRT Line 5 Location in Geology of Bangladesh Map

[1] The Dhaka Terrace is found along the southern edge of the Madhupur Tract. The area is includes Mirpur, Kurmitola (old Dhaka Airport), Dhaka and Demra, between the Buriganga on the west and the Sitalakhya on the east.

Fault Zone

Faults and lineaments that have occurred due to tectonic movements appear along the edge of the Dhaka terrace on the east, trending south-west and along the Tongi Khal in Tongi-Uttara-Uttar Khanarea, trending east-west.

Dhaka city falls in seismic zone II of the seismic zoning map of Bangladesh. It is classified as being on the upper end of the scale for moderate risk. Significant damaging historical earthquakes have occurred in and around Bangladesh and damaging moderate-magnitude earthquake occur every few years. The country's position adjacent to the very active Himalayan subduction plate in the north, moving east, and the westward movement of the Burma deformation produce the potential for earthquakes. A history of earthquake activity in Bangladesh, focusing on probable effects for Dhaka, can be found in Akhter (undated). Apparently the risk of a large magnitude quake is fairly great. Vulnerability to damage and to loss of life is increased due to the lack of an effective earthquake building code.

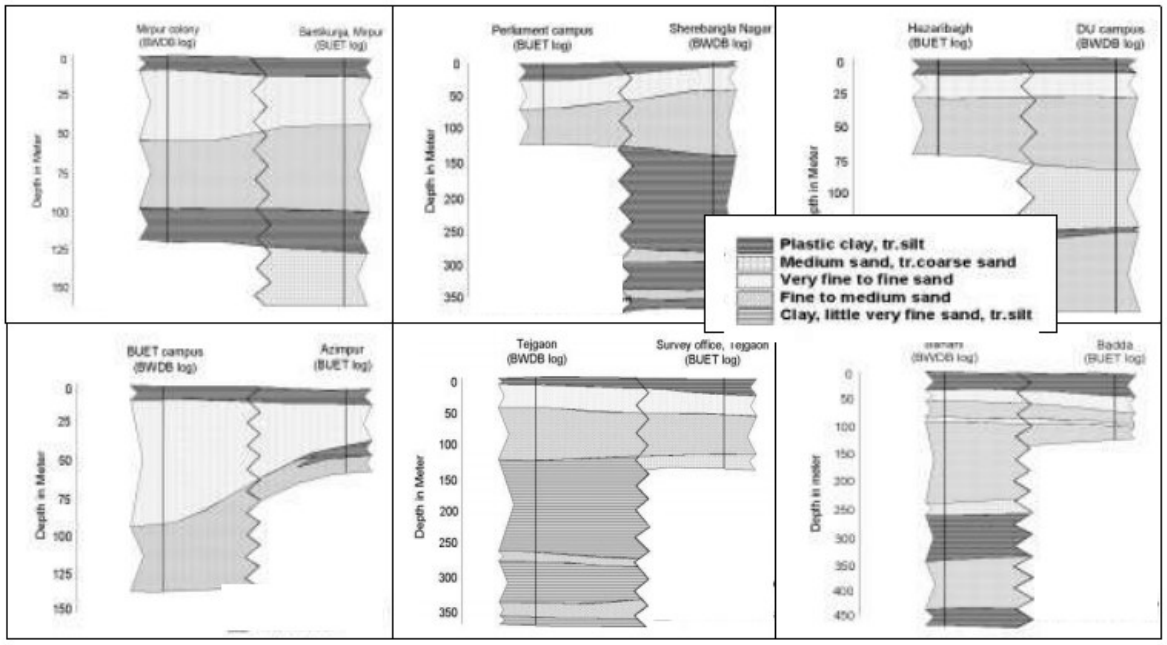
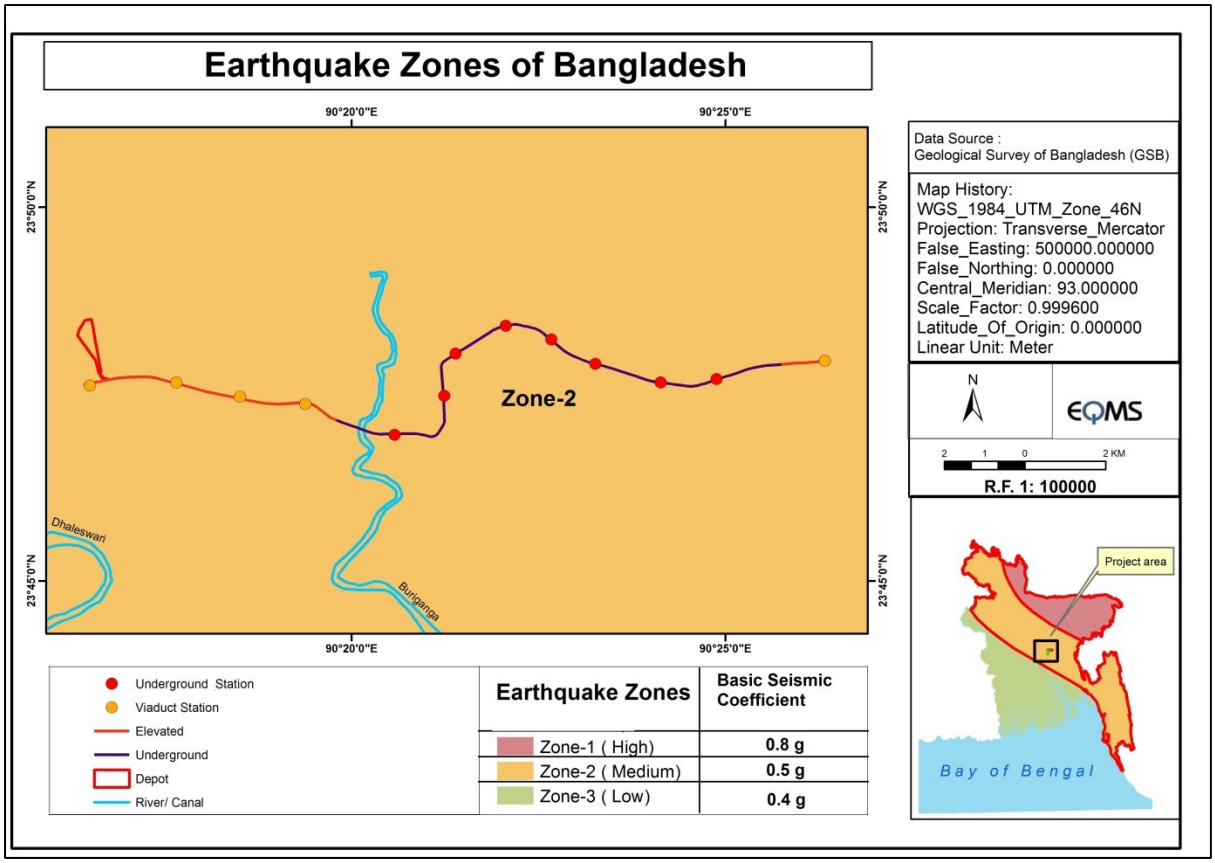


Figure 4-2: Lithology of Dhaka Area



Source: Geological Survey of Bangladesh

Figure 4-3: Earthquake Zone of Bangladesh

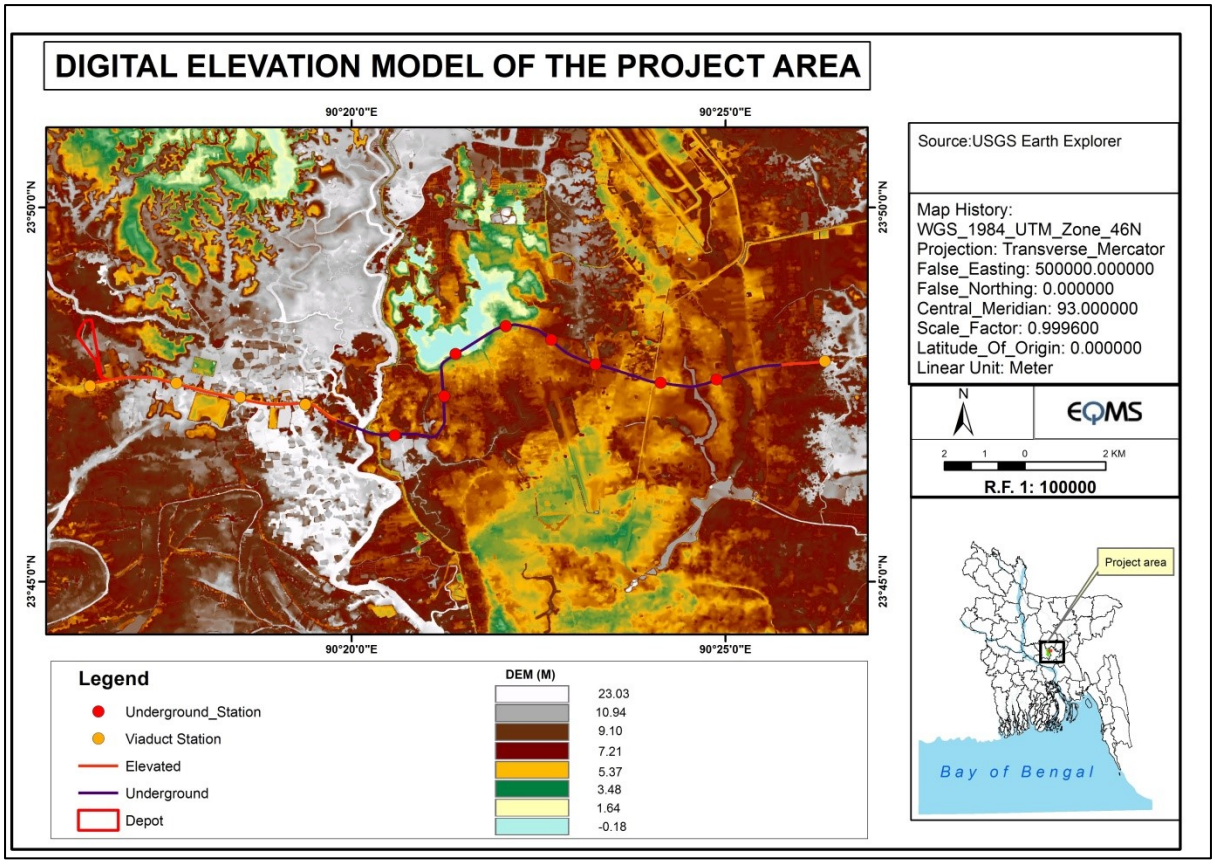
Subsidence

According to Higgins (2014) land subsidence in Dhaka occurs at the rate of 0 to > 10 mm/y, and is likely related to groundwater abstraction. Variations in the rate of subsidence correspond to local variations in shallow subsurface sediments. Outside of the city, rates vary from 0 to > 18 mm/y, with the lowest rates appearing primarily in Pleistocene Madhupur Clay and the highest rates in Holocene organic-rich muds. Subsidence is primarily controlled by local stratigraphy, with rates varying by more than an order of magnitude depending on lithology. According to surveyed data for MRT line 6, subsidence rates on the order of 2-4 mm/yr are typical in the project area.

4.3 Topology

The city is surrounded by four major River systems, namely the Buriganga, Turag, Tongi and Balu, which are flowing to the south, west, north and east sides, respectively. The edges of the high lands are flanked by marshes and old river beds.

The surface elevation of the area Dhaka are ranges between 1 and 14m and most of the built up areas located at the elevations of 6-8m. The land area above 8 meters msl covers about 20 square kilometers. The land ranging from 6-8 meters while 170 square kilometers of Greater Dhaka is below 6 meters (FAP 1991).



Source: USGS Earth Explorer

Figure 4-4: Elevation Map of the Project Area

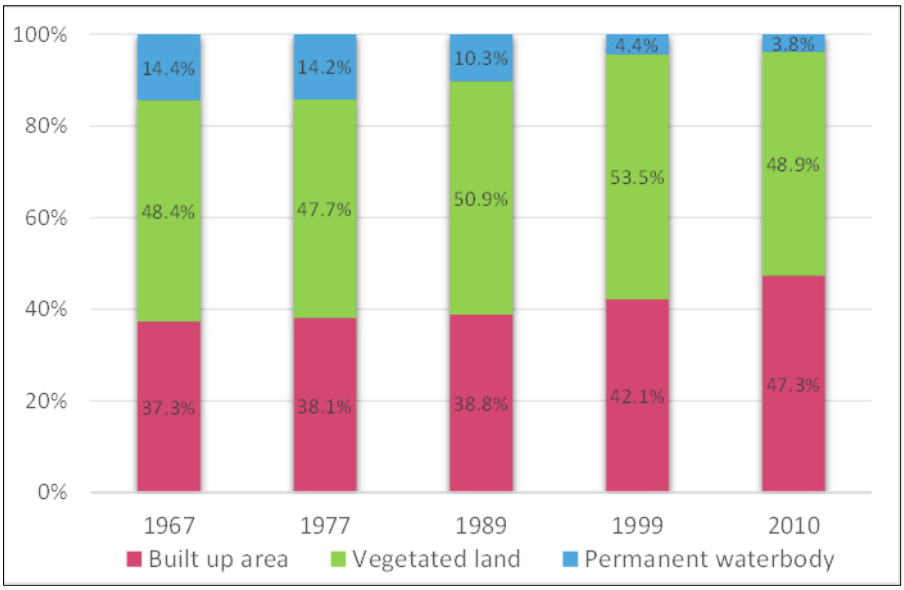
4.4 Land Use

Similar with other developing cities, the growth of Dhaka's land use has been changing since 1967. While the vegetation of area is almost fixed at 70,000 ha in the past 40 years, the current water body became a quarter since 1967, which is 5,520 ha in 2010 from 206,868 ha in 1967 as shown in Figure 4-5**.**

Thus, the water body has been converted to built-up area. The lack of growth management and planned urbanization causes extensive urban poverty, recurrent episodes of flash flooding, substantial growth of slums, and exploitation of resources and the mismanagement of limited land resources.

In 1967 to 1989, the built-up area had increased gradually from 53,727ha to 55,921ha with 0.2% of the annual increase rate. After that period, the urbanization has been accelerated. The built-up area increased by about 5,000 ha in the period of 1989 to 1999 and by 7,500 ha in the period of 1999 to 2010, respectively.

Figure 4-5 indicates the speedy expansion of built up area within RAJUK area through transformation of permanent water bodies and vegetation areas. The expansion of built up area mainly occurred to the northern region of RAJUK area specifically towards Savar, Ashulia and Uttara areas.



Source: JICA Study Team, 2014

Figure 4-5: Land Cover Changes between 1967 and 2010

RAJUK area is further divided into six regions, namely Dhaka Central Region, Northern Region, Eastern Region, Western Region, Southern Region and South-Western Region. The coverage of each region is as follows:

Dhaka Central Region: the existing Dhaka City consisting of 41 Thanas of DMA;

Northern Region: all the unions (except Mirzapur union) of Gazipur Sadar Upazila and the entire area of Gazipur City Corporation;

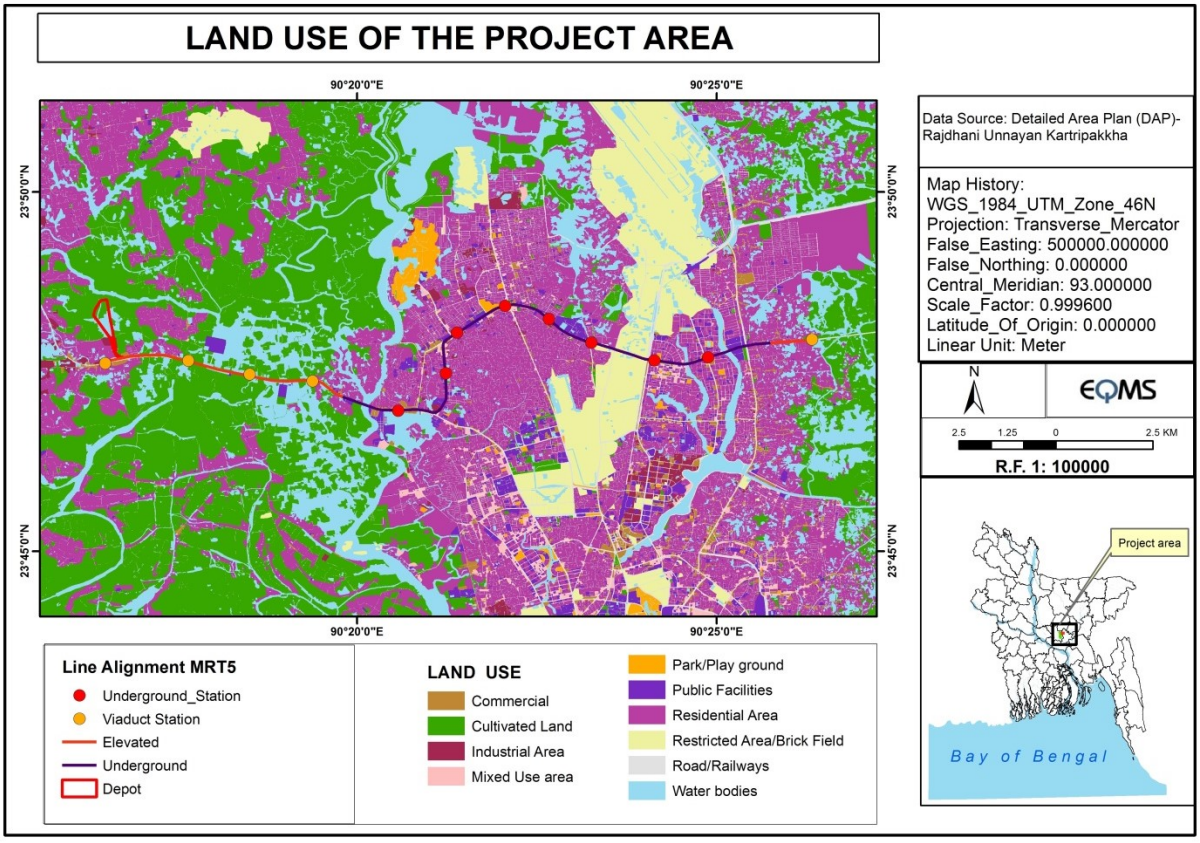
Eastern Region: two Paurashava (Kanchan and Tarabo) and six union of Rupjanj Upazila and one Paurashava (Kaliganj) and two unions of Kaliganj Upazila;

Western Region: Savar Paurashava and 11 unions of Savar Upazila;

Southern Region: Two Paurashavas (Narayanganj and Siddhiraganj) and seven unions of Narayanganj Sadar Upazila, one Paurashava (Kadam Rasul Paurashava) and five unions of Bandar Upazaila, and one Paurashava (Sonargaon) and seven unions of Sonargaon Upazila (part); and

South-western Region: eleven unions of Keraniganj Upazila of Dhaka District.

The total RAJUK area is 152,000 ha; in which the Northern Region accounts the largest area with 23.4%, followed by Dhaka Central Region with 19.8% and Western Region with 16.6%. In terms of land use type, the agricultural use is still dominant, which shares more than 40% of the total area in RAJUK. These agricultural lands are expanded towards north and west regions. Residential area is the second largest area with 56,024ha, which has been developed in Dhaka Central Region and Northern Region. The development direction of residential areas is the same as the direction of urban expansion. Other urban use of land such as commercial and mixed-use areas can also be found mainly in Dhaka Central Region and Northern Region. On the other hand, industrial areas are concentrated more in Northern Region and Southern Region. The Western Region has relatively high share of public facilities and recreational area.



Source: Detail Area Plan, RAJUK

Figure 4-6: Map Showing the MRT Line 5 Alignment in Land use Map

Table 4-2: Existing Land Use of the RDP Area

Land Use Type	Area (ha)							Share (%)						
	Region						Total	Region						Total
	DCR	NR	ER	WR	SR	SWR		DCR	NR	ER	WR	SR	SWR	
Agriculture	7,105	16,560	9,813	11,156	8,095	10,997	63,713	11.1	26.0	15.4	17.5	12.7	17.3	100.0
Industrial Area	541	864	557	727	909	144	3,810	14.5	23.1	14.9	19.4	24.3	3.9	100.0
Commercial	694	291	134	139	242	71	1,572	44.2	18.5	8.5	8.8	15.4	4.5	100.0
Mixed Use Area	612	128	4	82	124	21	971	63.0	13.1	0.4	8.5	12.7	2.2	100.0
Residential Area	12,988	14,248	7,022	8,852	8,759	4,154	56,024	23.2	25.4	12.5	15.8	15.6	7.4	100.0
Purbachal New Town	6	0	2,392	0	0	0	2,379	0.3	0.0	99.7	0.0	0.0	0.0	100.0
Public Facilities	1,294	780	90	1,178	337	89	3,767	34.3	20.7	2.4	31.3	8.9	2.4	100.0
Recreational Area	289	4	0	87	9	0	390	74.1	1.0	0.0	22.4	2.4	0.0	100.0
Restricted Area	2,030	931	30	754	321	303	4,302	46.5	21.3	0.7	17.3	7.4	6.9	100.0
Road/Railways	1,859	553	212	418	423	192	3,657	50.8	15.1	5.8	11.4	11.6	5.3	100.0
Waterbody	2,643	1,203	1,273	1,902	2,416	1,966	11,758	23.2	10.6	11.2	16.7	21.2	17.2	100.0
Total	30,061	35,562	21,528	25,296	21,635	17,937	152,343	19.8	23.4	14.2	16.6	14.2	11.8	100.0

Source: JICA Study Team worked out based on Regional Development Planning (RDP) Survey Report (RAJUK, 2014)
Note: DCR = Dhaka Central Region, NR = Northern Region, ER=Eastern Region, WR = Western Region, SR = Southern Region, SWR = South-western Region

4.5 Hydrology and Drainage

4.5.1 Hydrology

Dhaka city is surrounded by four major river systems. The south of Dhaka city is surrounded by the Buriganga River. The western part of Dhaka is bounded by the Truag River which is connected by a small Tongi Khal on the north. The eastern part of Dhaka is bounded by the Balu River which is also hydrologically connected with Tongi Khal.

The surface water area of Dhaka City is about 10-15% of total land area. The major lakes are Dhanmondi lake, Ramna lake, Gulshan lake and Crescent lake. It has been known from different government and non-government organizations and available surface water drainage map that there were more than 35 canals within Dhaka city area (Khan 2001). The conditions of some of the canals are very criticals at present and some of them are already vanished. The major canals which are till used as open channel is Begunbari Khal, Abdullahpur Khal, Diabari Khal, Manda Khal, Digun Khal, Meradia-Gazaria khal and Kallyanpur Khal (DoE, BCAS and UNEP 2006).

Water level data of one major station in each of the four surrounding rivers of Dhaka city has been analyzed. Data from Dhaka station in the Buriganga river, Mirpur station in the Turag river, Tongi station in the Tongi Khal and Demra station in the Balu river were used to compare flood situation. **Table 4-3** shows water level hydrographs of surrounding rivers for four major flooding years, namely 1988, 1998, 2004 and 2007.

Table 4-3: Comparison of characteristics of Flood 2004, 2007, 1998 and 1988

Parameters	**River**	**Gauge Stn.**	**2007**	**2004**	**1998**	**1988**
Danger Level in meters above datum	Buriganga	Dhaka	6	6	6	6.1
	Turag	Mirpur	5.94	5.94	5.94	5.94
	Tongi Khal	Tongi	6.08	6.08	6.08	6.08
	Balu	Demra	5.75	-	-	-
Date of crossing Danger Level at rising stage	Buriganga	Dhaka	07.08.07	20.07.04	26.07.98	29.08.88
	Turag	Mirpur	03.08.07 & 16.09.07	17.07.04	18.07.98	24.08.88
	Tongi Khal	Tongi	01.08.07 & 18.09.07	21.07.04	22.07.98	28.08.88
	Balu	Demra	02.08.07 &16.09.07	-	-	-
Date of crossing Danger Level at falling stage	Buriganga	Dhaka	07.08.07	05.08.04	20.09.98	20.09.88
	Turag	Mirpur	18.08.07 & 24.09.07	11.08.04	24.09.98	22.09.88
	Tongi Khal	Tongi	21.08.07 & 25.09. 2007	11.08.04	24.09.98	21.09.88
	Balu	Demra	16.08.07 & 20.09.07	-	-	-

Height of peak flood level in meter above Danger Level	Buriganga	Dhaka	0.02	0.7	1.23	1.58
	Turag	Mirpur	0.68	1.35	2.03	2.41
	Tongi Khal	Tongi	0.78	1.05	1.46	1.75
	Balu	Demra	0.5	-	-	-
Duration of floods in above Danger Level	Buriganga	Dhaka	1	17	56	22
	Turag	Mirpur	25	26	69	30
	Tongi Khal	Tongi	29	22	65	25
	Balu	Demra	20	-	-	-

4.5.2 Existing Natural Drainage System in Dhaka City

The natural drainage system in the Dhaka City comprises of several retention and detention areas including khals (canal), which are linked to the surrounding rivers. The city rainfall is accumulated in the retention and detention areas and discharged to the surrounding rivers through the khals.

The Dhaka West has 13 khals having total length more than 31 km while the Dhaka East has 27 khals of total length of about 60 km. Approximately 80% of the city area is drained through these channels to the surrounding rivers. The catchment areas of the khals in the Dhaka west varies from 6 to 40 sq. km (Chowdhury 1998)

Among the city canals, the Dholai Khal which once used to be the artery of an important navigational route for country boat to and from destinations within the metropolis, has almost disappeared due to four decades of wrong policies of the city administration to construct roads by closing the canal (Huq and Alam 2003). The closing of the khal had far reaching impact on the natural drainage system of the city.

If the current rate of loss of wetland continues, before the year 2031 all temporary wetlands of Dhaka will disappear (Chowdhury 1998). This is alarming for earthquake scenario, all these lands are continuously being converted into urban land through landfill and these filled lands are vulnerable to liquefaction effect. Even after the enactment of the water body conservation act 2000, the city has lost huge amount of wetlands (Yeasmin 2003).

Many ponds that worked as runoff reservoir and met the domestic water needs besides being used as community space are filled up to create space for housing and roads. Being one of the largest mega cities in the world and without any hydrological planning, remaining surface water is being excessively polluted or destroyed. Ground water extraction poses a great threat to the sustainability of the city itself Dhaka.

On the other hand, the sewerage system of Dhaka city covers only one third of total urban area. Dhaka WASA utilizes the existing canals and sewerage pipes to collect the waste water from different areas, carry the effluent to dispose, most of it, into surrounding river systems without any treatment. Many canals are cutoff and transformed into lakes e.g. Dhanmondi, Gulshan, Banani or Baridhara lake.

4.5.3 Ground Water Table of Dhaka City

The maximum depth to water table in the central part of the city i.e. Tejgaon and Sabujbagh areas, observed from BWDB piezometers, is about 67 to 57m below ground surface that is about 55m at Mirpur and 20-34m at Mohammadpur, Dhanmondi and Sutrapur areas close to

the river periphery. The depth of the water table moves seasonally with annual recharge and discharge conditions. The amount of seasonal fluctuations varies from less than a meter to more than 10m depending on the local hydrological conditions, amount of ground water abstraction and natural discharge of ground water. In recent years, there is a declining trend in the water table due to large amount of ground water withdrawal (Bangladesh Water Development Board, 2007).

4.5.4 Ground Water depletion of Dhaka City

In Dhaka City, Ground Water extraction started from a depth of 100m and in some extreme condition the well goes up to 300 meters to reach the main aquifer. The depletion rate varies from area to area as in Mirpur the ground water level dropped 53.75 meters between 1991 and 2008 at a rate of 3.2m per year. While the decline was 1.1m/y in Mohammadpur, 2.2m/y in Sabujbag, 0.5m/y in Sutrapur and 0.8 m/y in Dhaka Cantonment During the same period. The city's groundwater level has dropped about 20m over the last seven years at a rate of 2.81m per year, from the year of 2000, the rate is increasingly high.

Long term hydrographs from different parts of the Dhaka city indicate the drop in water level is increasing very rapidly throughout the city. For assessing hydrographs, eight groundwater monitoring station of BWDB and BADC have been selected at different locations i.e. Gulshan, Sabujbagh, Lalbagh, Sutrapur, Mohammadpur, Dhanmondi, Tejgaon and Mirpur. Ground water levels at different locations of Dhaka city are given below **Table 4-4.**

Table 4-4: Ground water level at different locations of Dhaka city (2001 and 2007)

Year	Location							
	Gulshan	Sabujbagh	Lalbagh	Sutrapur	Mohammadpur	Mirpur	Dhanmondi	Tejgaon
2001	38.5	51.78	39.3	19.5	25.17	45.5	42.5	40.13
2007	62.0	58.75	47.5	20.5	37.56	68.5	67.0	60.42

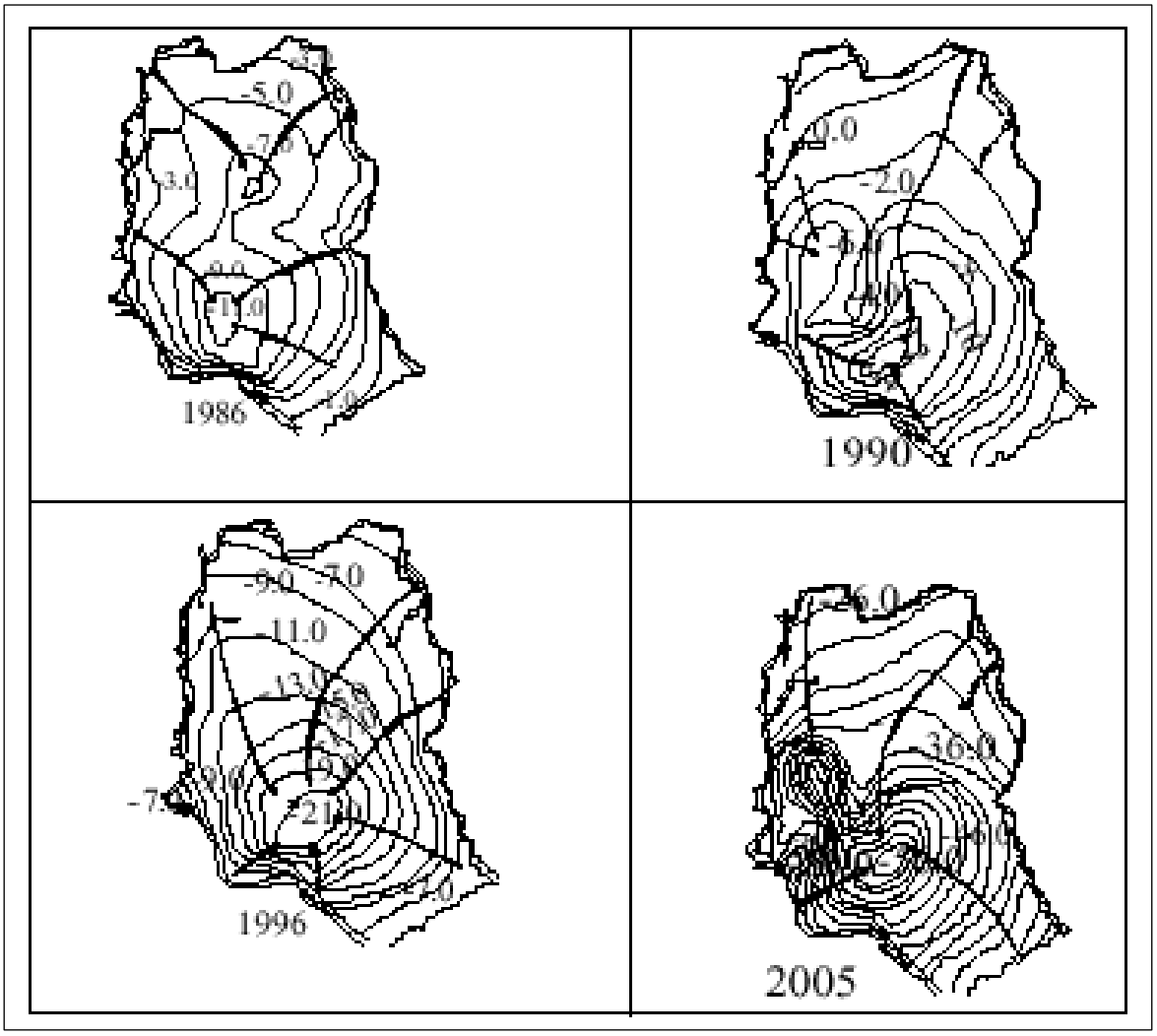
Source: (BWDB, 2007)

The maximum depth to water table in the central part of the city i.e. Tejgaon and Sabujbagh areas, observed from BWDB piezometers, is about 67 to 57m below ground surface that is about 55m at Mirpur and 20-34m at Mohammadpur, Dhanmondi and Sutrapur areas close to the river periphery. This continuous decline of water table with little or even no fluctuation is typical of over exploited aquifers (Bangladesh Water Development Board, 2007).

The declining rate of groundwater level is alarming as well at Tejgaon (60.42 m),Gulsan (62 m), and Sabujbagh (58.75 m). In these areas the water abstraction rate is higher than the recharge. The level of groundwater table of upper aquifer (<170 m depth) is declining about 2-3meter in every year. The overall groundwater level in the city is below 50 m (DWASA, 2006).

The areas where the water crisis is most acute are Pallabi, Mugdhapara, Shewrapara, West Dhanmondi, Rayerbazar, Kamalbagh, Islambagh, Nawabpur, Paikpara, Kalabagan, Naya

Paltan, Khilgaon, Moghbazar, Bashabo, Kodomtola, Madartek, Sipahibagh, Meradia, Vuiyapara, Mugda, Manda, Shantibagh, Malibagh, Shiddeshwari, Rampura, Bonosree, Maximum part of Old Dhaka, Poribagh, Crisent Road, Kathalbagan, Hazaribagh, Jigatola, Lalbagh, Azimpur, Noorjahan Road, Salimullah Road Shekhertek, Housing Society and Picci Culture of Mohammadpur. Badda, Khilkhet, Section-1, 2, 5, 10, 12 of Greater Mirpur, Borobagh, Senpara Porbota, Shewrapara, Kazipara, Kallyanpur, Pirerbagh, Ibrahimpur and Kafrul (The Daily Prothom Alo, 2008).



Source: Akhter et al, 2009

Figure 4-7: Ground water contour map of Dhaka city during late dry season (Mid-May) in 1986, 1990, 1996 and 2005

Groundwater level is comparatively high in periphery and low in the central portion of the city. Among the periphery, the Northern portion of the city has comparatively higher water level than Southern portion of the city. Because Northern portion have large open space, many small surface water bodies dispersed there and moreover, the low rate of withdrawal of groundwater. Groundwater level fluctuation patterns had abruptly changed and steeply declined after 1990.

In Dhaka City, Ground Water extraction started from a depth of 100m and in some extreme condition the well goes up to 300 meters to reach the main aquifer. The depletion rate varies from area to area as in Mirpur the ground water level dropped 53.75 meters between 1991 and 2008 at a rate of 3.2m per year. While the decline was 1.1m/y in Mohammadpur, 2.2m/y in Sabujbag, 0.5m/y in Sutrapur and 0.8 m/y in Dhaka Cantonment During the same period. (The Daily Star, 2010). The city's groundwater level has dropped about 20m over the last seven years at a rate of 2.81m per year, from the year of 2000, the rate is increasingly high.

4.5.5 River Morphology

The base line information study by JICA (JICA 2000) is the only account which describes the morphological changes in the rivers surrounding Dhaka. As part of the JICA study, additional cross section surveys were carried out, and historical satellite images retrieved and analysed. With this information the study determined the changes in top width and bank line changes of the river system. The table below summarizes the observed changes in cross section top width and bank line changes as reported in (JICA 2000).

Table 4-5: Morphological Changes on the Rivers around Dhaka

River Name	Changes in River Bed Elevation (m)	Changes in top Width (m/year)	Left/Right Bank Line Change (m/year)
Turag (1989-2009)	-0.01 to -9.0	0.4-3.2	LB: 0.7-3.9 RB: 0.1-2.5
Buriganga (1989-2009)	-6.3 to -16.2	7.3-12.4	LB: 1.7-5.8 RB: 1.3-6.8
Tongi Khal (1991-2009)	None	0-0.6	LB: 0.1-3.6 RB: 0.2-3.4
Balu (1991-2009)	None	0.2-1.8	LB: 0.3-6.6 RB: 0.0-6.7
Lakhya (1985, 1989,1995, 1999, 2009)	-0.4 to 14.1	3.3-9.67	LB: 0.125-6.6 RB: 0.04-7.3
Dhaleswari (1989, 11990, 1993, 2009)	-0.25 to -13.4 0.15 to -5.6	18-45 10-60	LB: 0.56-5.4 RB: 0.4-1.5

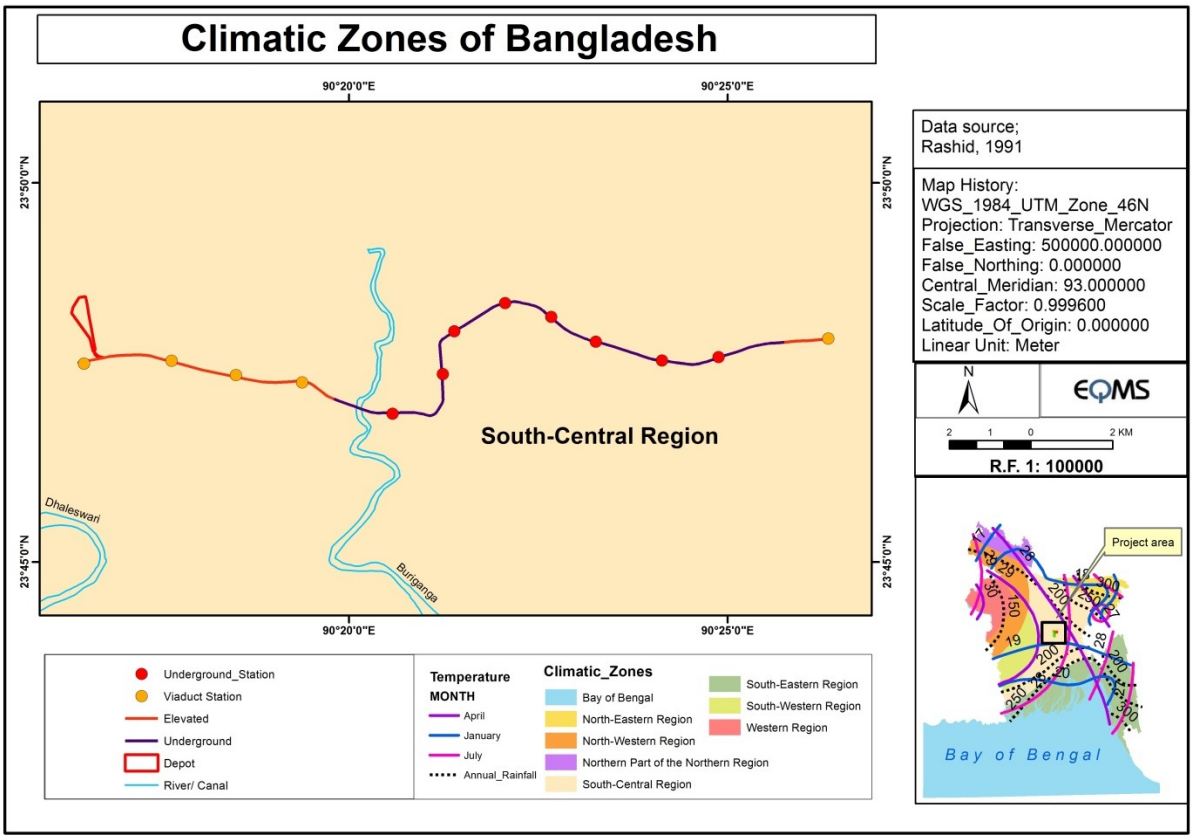
Source: JICA, 2000

The JICA study (JICA 2000) reports that even though limited data have been available for the study, the following indications have been obtained:

- The river system is not highly morphologically dynamic.
- The rivers are more or less stable.
- The bank line and top width changes are not high.
- The rivers are more or less straight.
- Sediment concentrations are not very high.
- Bed sediment of most of the rivers is non-cohesive in nature and the rivers are not braided.

4.6 Meteorology

The project site is located in Dhaka Division. According to Köppen climate classification, it falls under Aw category which is characterized by tropical wet and dry climate. Hence, it experiences hot and humid summer and dry winter. According to the climatic characteristics, Bangladesh is divided into 7 different climatic sub-regions. The study area of the project falls under the south-central climatic zone of the country (Figure 4-8).



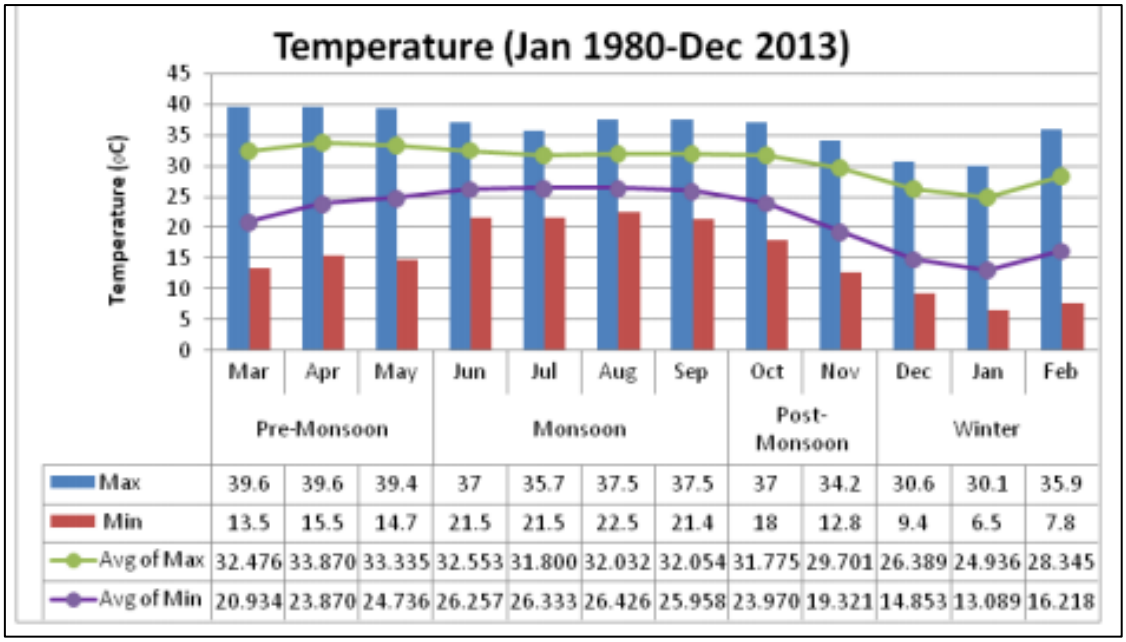
Source: Rashid, 1991

Figure 4-8: MRT Line 5 in Climatic Zone of Bangladesh

The summary of the analysis of the climatic and meteorological parameters are discussed in the following sections:

4.6.1 Temperature

Temperature data of Dhaka Station from Bangladesh Meteorological Department (BMD) for 34 years (from January 1980- December 2013) has been analyzed to see the monthly variation of the average maximum temperature which is between 39.6°C to 30.1°C. The monthly variation of the average minimum temperature is 22.5°C to 6.5°C. The maximum recorded temperature in Dhaka station was 39.6°C, which occurred on March, 1999 and April, 2009. On January 1995, the minimum temperature was recorded as 6.5°C in Dhaka. The warmest month of the year is April and the coldest month of the year is January. Figure 4-9 shows the maximum, minimum, average of maximum and average of minimum temperature of Dhaka station from 1980 to 2013.



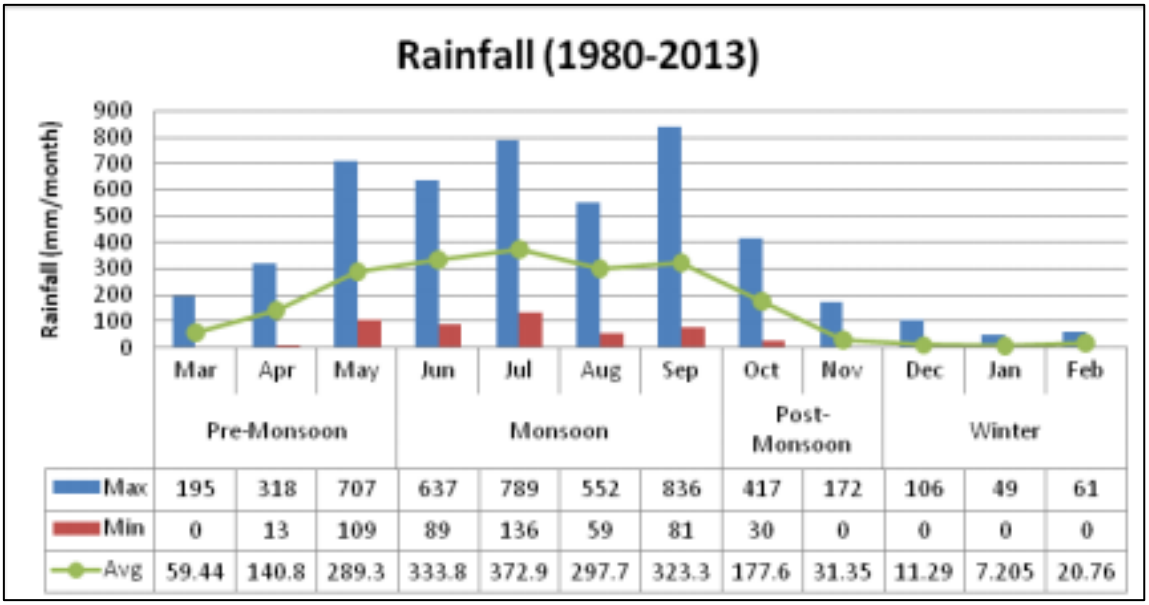
	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Max	39.6	39.6	39.4	37	35.7	37.5	37.5	37	34.2	30.6	30.1	35.9
Min	13.5	15.5	14.7	21.5	21.5	22.5	21.4	18	12.8	9.4	6.5	7.8
Avg of Max	32.476	33.870	33.335	32.553	31.800	32.032	32.054	31.775	29.701	26.389	24.936	28.345
Avg of Min	20.934	23.870	24.736	26.257	26.333	26.426	25.958	23.970	19.321	14.853	13.089	16.218

Source: Dhaka Meteorological Station

Figure 4-9: Monthly maximum, minimum and average temperature

4.6.2 Rainfall

Monsoon is a prominent season in this area. The average monthly rainfall during monsoon (June-September) season from 1980-2013 is 332 mm/month. The variance in the maximum rainfall during monsoon season is 836 mm/month to 552 mm/month, whereas the variance in the minimum rainfall is 136 mm/month to 59 mm/month. The maximum 836 mm/month rainfall was recorded during September of the year 2004. Annual average rainfall is 2066 mm/year and the highest recorded yearly rainfall was 3028 mm in the year 1984. The driest period of the year is winter when the average monthly rainfall varies from 21 mm/month to 7.21 mm/month. Figure 4-10 shows the maximum, minimum and average rainfall from 1980-2013.



	Mar	Apr	May	Jun	Jul	Aug	Sep	Oct	Nov	Dec	Jan	Feb
	Pre-Monsoon			Monsoon				Post-Monsoon		Winter		
Max	195	318	707	637	789	552	836	417	172	106	49	61
Min	0	13	109	89	136	59	81	30	0	0	0	0
Avg	59.44	140.8	289.3	333.8	372.9	297.7	323.3	177.6	31.35	11.29	7.205	20.76

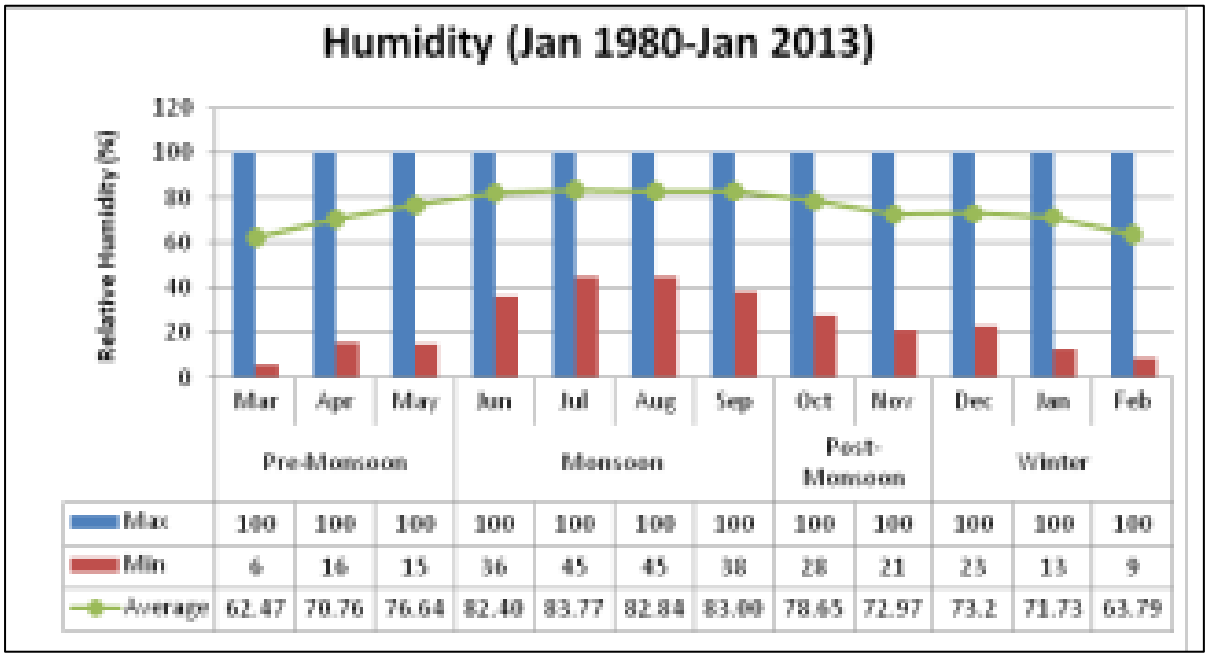
Source: Dhaka Meteorological Station

Figure 4-10: Monthly Maximum, Minimum and Average Rainfall

4.6.3 Humidity

The average relative humidity remains higher during the monsoon season. The variance in the average relative humidity throughout the year is 83.77% to 62.47%, whereas during monsoon the variance is 83.77% to 82.40%. Source: Dhaka Meteorological Station

Figure 4-11 shows the maximum, minimum and average relative humidity of Dhaka station from January 1980 to January 2013.



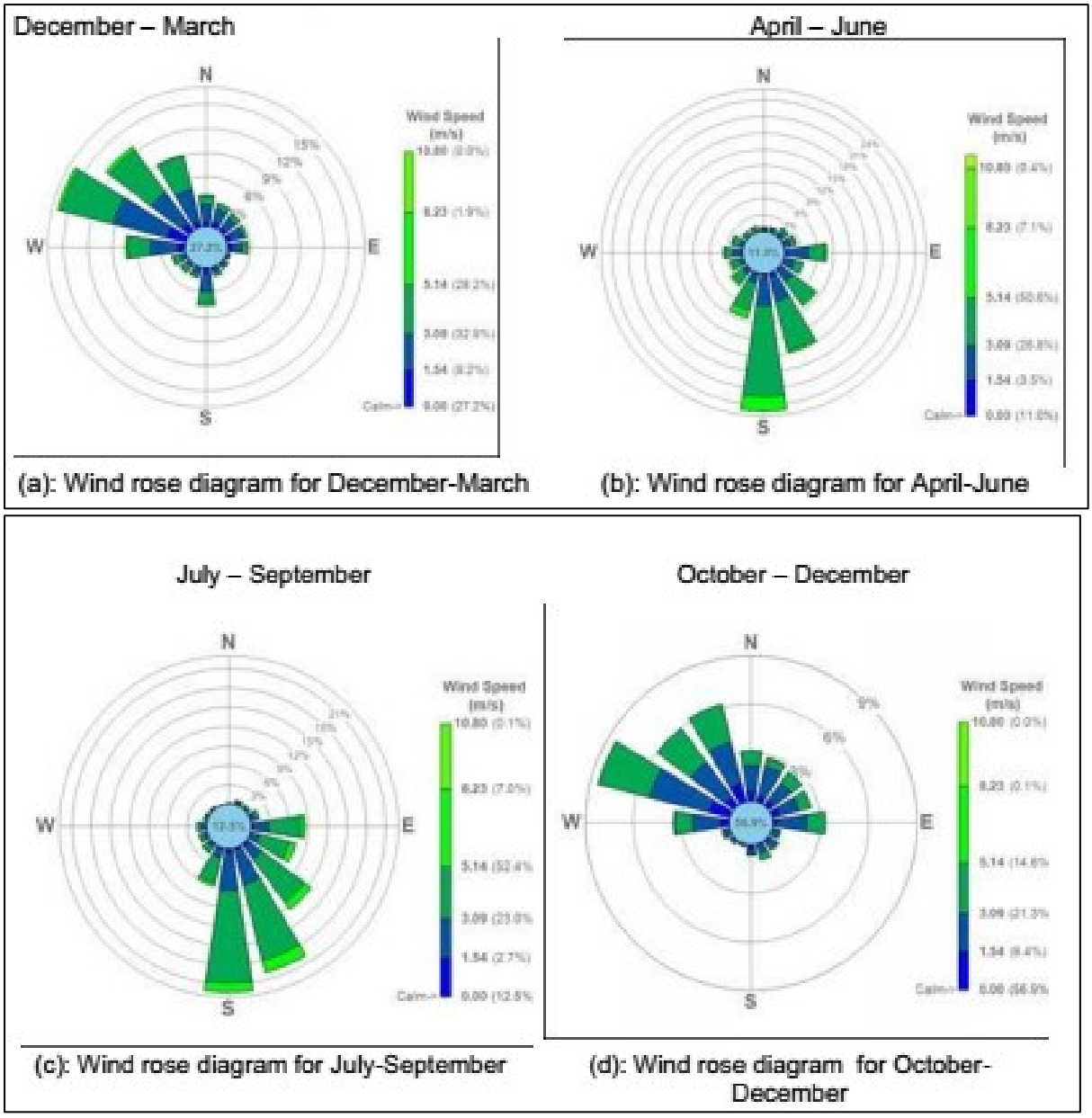
Source: Dhaka Meteorological Station

Figure 4-11: Maximum, Minimum and Average Relative Humidity

4.6.4 Wind Speed and Direction

The direction of wind varies depending on the seasons. Therefore, whole year has been categorized into four clusters of months and these are:

Cluster-1: December-March, Cluster 2: April-June, Cluster 3: July to September, and Cluster 4: October to December. Wind speed data and direction have been collected from the Dhaka BMD station at a height of 10 m from the ground level. During clusters 1 and 4 months wind direction is predominantly from northwest to southeast direction, inclined towards east and for clusters 2 and 3 it is predominantly from south and southeast to north and northwest. In cluster 1 calm wind prevails for 27.2% of total period, similarly it is 11.0% for cluster 2, 12.5% for cluster 3, and 56.9% for cluster 4, respectively. Figure 4-12 (a, b, c and d) present wind speed and direction graphically round the year.



Source: Dhaka Meteorological Station

Figure 4-12: Wind rose at Dhaka station

4.7 Water Quality and Use

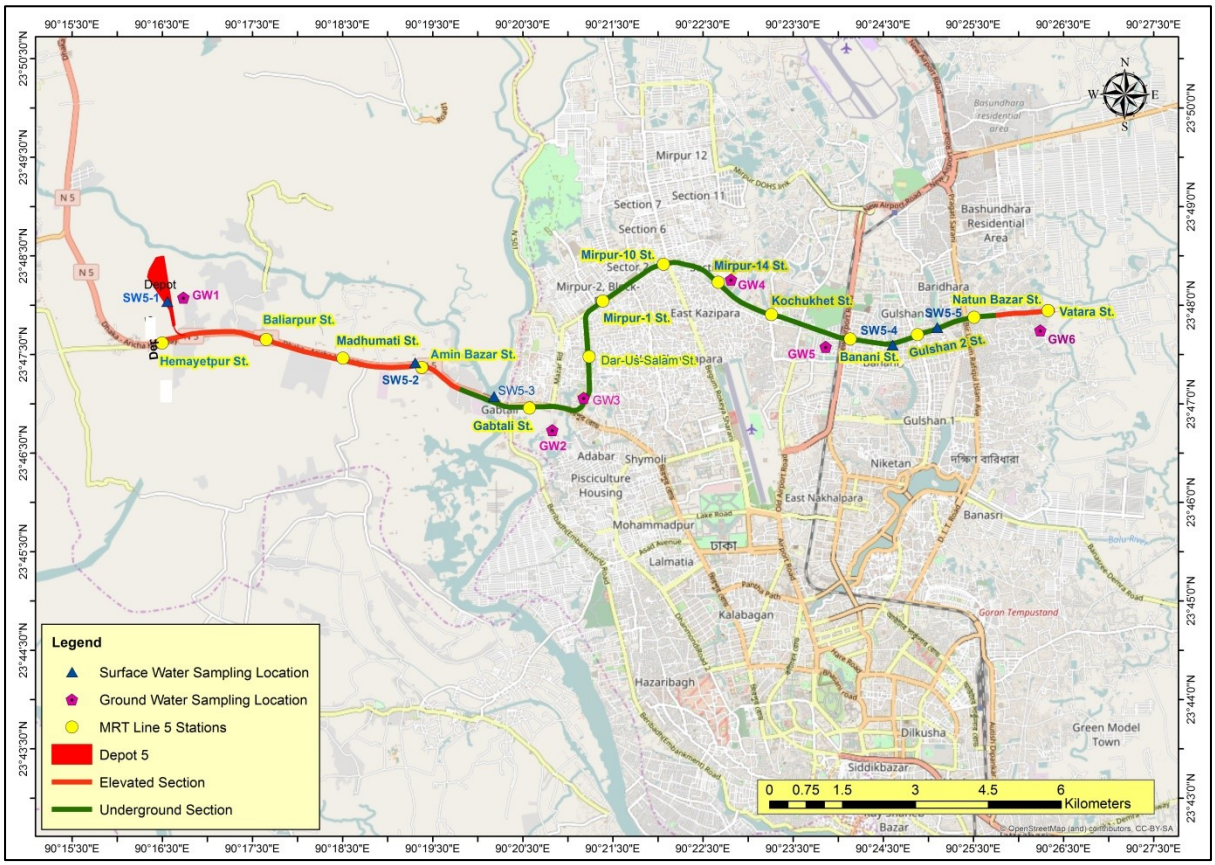
4.7.1 Surface Water

Surface water samples were taken once from 5 different locations for MRT line 5. Surface water sample were collected on 19th to 22nd March 2017. Detail Sampling Locations are provided in the following **Table 4-6** and depicted in the Figure 4-13.

Table 4-6 : Surface water Sampling Location of MRT Line 5

No.	Location	Geographic Coordinate
SW5-1	Depot Site of Line 5	23°48'2.20"N 90°16'33.40"E
SW 5-2	Wetland between Modhunmoti Station and Amin Bazar	23°47'25.00"N90°19'18.40"E
SW 5-3	Turag River	23°47'4.40"N 90°20'10.80"E
SW 5-4	Banani Lake	23°47'35.70"N 90°24'36.20"E
SW 5-5	Gulshan Lake	23°47'46.40"N 90°25'6.00"E

Source: EQMS



Source: EQMS

Figure 4-13: Surface and Ground Water Sampling Location of MRT Line5

Water samples were collected as grab water sample in a pre-washed 5-litre plastic jerry can and 250 ml sterilized clean PET bottle for complete physio-chemical tests respectively.

The samples were analyzed as per standard procedure/method given in Standard Method for Examination of Water and Wastewater Edition 20, published by APHA. Details of the analysis method and protocol are presented in **Table 4-7.** The samples were analyzed for

parameters covering Bacteriological and physico-chemical characteristics which include certain heavy metals and trace elements.

Water samples were collected as grab water sample in a pre-washed 5-litre plastic jerry can and 250 ml sterilized clean PET bottle for complete physio-chemical tests respectively.

The samples were analyzed as per standard procedure/method given in Standard Method for Examination of Water and Wastewater Edition 20, published by APHA. Details of the analysis method and protocol are presented in **Table 4-7.**

Table 4-7: Methods of Water Parameter Analysis

Sl.	Parameter	Test method
1.	Temperature (˚C)	Digital thermometer
2.	pH	Hanna Combo Meter (Temperature, pH, EC, TDS)
3.	Salinity	Salinity Meter
4.	Dissolved Oxygen (DO)	Lutron 5509 Dissolved Oxygen Meter
5.	Biochemical Oxygen Demand (BOD)	5 Day Incubation
6.	Chemical Oxygen Demand (COD)	CRM
7.	Coliform (Faecal)	MFM
8.	Colour	UVS
9.	Total Suspended Solid (TSS)	Gravity Multimeter
10.	Sodium	AAS
11.	Potassium	AAS
12.	Calcium	AAS
13.	Bicarbonate	Titrimetric
14.	Chloride	Titrimetric
15.	Sulfate	UVS
16.	Nitrate	UVS
17.	Nitrite	UVS
18.	Arsenic	AAS

Note: AAS: Atomic Absorption Spectrophotometer, UVS- UV- Visible Spectrophotometer, MFM- Membrane Filtration Method

The quality of surface water was compared with the standards for Inland Surface Water, Environment Conservation Rules (ECR), 1997-Schedule 3 (a) whereas the groundwater was compared with the Drinking Water Standard ECR-Schedule-3 (b), 1997. The standards have been presented along with the monitoring results of surface and groundwater for comparison.

Surface water quality of the collected samples is poor compare to the Bangladesh inland surface water quality standard. The main causes of the degraded water quality are liquid waste discharge as well as sewage discharge in the surface water body. The Surface water quality of MRT line 5 is shown in the **Table 4-8.**

Table 4-8: Surface Water Quality Analysis Result

Parameter	Unit	SW5-1	SW5-2	SW5-3	SW5-4	SW5-5	Standard for Inland Surface Water*					
							a	b	c	d	e	f
Colour	Hazen	2.1	1.8	2.0	1.3	1.7	-	-	-	-	-	-
Temperature	°C	23.2	23.1	24.5	24.4	24.0	-	-	-	-	-	-
pH	-	7.22	7.08	7.46	7.00	7.34	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5	6.5-8.5
DO	mg/l	4.1	3.2	2.7	1.3	2.9	6 or above	5 or more	6 or more	5 or more	5 or more	5 or more
BOD	mg/l	13	08	12	13	10	2 or less	3 or less	6 or less	6 or less	10 or less	10 or less
COD	mg/l	48	32	44	48	36	-	-	-	-	-	-
TSS	mg/l	24	15	42	28	21						
Coliform (Faecal)	N/100ml	475	786	995	840	787	50 or less	200 or less	5000 or less	---	5000 or less	1000 or less
TDS	mg/l	280	290	530	320	300	-	-	-	-	-	-

Source: EQMS laboratory and Department of Public Health and Engineering Lab; Analysis date: 22/03/2017- 30/04/2017 and 30/04/2-17-22/05/2017

*Note: a- Source of drinking water for supply only after disinfecting
b- Water usable for recreational activity
c- Source of drinking water for supply after conventional treatment
d- Water usable by fisheries
e- Water usable by various process and cooling industries
f- Water usable for irrigation

From the Table 4-8, pH concentration of the surface water in all samples are not crossed the Bangladesh standard. Dissolved Oxygen level of all parameters are below the standards whereas BOD and COD concentration of all samples are very high and cross the Bangladesh standard limit. TSS concentrations of all samples are relatively high. Fecal coliform concentrations are very high in all samples.

4.7.2 Ground Water

Ground water samples were taken once during the study period from nine different locations for MRT line 5. The ground water samples were collected on 19th to 22nd March 2017. Detail Sampling Locations are provided in the following Table 4-9 and shown in the Figure 4-13**.**

Table 4-9: Ground water Sampling Location of MRT Line 5

SL#	Location	Sampling ID	Geographic Coordinate
1.	Abdul Malek house, Guydar Tak, Gabtoli	GW5-1	23°46'44.0"N 90°20'49.7"E
2.	Mirpur Bangla College WASA pump	GW5-2	23°47'03.6"N 90°21'10.5"E
3.	Mirpur 10 WASA Pump	GW5-3	23°48'24.4"N 90°22'24.5"E
4.	Police Staff Collage Mirpur 14	GW5-4	23°48'15.3"N 90°22'47.1"E
5.	Banani DOHS Pump House	GW5-5	23°47'33.59"N 90°23'51.38"E
6.	Vatara WASA Pump house	GW5-6	23°47'44.7"N 90°26'14.6"E

Source: EQMS

Ground water qualities of all samples are well within the permissible limit in accordance with the Environmental Conservation Rules, 1997. The Ground water quality of the MRT line 5 is shown in the following **Table 4-10.**

The concentration levels of pH, chloride, sulfate, Na, K, Ca, Mn, As, Fe, Ammonia Nitrate, total hardness, chloride and Faecal coliform for tube well were found within limit of drinking water standard.

Table 4-10: Ground Water Quality of MRT Line 5

Parameter	Unit	GW5-1	GW5-2	GW5-3	GW5-4	GW5-5	GW5-6	ECR, 1997 Standard
Depth of the Tube well/Pump	m	122	275	275	305	275	275	-
Colour	Hazen	0.9	1.3	1.0	1.7	0.8	1.0	15
Temperature	˚C	25.9	23.8	24.9	29.3	28.3	26.8	20-30
pH	-	6.75	7.14	6.78	6.96	7.06	26.80	6.5-8.5
Sodium	mg/l	28	29	24	28	23	17	200
Potassium	mg/l	04	04	03	03	03	03	12
Calcium	mg/l	10	15	07	07	09	05	75
Bicarbonate	mg/l	170	205	135	160	165	90	-
Chloride	mg/l	12	16	13	15	14	12	150-600
Sulfate	mg/l	02	1.0	02	1.0	1.0	1.0	400
Nitrate	mg/l	0.10	< LOQ	< LOQ	2.38	< LOQ	0.28	10
Nitrite	mg/l	< LOQ	< LOQ	0.017	< LOQ	< LOQ	< LOQ	<1.0
Arsenic	mg/l	0.002	0.001	0.001	0.003	0.002	0.001	0.05
Fecal Coliforms	N/ 100ml	0	0	0	04	0	0	0

Source: EQMS Laboratory and Department of Public Health and Engineering Lab; Analysis date: 22/03/2017- 30/04/2017 and 30/04/2017-22/05/2017

Note: LOQ- Limit of Quantitation

4.8 Air Quality and Noise

4.8.1 Air Quality

Air Quality Sample has been taken from total 5 different Locations for MRT Line 5. Air quality sampling locations is provided in the Table 4-11 and shown in Figure 4-14.

Table 4-11: Air Quality Sampling Location of MRT Line 5

No.	Location	Geographic Coordinate
AQ5-1	Depot Site of Line 5	23°48'1.79"N 90°16'44.04"E
AQ5-2	Gabtoli Station	23°47'0.29"N 90°20'36.07"E
AQ5-3	Mirpur 10 Station	23°48'26.44"N 90°22'13.12"E
AQ5-4	Gulshan 2 Station	23°47'40.79"N 90°24'46.65"E
AQ5-5	Vatara Station	23°47'57.44"N 90°26'23.25"E

Source: EQMS

Source: EQMS

Figure 4-14: Air Quality Sampling Location of MRT Line 5

The particulate and gaseous samples collected during the monitoring have been analyzed as per the procedures specified in Table 4-12.

Table 4-12: Methodology for Analysis of Ambient Air Quality

Sl.	Parameter	Analysis Procedure
1.	PM_{10}	Gravimetric method
2.	$PM_{2.5}$	Gravimetric method
3.	SO_2	Colorimetric method at 560nm using spectrophotometer (West-Gaeke method)
4.	NOx	Colorimetric method at 540 nm using spectrophotometer (Jacob and Hochheiser method)
5.	Ozone (O_3)	UV Photometric
6.	Lead (Pb)	ED-XRF using Teflon Filter
7.	CO	Digital CO meter (HTC ™)

Air quality sample has been taken from total five locations of MRT line 5. Total seven parameters (PM10, PM2.5, SO_2, NO_2, CO, Pb and O_3) of ambient air quality have been analysed for each location. Out of seven parameters, the PM10 and PM2.5 concentration exceed the NAAQS in the Gabtoli, Mirpur 10 and Gulshan 2 stations of MRT line 5. The SO_2 concentration exceeds the NAAQS in the Gabtoli and Mirpur 10 station. Rest of the parameters (SO2, CO, Pb and O_3) concentrations was present well within the NAAQS in all stations of MRT line 5. The result of the Air Quality has been provided in **Table 4-14.**

Table 4-13: National Ambient Air Quality Standards for Bangladesh

Pollutant	Standard	Average Time
SPM	200µg/m^3	8 hours
CO	10 mg/m^3 (9 ppm)	8 hours
	40 mg/m^3 (35 ppm)	1 hours
Pb	0.5 µg/m^3	Annual
NO_2	100 µg/m^3 (0.053 ppm)	Annual
PM10	50 µg/m^3	Annual
	150 µg/m^3	24 hours
PM2.5	15 µg/m^3	Annual
	65 µg/m^3	24 hours
O_3	235 µg/m^3 (0.12 ppm)	1 hours
	157 µg/m^3 (0.08 ppm)	8 hours
SO_2	80 µg/m^3 (0.03 ppm)	Annual
	365 µg/m^3 (0.14 ppm)	24 hours

Source: Environmental Conservation Rules 1997 and subsequent amendment in 2005

Table 4-14: Ambient Air Quality of MRT 5

Location	Present Concentration in µg/m^3						CO (ppm)
	PM10	PM2.5	NO_2	SO_2	O_3	Pb	
Depot Site of Line 5	68.2	33.8	33.6	5.5	2.4	BDL	0.2
Gabtoli Station	345.5	145.6	120.5	24.6	23.2	0.1	5.1
Mirpur 10 Station	318.4	134.9	101.7	13.7	15	0.07	1.6
Gulshan 2 Station	268.5	88.4	87.9	12.0	12.8	BDL	0.5
Vatara Station	72.4	36.8	46.7	6.4	3.2	BDL	0.1
Standard ECR1997	150	65	100	365	157	0.5	9
Duration	24 hours	24 hours	Annual	24 hours	8 hours	Annual	8 hours

Source: EQMS Laboratory Analysis, Sampling Date: 28th February to 5th March, Analysis date: 1st-15th March

Note: BDL- Below Detection Limit

Exceeding Standard Level

4.8.2 Noise Level

Noise levels were recorded at nine locations in the study area during the monitoring period. Noise levels were recorded in the form of sound pressure levels with the help of a digital sound level meter. The details of noise monitoring locations are given in Table 4-15 and depicted in Figure 4-15.

The purpose of ambient noise level measurement was to determine sound intensity at the monitoring locations. These locations are chosen in such a way that a representative data could be recorded all over locations. The sound level is recorded in form of A-weighted equivalent continuous sound pressure level (Leq) values with the use of A-weighting filters in the noise measuring instrument.

Table 4-15: Noise Level Sampling Location of MRT Line 5

No.	Location	Geographic Coordinate
NL5-1	Depot Site of Line 5	23°48'0.55"N 90°16'36.97"E
NL 5-2	Modhunmoti Station	23°47'27.93"N 90°18'31.56"E
NL 5-3	Gabtoli Station	23°46'57.69"N 90°20'24.27"E
NL 5-4	Dar-Us-Salam Station	23°47'31.21"N 90°21'14.54"E
NL 5-5	Mirpur 10 Station	23°48'26.35"N 90°22'12.88"E
NL 5-6	Mirpur 14 Station	23°48'15.31"N 90°22'38.85"E
NL 5-7	Banani Station	23°47'38.50"N 90°24'10.17"E
NL 5-8	Gulshan 2 Station	23°47'42.09"N 90°24'46.49"E
NL 5-9	Vatara Station	23°47'57.09"N 90°26'20.62"E

Source: EQMS

Source: EQMS

Figure 4-15: Noise Level Monitoring Location of MRT Line 5

Noise level monitoring was carried out for 24 hours (once) during monitoring period with 1-min equivalent sound pressure levels. At all the locations, measurement was taken at 1-min intervals over a 24 hour period. Further to that the equivalent noise levels have been converted to hourly equivalent noise levels. Finally, the measurements were done by dividing the 24 hours into two parts, i.e. daytime, which is considered from 0600 to 2200 hours and night from 2200 to 0600 hours. At each location, day time Leq has been computed from the hourly sound pressure level values measured between 0600 to 2200 hours and night time Leq has been computed from the hourly sound pressure level values measured between 2200 to 0600 hours.

The recorded noise levels in the study area are detailed in Table 4-16 and summarised in Table 4-17.

Table 4-16: Hourly Equivalent Noise Level in the Monitoring Locations

Hour	NL5-1	NL5-2	NL5-3	NL5-4	NL5-5	NL5-6	NL5-7	NL5-8	NL5-9
1:00-1:59 AM	49.9	61.5	71.8	67.6	62.6	60.6	65.8	60.7	54.7
2:00-2:59 AM	48.4	59.2	67.4	63.4	60.6	58.1	67.7	56.5	52.0
3:00-3:59 AM	48.5	58.3	65.6	60.5	58.7	57.4	65.0	53.6	53.1
4:00-4:59 AM	49.6	58.3	67.2	59.4	60.9	56.9	67.4	55.1	50.8
5:00-5:59 AM	51.6	60.2	65.7	65.8	59.7	57.9	68.2	54.9	52.6
6:00-6:59 AM	52.1	64.1	67.2	68.1	65.2	59.7	70.4	59.6	53.5
7:00-7:59 AM	54.9	66.1	68.3	69.9	69.9	65.3	71.9	61.3	57.2
8:00-8:59 AM	53.0	68.0	69.0	68.0	70.8	69.4	70.3	63.8	60.7
9:00-9:59 AM	54.8	71.2	71.6	68.4	69.4	68.8	69.2	64.2	63.2
10:00-10:59 AM	55.5	70.3	66.7	67.0	67.5	69.6	67.5	66.3	62.8
11:00-11:59 AM	53.6	72.1	68.8	66.2	65.5	64.5	69.6	65.6	65.8
12:00-12:59 PM	52.8	70.3	70.2	69.2	67.8	65.3	67.0	67.4	64.0
13:00-13:59 PM	51.4	69.4	69.9	70.9	65.2	63.4	68.9	68.2	67.5
14:00-14:59 PM	55.2	67.2	71.0	67.2	68.6	63.9	67.2	65.2	68.0
15:00-15:59 PM	53.3	68.1	72.6	66.3	65.7	64.4	65.0	64.6	66.0
16:00-16:59 PM	55.4	66.9	68.3	67.5	66.5	63.6	67.1	63.7	65.9
17:00-17:59 PM	52.8	70.7	70.5	69.3	64.3	67.5	70.3	65.0	64.9
18:00-18:59 PM	51.6	72.6	72.4	70.9	65.0	71.6	68.6	63.6	65.3
19:00-19:59 PM	50.6	69.3	71.1	68.5	67.2	70.1	69.5	66.6	63.3
20:00-20:59 PM	51.2	67.8	69.0	66.4	68.7	67.4	71.9	67.4	63.5
21:00-21:59 PM	50.5	68.8	68.2	68.1	69.8	65.1	69.3	64.1	65.1
22:00-22:59 PM	50.2	67.3	67.7	65.5	65.8	64.9	68.3	63.3	62.9
23:00-23:59 PM	51.3	61.3	68.5	66.9	64.9	66.0	70.5	62.9	59.2
00:00-00:59 AM	50.8	58.6	66.2	64.8	63.1	64.7	67.4	63.4	59.9

Source: Field Study by EQMS, Monitoring Date: 28th February, 2017 – 10th March, 2017

Table 4-17: Noise Level Analysis of MRT Line 5

Code	Lmax	Lmin	Leq_{day}	Leq_{night}	L90	L50	L10	Area Setting*	Standard**	
									Day	Night
NL1	65.6	43.7	54.3	50.1	47.6	50.4	56.3	Residential	55	45
NL2	84.2	58.8	69.2	63.5	60.1	64.3	70.5	Commercial	70	60
NL3	95.5	56.2	74.8	68.0	62.1	64.9	71.9	Commercial	70	60
NL4	82.7	55.1	69.3	65.7	60.7	63.7	70.1	Mixed	60	50
NL5	87.5	57.8	68.2	63.9	61.3	63.8	66.2	Commercial	70	60
NL6	84.8	53.4	67.3	62.3	59.1	61.9	69.5	Commercial	70	60
NL7	82.2	56.5	71.0	68.1	62.8	64.4	71.5	Commercial	70	60
NL8	90.3	52.7	65.9	59.7	56.1	60.5	67.3	Commercial	70	60
NL9	74.9	46.7	64.5	57.1	55.1	59.6	66.5	Commercial	70	60

Source: Field Study by EQMS

* Area setting (according to the ECR, 1997)

**Standard according to the ECR, 1997 and subsequent amendment in 2006

Note: The time from 0600 hrs to 2100 hrs is counted as daytime and from 2100 hrs to 0600 hrs is counted as night time

Exceeding Standard Level

Ambient daytime noise level (Leq_{day}) was recorded in the range of 54.3 to 74.8 dB (A). Whereas, ambient night time noise level (Leq_{night}) in the study area were 50.1 to 68.1 dB (A). Maximum noise levels ($L_{maximum}$) at the monitoring locations were recorded in the range of 65.5 to 95.5 dB(A) and the minimum noise levels ($Leq_{minimum}$) at the monitoring locations were recorded in the range of 43.7 to 58.8 dB(A).

From the analysis data it has been found that most of the noise level of monitoring station exceeds the ECR, 1997 standard during the night time. Noise level exceeds the standard level due to the huge number of traffic movement during day and night time.

4.9 Ecological Components

The biodiversity component of the study focused on biological components like flora, birds, reptiles, amphibians and mammals. Field work has been conducted in the depot site of MRT line 5. A multidisciplinary team related to ecology (terrestrial & aquatic) has been engaged to conduct the study.

The depot area is located near to the Bangshi (Savar) River which is the tributary of Turag River. The depot of MRT line 5 area is depressed land as well as agricultural land. During the monsoon season the depot land is inundated by the River water whereas the agricultural production has been carried out in the depot area during the dry period. Fish are found in the depressed area as the depot site is connected with the River.

4.9.1 Methodology

4.9.1.1 Flora

Ecological survey was undertaken in March 2017 in the depot of the MRT Line 5 using quadrate sampling method for different habitats. It has not been found any tree species in the depot site. According to the local people consultation, the depot site is used as agriculture and fisheries. The Quadrates study details have been provided in the Table 4-18.

Table 4-18: Vegetative study in the project area

Vegetative types	Area	Quadrates ID	GPS coordinates
Fallow Land (3 Quadrates) (size 2 m X 2 m)	Adjacent of the South-eastern part of the long demarcation	FLQ1	23°48'11.2"N 90°16'47.6"E
	North-West part of the Depot area	FLQ2	23°48'06.7"N 90°16'46.36"E
	South-Eastern Part of Long demarcation	FLQ3	23°48'04.9"N 90°16'45.55"E
Grass Land (3 Quadrates) (size 1 m X 1 m)	South-Eastern Corner of the Depot	GLQ1	23°48'09.8"N 90°16'33.5"E
	North-West part of the Depot area	GLQ2	23°47'58.5"N 90°16'26.14"E
	Adjacent of the South-eastern long demarcation	GLQ3	23°48'06.10"N 90°16'30.13"E

Pic#1 proposed depot area

Pic#2 Agricultural land in the depot area

Pic#3 Grassland of the depot area

Pic#4 Fallow land of the depot area

4.9.1.2 Fauna

Bird

The basic methods has been chosen based on setting up a single line at each site called a “transect”. The birds was identified either visually, by their calls or digitally recorded. This methods involves identifying all the birds; it has been seen or heard while standing at a series of points along a transect (Straight line through the site). Bird’s counts were conducted at the start of first light which is before sunrise. This time was when birds vocalized most, and is known as the “Dawn Chorus”. It is also time of maximum bird movement as birds through the bush to begin feeding. A systematic search in the project area (over a fixed area and/ or for a fixed time) such as the method specified here has been the added advantage of providing an index of the abundance of individuals and species. The reliability of the abundance index can be reduced by either overestimates or underestimates of bird numbers. To reduce overestimates, particularly when a member is observing, try to ensure that each individual bird is recorded only once. Hence, ensure that a least one member of the team was watching at all times. Focus Group Discussion (FGD) with local people (including villagers, school teachers, Mosque Imam) to get information of the local species available in the depot area.

Amphibians and Reptiles

Amphibians and Reptiles have been assessed on an opportunistic basis by the team. For this inventory, it has been used a combination of diurnal and nocturnal time-recorded visual encounter surveys ("general surveys"), road driving with capturing digital image from the spot. Interviews were held with local people in the area to assess the presence of game species. Focus Group Discussion (FGD) with local people (including villagers, school teachers, Imam) to get information of the local species available in the depot area.

Mammals

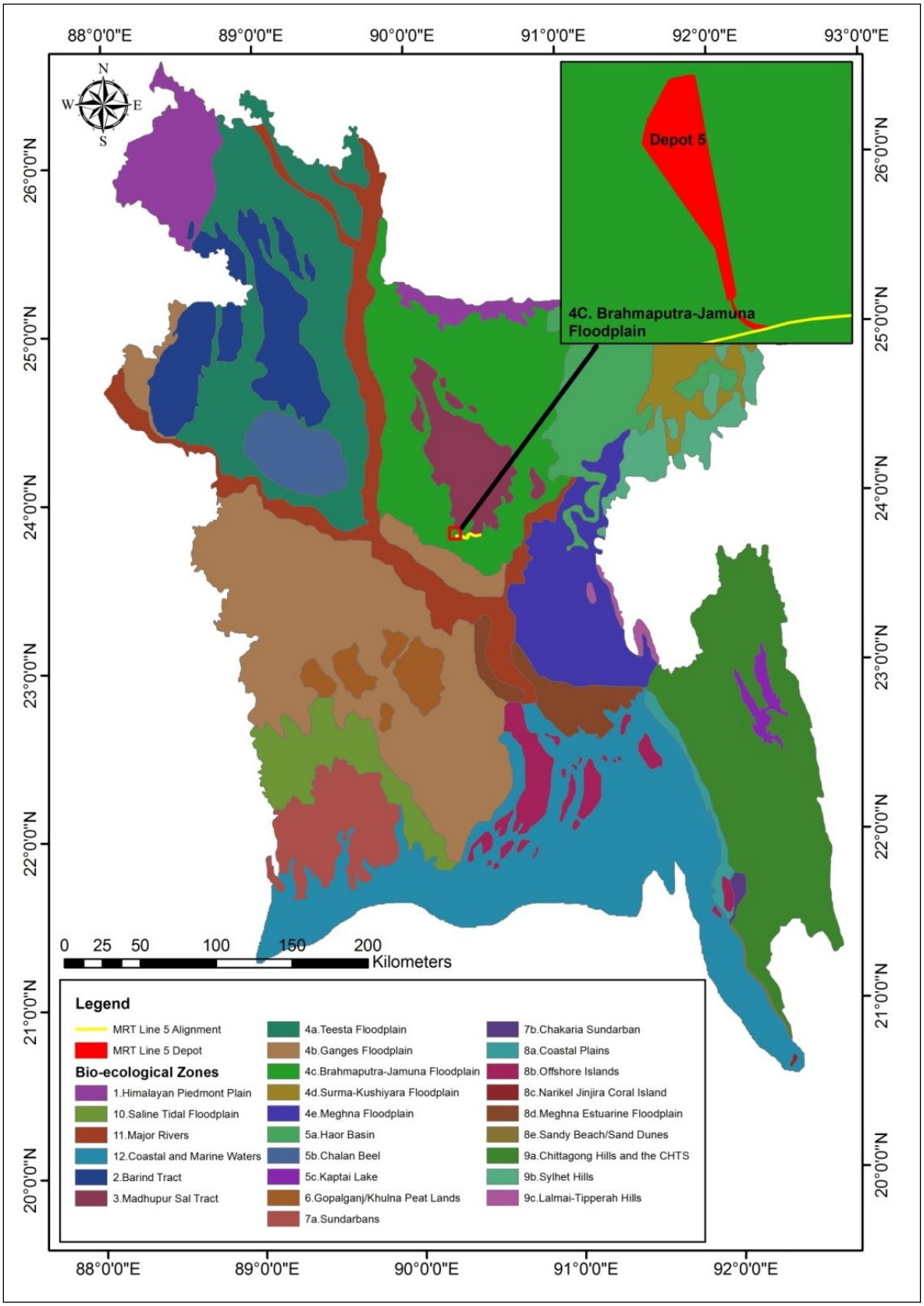
For mammal's inventory, it is generally huge challenging, time consuming as well as costly. During the inventory of this project area with the stipulated short time, it has been followed "Observational methods" including imaging record by digital camera, identification of dung or feces, tracks and others signs. Focus Group Discussion (FGD) with local people also consider during this inventory of the depot area.

Fisheries

Fisheries information collected from FGD with local people, Stakeholder consultation and secondary information.

4.9.2 Bio-Ecological Zone

Twenty-five bio-ecological zones have been delineated within Bangladesh by the IUCN. Six parameters were used to determine the areas including: physiography, soil, rainfall and temperature, floral distribution, faunal distribution and flood depth (IUCN 2002). The depot site falls in Brahmaputra-Jamuna Floodplain bio-ecological zone (Figure 4-16).



Source: IUCN 2002

Figure 4-16: Depot Location in Bio-ecological Zones of Bangladesh

Brahmaputra-Jamuna floodplain

The Brahmaputra-Jamuna floodplain possesses a unique variety of plants, medicinal herbs, fruits bearing trees, hundreds of jungle shrubs, creepers and climbers, flowering trees, etc., many of which yield valuable products. Some of floral species which are valued as timber products are: the Banyan (*Ficus bengalensis*), Tamarind (*Tamarindus indica*), Sada koroi (*Albiza Procera*), Shimul (*Bombax ceiba*), and Ashwath (*Ficus religiosa*). The prominent fruit bearing trees of this zone are: The Mango (*Mangifera indica*), Jackfruits (*Artocarpus heterophylus*), and Litchi (*Litchi chinensis*). Bushes of reeds and canes are also found here. This zone is similarly increased with orchids. The Rasna (*vanda roxburghii*) is commonly found in this zone (Khan, 1991).

Like the floral diversity this zone equally enjoys riches of faunal verity. According to Hunters (1875), Leopards were frequently sited in this zone. A few species of deer, such as Samber (*Cervus unicolor*), Hog deer (*Axis Procinus*), Swamp deer (*Cervus duvauceli*), and Barking deer (*Muntiacus muntjak*) were also once in around the everywhere in forest of this zone. Among the bird's species, small game birds such as common peafowl (*Pavo cristatus*), Red jungle fowl (*Gallus gallus*), partridges, and several verities of pheasants were commonly found. The Bangle florican (*Houbaropsis bengalensis*) and snipes are plentiful in the sandbanks and chars of this zone. On the other hand the most common poisonous snake is the Banded krait (*Bangarus fasciatus*) in this zone, which could easily be identified by its broad black and yellow bands.

4.9.3 Floral Component

The EQMS team had conducted ecological survey on flora and fauna in the depot area. The team also collected secondary information from literature and FGD from the study area to understand the overall terrestrial ecosystem. No tree species found in the depot location during the study period. The floral habitat has been described below.

4.9.3.1 Agricultural Land Vegetation

Some land in the depot area is used for agricultural activities. Generally paddy is cultivated in the agricultural land. Vegetable and mustard has been cultivated in the depot area agricultural land during winter season.

Pic#5: Agricultural crops in the project area

Pic#6: Agricultural Crops in the depot area

4.9.3.2 Fallow Land Vegetation

Three fallow land quadrates (each of size 2 m x 2 m) have been studied in the depot area. Out of 3 quadrates, a total of 12 species belonging 12 families have been found in the depot

area. Among the 12 species 75% are medicinal plants, 17% vegetables and 8% cattle fodder.

Fallow lands were dominated by herb species of Taro *(Colocasia esculenta)* Shame plant (*Mimusa pudica),* Scutchgrass (*cynodon dactylon*), Black nightshade (*Solanum nigrum*), spiny amaranth (*Amaranthus spinos*), Hill glory bower (*Aleroden dronviscosum*), Nut Grass (*Cyperus rotundus*), Ironweed (*Vernonia cinerea*), Yellow fruit nightshade (*Solanum xanthocarpum*), Caesarweed (*Eurena lobata*), Rattlebox Plant (*Crotalaria pallida*), diamond burbark (*Triumfetta rhomboidea).*

4.9.3.3 Grass Land Vegetation

Three quadrates of grass land (each of size 1 m x 1 m) were studied in this depot area. During study period 7 families have been recorded with 11 different species and Cyperraceae family has been found three times among those species. The second dominating family was Poaceae and Compositae which found twice during the survey tenure. Among the common grasses species *Cyperus rotundus, Cynodon doctylon, Amaranthus philoveroides, Alternanthera sessilis, Alerodendron viscosum* and *Eurena loba were notable***.**

4.9.3.4 Aquatic Vegetation

There is a depressed land in the depot area. The ecology team has been considered the depressed area for aquatic vegetation survey. A visual observation study has been carried out for the aquatic vegetation survey in this area.

Total of 16 aquatic species belonging 12 families were found whereas Lemnaceae and Polygonaceae family has been found maximum three times. List of aquatic vegetation is shown in the following Table 4-19.

Table 4-19: List of Aquatic Vegetation in the Depot Area

Sl.	Common Name	Family name	Scientific name	Types	Uses	Red Data Book of Bangladesh (National Herbarium Bangladesh 2001)
1.	Alligator Weed	Amaranthaceae	*Alternanthera philoxeroides*	Herb	Medicine	Not Evaluated
2.	Coco Yam	Araceae	*Colocasia esculenta*	Herb	Medicine	Not Evaluated
3.	Flatsedge	Cyperaceae	*Cyperus sp.*	Herb	Medicine	Not Evaluated
4.	Common Water Hyacinth	Pontaderiaceae	*Eichhornia crassipes*	Herb	Medicine	Not Evaluated
5.	Helencha	Cyperaceae	*Enhydra fluctuans*	Herb	Medicine	Not Evaluated
6.	Swamp Morning-Glory	Convolvulaceae	*Ipomoea aquatica*	Herb	Vegetable	Not Evaluated
7.	Four Leaf Clover	Mersileaceae	*Marsilea quadrifolia*	Herb	Vegetable	Not Evaluated
8.	Arrow Leaf Pondweed	Pontaderiaceae	*Monochoria hatata*	Herb	Fertilizer	Not Evaluated

Sl.	Common Name	Family name	Scientific name	Types	Uses	Red Data Book of Bangladesh (National Herbarium Bangladesh 2001)
9.	Water Lily	Nymphaeaceae	*Nymphaea nouchali*	Herb	Ornamental & vegetable	Not Evaluated
10.	Tall Reed	Gramineae	*Phragmites karka*	Herb	Grass	Not Evaluated
11.	Denseflower Knotweed	Polygonaceae	*Polygonum glabrum*	Herb	Grass	Not Evaluated
12.	Bishkatali	Polygonaceae	*Polygonum lanatum*	Herb	Medicinal	Not Evaluated
13.	Asian Water moss	Salviniaceae	*Salvina cucullata*	Herb	Fertilizer	Not Evaluated
14.	Common Duckweed	Lemnaceae	*Spirodela polyrhiza*	Herb	Fertilizer	Not Evaluated
15.	Sticky Nightshade	Solanaceae	*Solanum sisymbriifolium*	Shrub	Aesthetic	Not Evaluated
16.	Water Lettuce	Araceae	*Pistia stratiotes*	Herb	Fertilizer	Not Evaluated

Source: Field Survey by EQMS

4.9.4 Faunal Component

4.9.4.1 Birds (Avifauna)

Common bird species has been found in the depot area during the survey period. During the survey tenure, a total of 22 species belongings of 15 families have been founded at the depot site.

The highest number of families has been found four times of Sturnidae and second highest has been found in Alcedinidae family. The depressed and grass lands are the feeding and roosting ground of wild birds. All species are least concern (LC) according to IUCN Red List 2015. A detail of bird's species checklist is presented in Table 4-20.

Table 4-20: Bird Species in the Depot Area

Sl.	Local Name	Common Name	Scientific name	Family	IUCN status Bangladesh 2015
1.	Doyel	Oriental Magpie Robin	*Copsychus saularis*	Muscicapidae	LC
2.	Deshi Kanibok	Indian Pond Heron	*Ardeola grayii*	Ardeidae	LC
3.	Chhoto pankouri	Little Cormorant	*Microcarbo niger*	Phalacrocoracidae	LC
4.	Kala Fingey	Black Drongo	*Dicrurus macrocercus*	Dicruridae	LC
5.	Gash pakhi	Striated Grass bird	*Megalurus palustris*	Locustellidae	LC
6.	Pati Chorui	House Sparrow	*Passer domesticus*	Passeridae	LC
7.	Telia Ghughu	Spotted Dove	*Spilopelia chinensis*	Columbidae	LC

Sl.	Local Name	Common Name	Scientific name	Family	IUCN status Bangladesh 2015
8.	Pati Hoodhood	Common Hoopoe	*Upupa epops*	Upupidae	LC
9.	Pakra Shalik	Asian Pied Starling	*Gracupica contra*	Sturnidae	LC
10.	Dhan salik	Common Myna	*Acridotheres tristis*	Sturnidae	LC
11.	Pati Maachranga	Common Kingfiher	*Alcedo atthis*	Alcedinidae	LC
12.	Pati Kak	House Crow	*Corvus splendens*	Corvidae	LC
13.	Bulbuli	Red-vented Bulbul	*Pycnonotus cafer*	Pycnonotidae	LC
14.	Sada Bok	Little Egret	*Egretta garzetta*	Ardeidae	LC
15.	Dar Kak	Jungle Crow	*Corvus levaillantii*	Corvidae	LC
16.	Moutusi	Sun bird	*Nectarinia asiatica*	Nectariniidae	LC
17.	Dholagola Maachranga	White-throated Kingfisher	*Halcyon smyrnensis*	Alcedinidae	LC
18.	Metepith Latora	Grey-backed Shrike	*Lanius tephronotus*	Laniidae	LC
19.	Pati Fotikjol, Towfi	Common Iora	*Egithina tiphia*	Aegithinidae	LC
20.	Bon salik	Jungle Myna	*Acridotheres fuscus*	Sturnidae	LC
21.	Kath Shalik	Chestnut-tailed Starling	*Sturnus malabaricus*	Sturnidae	LC
22.	Lenja Latora	Long tailed shrike	*Lanius schach*	Lanidae	LC

Source: Field Survey by EQMS

4.9.4.2 Amphibians and Reptiles

During field investigation, a total 5 species belonging same number of families has been found in the depot area. Bengal Monitor (*Varanus bengalensis),* Long-tailed Lizard *(Takydromous khasiensis),* Asian Common Toad *(Duttaphrynus melanostictus),* Common House Gecko *(Hemidactylus frenatus)* are found in the depot area. Bengal Monitor (*Varanus bengalensis)* has been found Near Threatened according to the IUCN red list status 2015 whereas rest of the species is Least Concern. A detail species list has been provided in (Table 4-21**).**

Table 4-21: List of Amphibians and Reptiles in Depot Area

SL.	Local Name	*English Name*	Scientific Name	Family	IUCN Red List Status (Regional)
1.	Anjon	Common Skink	*Eutropis carinata*	Scincidae	LC
2.	Gui shap	Bengal Monitor	*Varanus bengalensis*	Varanidae	NT
3.	Lamba Leiz Roktochusa	Long-tailed Lizard	*Takydromous khasiensis*	Lacertidae	LC

SL.	Local Name	*English Name*	Scientific Name	Family	IUCN Red List Status (Regional)
4.	Kono bang	Asian Common Toad	*Duttaphrynus melanostictus*	Bufonidae	LC
5.	Tiktiki	Common House Gecko	*Hemidactylus frenatus*	Gekkonidae	LC

Note: *LC-Least Concern, NT-Near Threatened*

4.9.4.3 Mammals

It has been recorded 4 mammal's species belonging three families in the study area. Mammals that were found within the project area are Small Asian Mongoose (*Herpestes auropunctatus*), Golden Jackal (*Canis aureu*), Little Indian field mouse (*Mus booduga*), and House mouse (*Mus musculus*). According to the IUCN red list status 2015, all species are least concern.

4.9.4.4 Fisheries

The depot site is almost depressed area and it is inundated by the River water during the monsoon season. Water present in the depressed area almost throughout the year and different types of fish species has been found in the depressed area. Ecology team has been consulted with Savar Upazila Fisheries officer and discuss with local people to know the status of fisheries in the depot area. According to the fisheries officer and local people total 15 fish species belongings to 10 families are found in the depot area. Cyprinidae family has been found eight times among this species. All species are least concern status according to the IUCN red list status 2015. The checklist of the fish species in the depot area has been provided in Table 4-22.

Pic#7: Fishing at the depot area

Pic#8: Fishing at the depot area

Table 4-22: Checklist of Fish Species in the Depot Area

Sl.	Local Name	English Name	Scientific Name	Family	IUCN Red List Status Bangladesh 2015
1.	Guchi Baim	Striped spinyeel	*Macrognathus pancalus*	Mastacembelidae	LC
2.	Khailsha	Giant gourami	*Colisa fasciata*	Osphronemidae	LC

Sl.	Local Name	English Name	Scientific Name	Family	IUCN Red List Status Bangladesh 2015
3.	Lal Khalisha	Red gourami	*Colisa lalia*	Osphronemidae	LC
4.	Koi	Climbing perch	*Anabas testudineus*	Anabantidae	LC
5.	Bele	Tank goby	*Glossogobius giuris*	Gobiidae	LC
6.	Shol	Striped snakehead	*Channa striatus*	Channidae	LC
7.	Taki	Spotted Snakehead	*Channa punctatus*	Channidae	LC
8.	Shing	Stinging catfish	*Heteropneustes fossilis*	Heteropneustidae	LC
9.	Magur	Air breathing Catfish	*Clarias batrachus*	Clariidae	LC
10.	Gutum	Cross fish	*Lepidocephalichthys guntea*	Cobitidae	LC
11.	Rui	Rohu	*Labeo rohita*	Cprinidae	LC
12.	Catla	Catla	*Catla catla*	Cyprinidae	LC
13.	Chola Punti	Swamp barb	*Puntius chola*	Cyprinidae	LC
14.	Jat punti	Pool barb	*Puntius stigma*	Cyprinidae	LC
15.	Mola	Mola carplet	*Amblypharyngodon mola*	Cyprinidae	LC

Note: *LC-Least Concern*

4.10 Social and Economic Factors

4.9.1 Socio Economic Environment condition

The present socio-economic conditions of the people of the project or study area will provide sound reference and assess probable socio-economic impact of the proposed interventions. This will enable us to compare the changes and impacts of the project interventions in future.

The socio-economic baseline scenario describes the socio-economic characteristics of project area on the basis of primary and secondary data. The socio-economic characteristics include administrative area, demographic, household size, education, occupation, housing, employment opportunity, health, housing, access to water and sanitation status, etc.

4.9.1.1 Administrative Divisions and Location

The Project site is located in Dhaka District. Dhaka is the most populous city in Bangladesh, the tenth-largest city in the world, and the political, economic and cultural heart of Bangladesh. It lies between 23º53` and 24º06` north latitudes and between 90º01' and 90º37' east longitudes. Dhaka city consists of 2 City Corporations - Dhaka North City Corporation and Dhaka South City Corporation for ensuring better civic facilities. These two corporations are headed by City Mayor. Area within city corporations divided into several wards, which each have a ward commissioner and wards are further subdivided into mouza. In the greater Dhaka Metropolitan Area, the prominent division is Thana, used also within

DCC, but subdivided further outside the DCC into unions and these unions are headed by Union Parishad Chairman.

These two city corporations have different administrative boundaries with overall 10 zones and 92 wards, where Dhaka South City Corporation has 56 wards and Dhaka North City Corporation has 36 wards.

On the other hand Savar Upazila consists of 12 union parishad. There are also 2 Thana, 1 Pourashava, 377 villages. Table 4-23 show the list of wards/union adjacent to the alignment in North and South Dhaka.

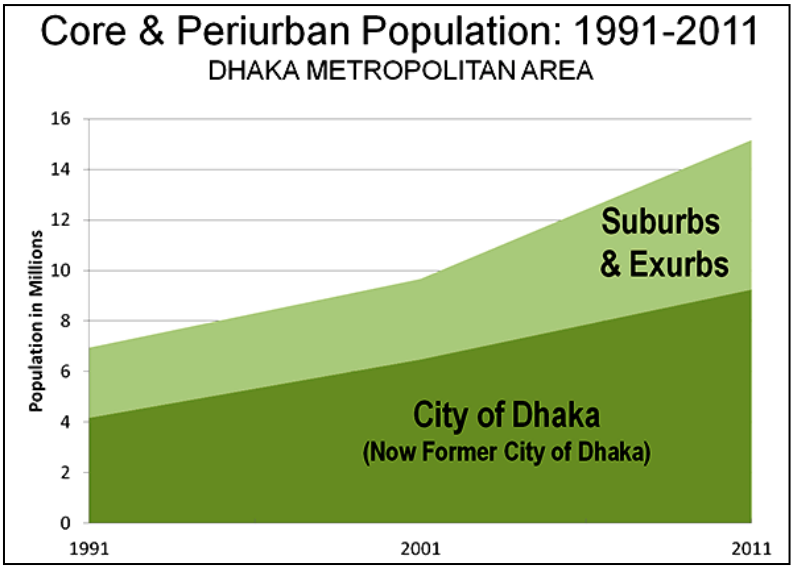
Table 4-23: Study Area/Wards of the MRT Line 5 Alignment

Upazila/Ward	Area/Thana/Union Covered
Dhaka North City Corporation	
Ward-03	Mirpur section-10
Ward-04	Mirpur section-14, Byshteki
Ward-07	Mirpur section-2, Rupnagar, Govt. housing Estate
Ward-08	Mirpur section-1, Box nagar, Zoo and Botanical Garden
Ward-09	Golartek, Bagbari, Gabtoli Bus Terminal
Ward-10	Gabtoli, Mirpur Colony, Darus Salam
Ward-11	Paikpara
Ward-12	Ahmed Nagar
Ward-14	Kazipara, Sawrapara, Senpara-parbata
Ward-16	Ibrahinpur, Kafrul
Ward-18	Baridhara, Shahjadpur
Ward-19	Gulshan, Banani
Savar Upazila and Tejgaon Unnayon Circle	
Savar Upazila	Banagram, Kaundia, Tetuljhora, Amin Bazar
Tejgaon Unnayon Circle	Bhatara.

(http://www.dncc.gov.bd/, 2017)

4.9.1.2 Population and Demography

Dhaka is the most populated city in Bangladesh, and it is also one of the most populated cities in the world. According to Population and Housing Census, 2011 the city itself has a population estimated at about 8 million. Over the past decade, both population and core areas administered by DCC have increased (**Figure 4-17**).



Source: (Cox, 2012)

Figure 4-17: Dhaka Metropolitan Area Population Growth

In the study area, there are 375541 households (HHs) including squatters with a total population of 1566290 that will be affected by the implementation of the Project. The average household size is 4.2. **Table 4-24** shows the Demography of the study area.

Table 4-24: Demography of the Study area crossed by the Project

City Corporation/ Upazila	Ward No./ Union	Total Population	Total HHs	Avg. HH size	Sex Ratio	Literacy (%)
Dhaka North City Corporation	Ward No-03	94664	22275	4.2	108	72.3
	Ward No-04	75246	18058	4.2	124	77.9
	Ward No-07	113750	26844	4.2	112	70.7
	Ward No-08	111251	27116	4.1	115	71.5
	Ward No-09	71260	16936	4.2	126	65.6
	Ward No-10	87879	23128	3.8	116	68.4
	Ward No-11	97033	22905	4.2	120	79.7
	Ward No-12	116544	27286	4.3	117	80.4
	Ward No-14	163797	38571	4.2	116	81.4
	Ward No-16	142413	35008	4.1	112	77.1
	Ward No-18	63616	14365	4.4	136	81.2
	Ward No-19	96291	22646	4.3	119	69.4
Savar Upazila	Banagram	33627	7813	4.3	112	51.7
	Kaundia	27796	6182	4.5	116	54.1
	Tetuljhora	106929	26287	4.1	119	63.9
	Amin Bazar	37500	8907	4.2	119	54
Tejgaon Unnoyon	Bhatara	126694	31214	4.1	134	70.9

City Corporation/ Upazila	Ward No./ Union	Total Population	Total HHs	Avg. HH size	Sex Ratio	Literacy (%)
Circle						
Study Area		1566290	375541	4.2	119	70.0

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Literacy rates are available by ward as shown in **Figure 4-18** alongside sex ratio. The correlation coefficient between these variables is 0.23, inferring there is little relationship. The Correlation of Sex Ratio and Literacy is shown in **Figure 4-18**. The illiteracy rate in the study area is 70% which is higher than the national average 42.1% and the average sex ratio (number of males per 100 females) is 119.

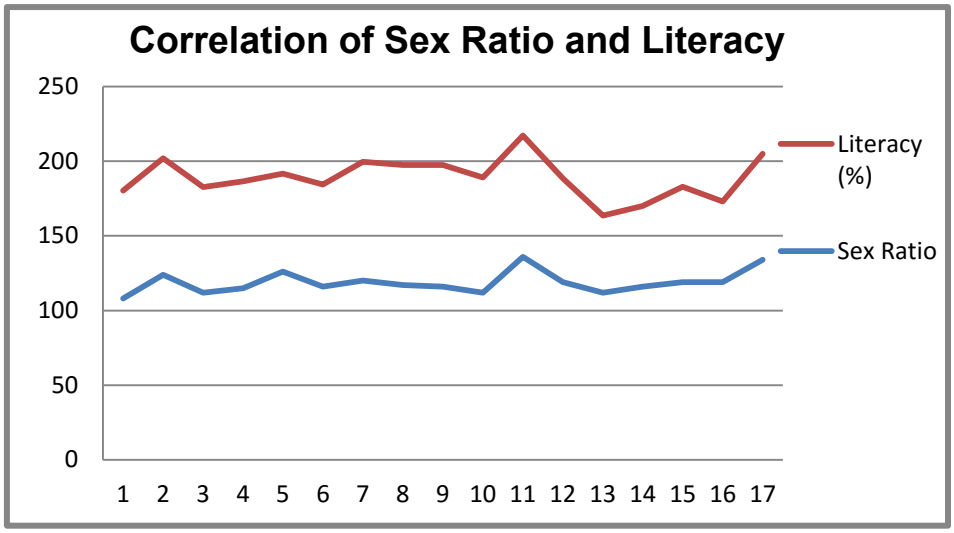
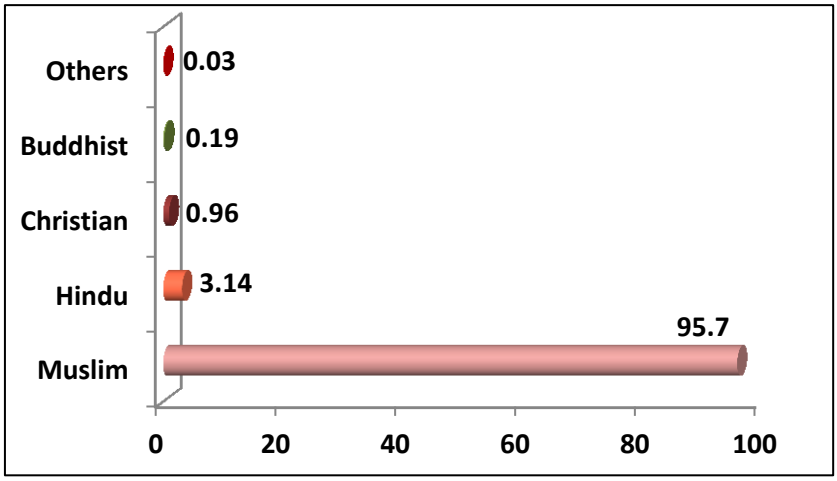


Figure 4-18: Correlation of Sex Ratio and Literacy

4.9.1.3 Religion

As per the 2011 census, the population of the study area dominated by The Muslim community (95.7%) in terms of faith. The second group goes to Hindu who is only 3.14% and other groups (Christian and Buddhist) are very negligible in percentage. The following Figure 4-19 indicates the various religious profile of the study area.

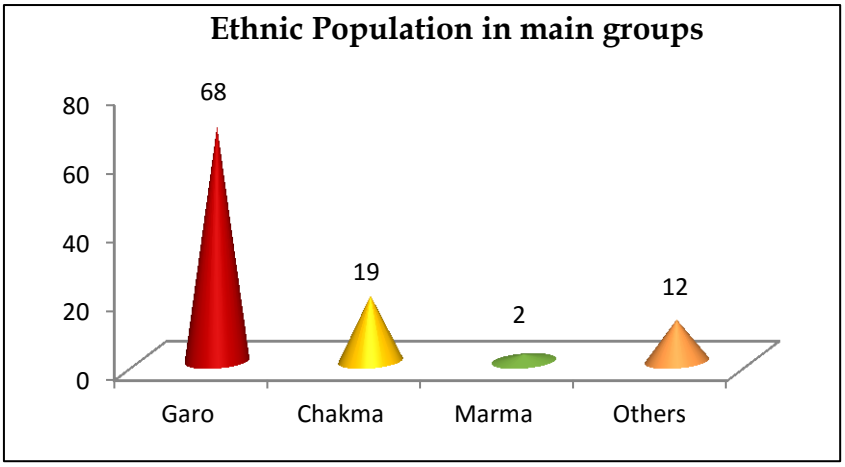


Source: Population a nd Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Figure 4-19: Religious Profile of the Study Area

4.9.1.4 Ethnic Composition

According to population census (2011), among the selected Unions 5409 ethnic households are found in the study area. Garo, Chakma, Marma and some other ethnic communities are over there. Ethnic composition of the Study area is dominated by the Garo community**.** **Figure 4-20** shows the distribution of ethnic community of the study area.

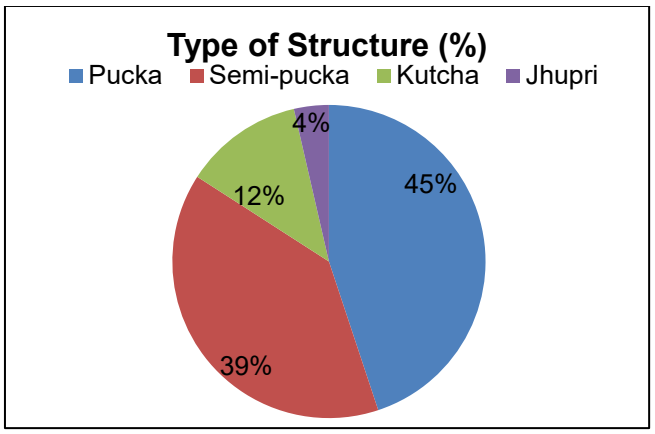


Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Figure 4-20: Distribution of Ethnic Community

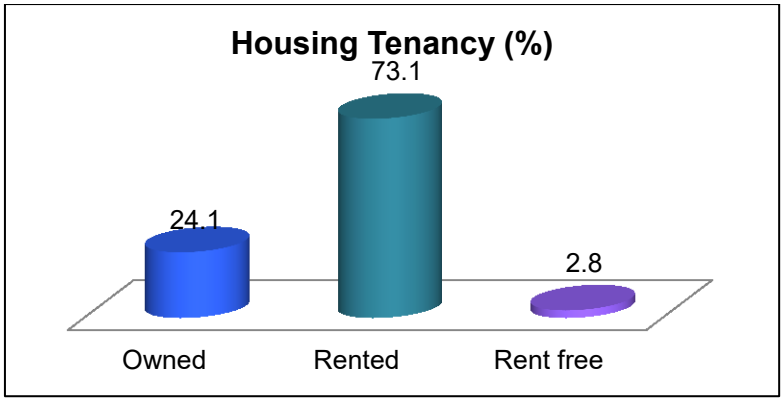
4.9.1.5 Human Settlement and Housing

According to population census (2011), total household of the study area is 356409. Predominant structure of this study area is Pucka (45%) followed by Semi-pucka (39%), Kutcha (12%) and Jhupri (4%). Housing tenancy of the study area is owned by (24.1%), rented (73.1%) and Rent free (2.8%). **Figure 4-21** and **Figure 4-22** show the Type of structure and Housing tenancy in the project study area.



Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS

Figure 4-21: Type of Housing Structure in the Study Area

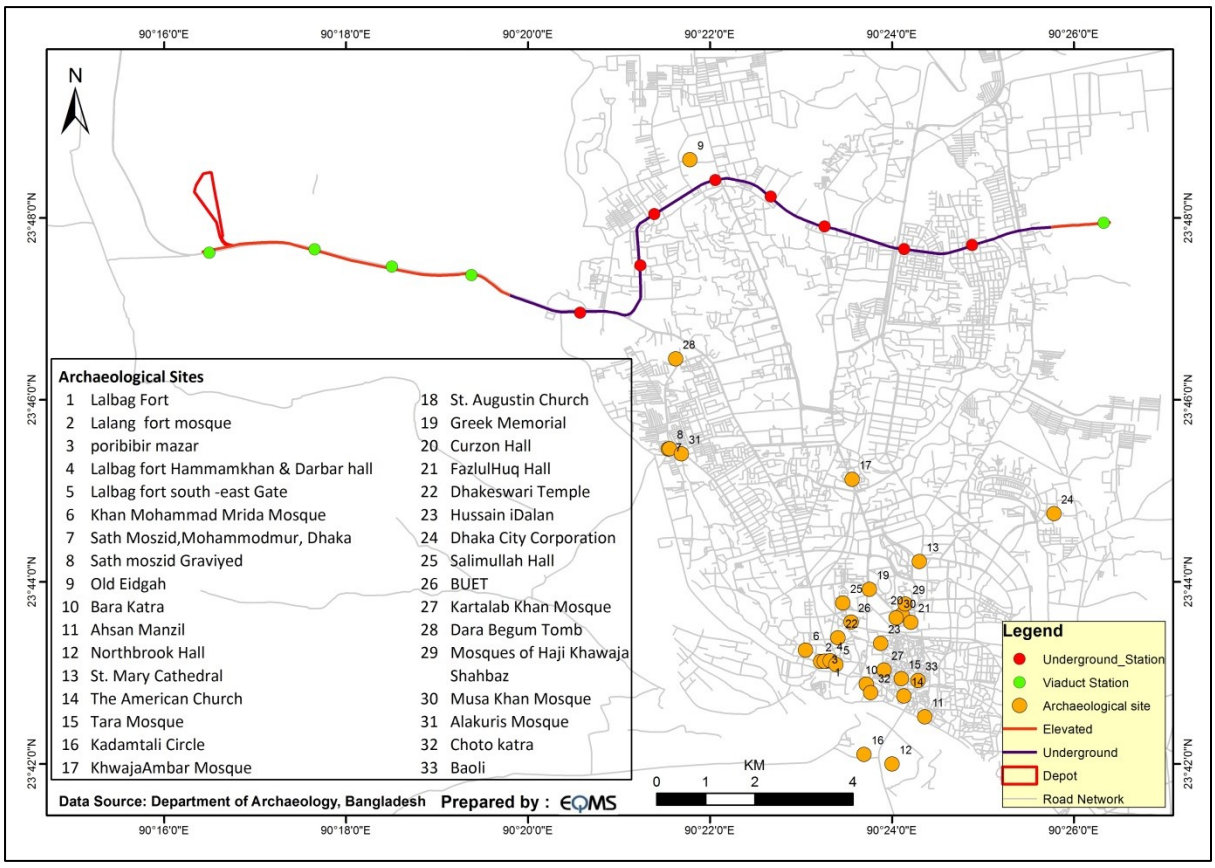


Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Figure 4-22: Housing Tenancy in the Study Area

4.9.2 Historical and Archaeological Features

In RAJUK area, seventy four archaeological heritages including the followings are pre-served. Major archaeological heritages in Dhaka city are shown Figure 4-23.



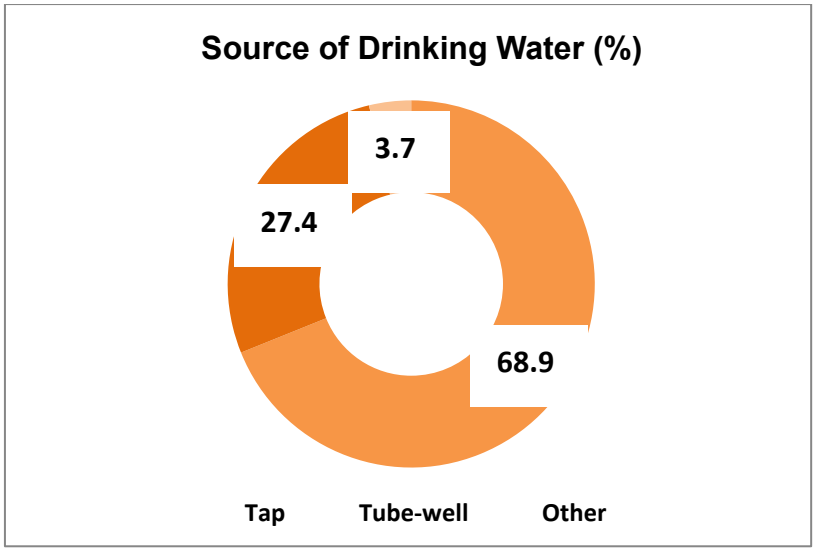
Source: Department of Archeology, Bangladesh

Figure 4-23: Archaeological Heritage in Dhaka city

4.9.3 Public Utilities

4.9.3.1 Water supply

In the project study area, the major source of drinking water is tap-water, where about 68.9% population use tap-water. About 27.4% people have access to tube-well. Other 3.7% people have access neither tube-well nor tap water. An overview is depicted in **Figure 4-24** below.

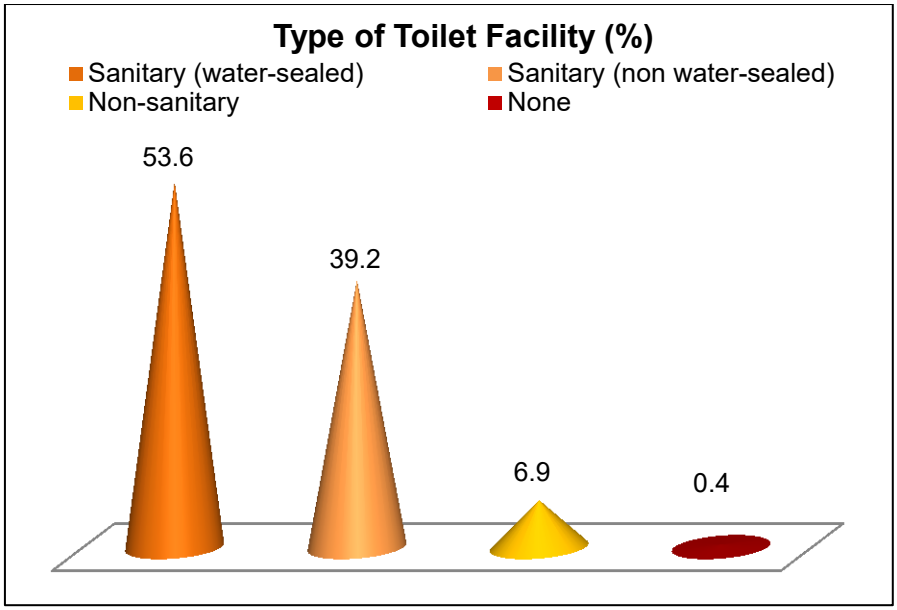


Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Figure 4-24: Sources of Drinking Water of the Study Area

4.9.3.2 Sanitation

In the study area only about 53.6% and 39.2% of households use respectively water sealed and non-water sealed sanitary latrine facility which represents the 92.8% households of the study area. 6.9% households use non sanitary facilities. Only 0.4% households defecate in open places with no access to hygienic latrine facilities. **Figure 4-25** shows sanitation facility of the project area.



Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

Figure 4-25: Sanitation Facility of the Project Area

4.9.3.3 Electricity

Electricity is an important indicator for measuring the quality of life in the Study area. According to Population and Housing Census 2011, in the study area 98.3% of the households have grid electricity connection.

4.9.4 Economic Activities

In accordance to the Census of Bangladesh (2011), service is the dominant source of employment in the study area. Approximately, 60204 and 30232 male and female involved in service related activities. Moreover, significant numbers of the population; 24218 male and 20279 female, of the study area are involved in industrial activities. According to census in the study area, agriculture (including livestock and farming) is another source of income. Though 6951 male and 612 female are involved in agricultural activities in the study area. Table 4-25 shows employment status of the Study area.

Table 4-25: Employment status of the study area

City Corporation/Upazila	Ward No./ Union	Population Aged 7+, not attending school but employed			Field of Activity					
					Agriculture		Industry		Service	
		Total	Male	Female	Male	Female	Male	Female	Male	Female
Dhaka North City Corporation	Ward No-03	94664	6421	3402	136	15	3299	1847	2986	1540
	Ward No-04	75246	3202	2718	25	0	926	1774	2251	944
	Ward No-07	113750	4645	3574	331	28	1567	1759	2747	1787
	Ward No-08	111251	7313	4262	467	98	2083	2350	4763	1814
	Ward No-09	71260	6728	2183	104	7	1096	910	5528	1266
	Ward No-10	87879	5972	3065	141	24	1563	1263	4268	1778
	Ward No-11	97033	3860	2699	77	11	621	885	3162	1803
	Ward No-12	116544	3850	2470	63	11	1038	884	2749	1575
	Ward No-14	163797	5284	4085	100	7	1618	1547	3566	2531
	Ward No-16	142413	6716	4274	122	7	1970	1664	4624	2603
	Ward No-18	63616	2564	1669	12	0	180	59	2372	1610
	Ward No-19	96291	6316	6220	221	69	947	826	5148	5325
Savar Upazila	Banagram	33627	3731	476	2140	57	318	128	1273	291
	Kaundia	27796	3592	651	183	10	1431	133	1978	508
	Tetuljhora	106929	8738	4370	2351	197	4017	3261	2370	912
	Amin Bazar	37500	4600	1429	201	36	85	117	4314	1276
Tejgaon Unnayon Circle	Bhatara	126694	7841	3576	277	35	1459	872	6105	2669
Project Study Area		1566290	91373	51123	6951	612	24218	20279	60204	30232

Source: Population and Housing Census, 2011, Bangladesh Bureau of Statistics (BBS)

4.11 Socio-economic Characteristics of Affected Households

4.11.1 Affected Population

A total of 3047 people have been identified as affected by losing residential structure, commercial structure, trees, ponds and other minor infrastructure. Community Property Resources (CPR) (22) have not been considered in calculating population. A total of 10 households will be displaced from their own residence and 15 will be displaced from the rented housing structure. On the other hand 111 household will lose their commercial structure, 04 household will lose both homestead and CBE, 02 household will lose their trees or other minor structures like gates, drains, walls etc. A total of 579 vendors or temporary shop owners will have to be displaced for the project intervention. Average household size of the project area is 4.2 which is lower than the national average (4.5). Out of the total affected population, 1684 (55.27%) male and 1363 (44.73%) female. Location wise number of affected male and female population is shown in the Table 4-26.

Table 4-26: Number of Male and Female Population by Zone

Location	Total HH	Population		
		Male	Female	Total population
Hemayetpur	40	109	93	202
Baliarpur	12	33	28	61
Bilamalia	07	17	12	29
Amin Bazar	106	283	248	531
Gabtoli	15	42	34	76
Dar-Us-Salam	28	68	62	130
Mirpur-1	17	36	35	71
Mirpur-10	314	647	479	1126
Mirpur-14	4	07	12	19
Kochukhet	38	85	70	155
Banani	13	25	25	50
Gulshan 2	00	00	00	00
Notun Bazar	47	101	92	193
Bhatara	78	228	169	397
Depot Area	02	03	04	07
Total	**721**	**1684**	**1363**	**3047**

Source: Census & Socioeconomic survey, April 2017

4.11.2 Ethnicity Religion and Gender

Based on findings of the survey, the Project will affect 721 households for this project. Out of total 721 households 700 are Muslim and 21 are Hindu. No ethnic minority is found in the proposed project locations. Detail of households in terms of religion is shown in Table 4-27.

Table 4-27: Affected Households by Location and Religion

Station Name	Religion				Total (No)	%
	Muslim (No)	%	Hindu (No)	%		
Hemayetpur	40	100.00	0	0.00	40	100.00
Baliarpur	12	100.00	0	0.00	12	100.00
Bilamalia	07	100.00	0	0.00	07	100.00
Amin Bazar	106	100.00	0	0.00	106	100.00
Gabtoli	14	93.33	1	6.67	15	100.00
Dar-Us-Salam	27	96.43	1	3.57	28	100.00
Mirpur-1	16	94.12	1	5.88	17	100.00
Mirpur-10	306	97.45	8	2.55	314	100.00
Mirpur-14	4	100.00	0	0.00	4	100.00
Kochukhet	35	92.11	3	7.89	38	100.00
Banani	13	100.00	0	0.00	13	100.00
Gulshan 2	00	00	00	00	00	00
Notun Bazar	44	93.62	3	6.38	47	100.00
Bhatara	74	94.87	4	5.13	78	100.00
Depot Area	02	100.00	0	0.00	02	100.00
Total	**700**	**97.10**	**21**	**2.90**	**721**	**100.00**

Source: Census & Socioeconomic survey, April 2017

Among the affected households 699 are male headed and 22 are female headed. In total less than 3.05 percent of the heads are headed by female.

4.11.3 Level of Education

Over last few decades a significant changes took place in education sector. Despite many problems, people are moving forward towards education. Only 0.60% household heads are illiterate and about 14.40% have completed secondary school and more than 06% of them are graduates (Table 4-28). More than 42% have education up to level V. However, level of education is low among the female heads of the households as compared to the male heads.

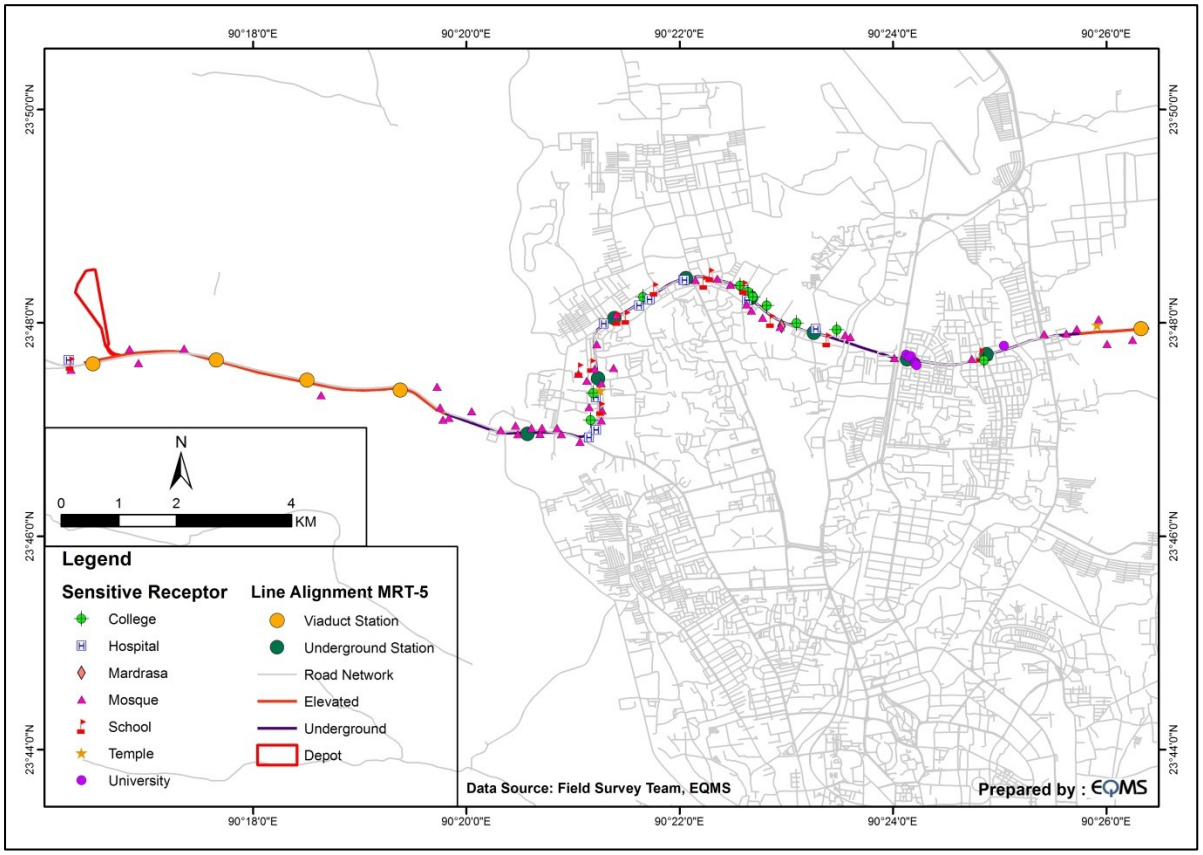
Table 4-28: Level of Education of the Head of the Households in Percentage by Location

Station Name	Level of Education						
	Illiterate	Class-I-V	Class VI-X	SSC & HSC	Graduate	Above Graduate	Total
Hemayetpur	0.00	52.50	27.50	12.50	2.50	5.00	100.00
Baliarpur	0.00	58.30	33.30	08.30	0.00	0.00	100.00
Bilamalia	14.30	42.90	42.90	0.00	0.00	0.00	100.00
Amin Bazar	0.90	30.20	48.10	17.90	0.00	2.80	100.00
Gabtoli	0.00	60.00	60.00	0.00	0.00	0.00	100.00
Dar-Us-Salam	3.57	64.29	64.29	14.29	0.00	0.00	100.00
Mirpur-1	0.00	64.71	64.71	11.76	0.00	0.00	100.00

Station Name	Level of Education						
	Illiterate	Class-I-V	Class VI-X	SSC & HSC	Graduate	Above Graduate	Total
Mirpur-10	0.00	38.85	38.85	15.61	3.18	2.55	100.00
Mirpur-14	0.00	100.00	100.00	0.00	0.00	0.00	100.00
Kochukhet	0.00	63.16	63.16	7.89	2.63	2.63	100.00
Banani	0.00	38.46	38.46	15.38	0.00	15.38	100.00
Gulshan 2	0.00	00.00	00.00	00.00	00.00	00.00	00.00
Notun Bazar	0.00	25.53	25.53	17.02	8.51	6.38	100.00
Bhatara	1.37	46.58	46.58	15.07	5.48	8.22	100.00
Depot Area	0.00	50.00	0.00	0.00	0.00	50.00	100.00
Total	**0.60**	**42.00**	**36.60**	**14.40**	**02.80**	**03.60**	**100.00**

Source: Census & Socioeconomic survey, April 2017

The numbers of school going children are increasing. Today, almost all the young children are going to school, girl children are more advanced in this regard as the GOB is providing facilities for them. This is an urban area with good opportunity to go to school. Young generations irrespective of sex have much higher level of education than compared to the heads of the households. There is several schools, college, university, Madrasa, Mosque along the proposed MRT line 5 alignment. The following Figure 4-26 shows the education and religious institution along the proposed MRT line 5 alignment.



Source: Field Survey by EQMS

Figure 4-26: Education and Religious Institution along the MRT Line 5 Alignment

4.11.4 Age and Occupation

The largest proportion of population is in age group 15-29 followed by age group of 30-44 and up to 14 irrespective of male and female population in all the locations. Population within the age group 45-59 is more than 16% and above 60 is more than 11%. Highest percentage of young population is found in Mirpur 14 followed by Bilamalia and Gabtoli. Table 4-29 shows in detail.

Table 4-29: Age Distribution of Affected Population

Station Name	Age Group										Total	
	Upto -14		15-29		30-44		45-59		60 & Above			
	No	%	No	%	No	%	No	%	No	%	No	%
Hemayetpur	47	23.30	53	26.20	40	19.80	35	17.30	27	13.40	202	100.00
Baliarpur	13	21.30	15	24.60	13	21.30	11	18.00	09	14.80	61	100.00
Bilamalia	07	24.10	08	27.60	05	17.20	03	10.30	06	20.70	29	100.00
Amin Bazar	118	22.20	162	30.50	114	21.50	86	16.20	51	09.60	531	100.00
Gabtoli	22	28.95	17	22.37	18	23.68	12	15.79	07	9.21	76	100.00
Dar-Us-Salam	28	21.54	37	28.46	28	21.54	19	14.62	18	13.85	130	100.00
Mirpur-1	13	18.31	26	36.62	14	19.72	13	18.31	05	7.04	71	100.00
Mirpur-10	203	18.03	376	33.39	229	20.34	200	17.76	118	10.48	1126	100.00
Mirpur-14	06	31.58	04	21.05	04	21.05	02	10.53	03	15.79	19	100.00
Kochukhet	32	20.65	50	32.26	27	17.42	31	20.00	15	9.68	155	100.00
Banani	10	20.00	12	24.00	12	24.00	9	18.00	07	14.00	50	100.00
Gulshan 2	00	00	00	00	00	00	00	00	00	00	00	00.00
Notun Bazar	43	22.28	54	27.98	44	22.80	31	16.06	21	10.88	193	100.00
Bhatara	104	26.20	99	24.94	98	24.69	51	12.85	45	11.34	397	100.00
Depot Area	00	00	01	14.30	04	57.1	00	00	02	28.60	07	100.00
Total	**646**	**21.2**	**914**	**30.0**	**650**	**21.3**	**503**	**16.5**	**334**	**11.10**	**3047**	**100.00**

Source: Census & Socioeconomic survey April 2017

Many of the stations under this project are located nearer to the business centers where people usually gather. This is why people who are living around the area have established business and some small shops on government land either by some arrangement or just squatters where they got the opportunity. It is found that more than 94% household head are involved in business. A total of 0.70% of the household heads' principal occupation is service in government or other organizations, 1.50% are involved in rickshaw/van pulling or work as mechanic and 1.40% are involved with household work who are mainly the female heads of the household. On the other hand 0.30% is aged/retired and have no specific income source. About 0.60% household heads are involved with other type of occupation; many of them are working as labor with special skill. Principal occupation of the heads of the households is shown in Table 4-30**.**

Table 4-30: Principal Occupation Head of the Households by Location

Station Name	Principal Occupation											Total
	Business	**Ser vice**	**Household work**	Teachers (School/ College)	Labor	Driver	Student	Children	Rickshaw/ Van puller/ Mistry	Retired/Old age/ Jobless	Others	
Hemayetpur	90.00	0.00	02.50	02.50	05.00	0.00	0.00	0.00	0.00	0.00	0.00	100
Baliarpur	91.70	0.00	0.00	0.00	0.00	08.30	0.00	0.00	0.00	0.00	0.00	100
Bilamalia	71.40	0.00	0.00	0.00	0.00	0.00	0.00	0.00	28.60	0.00	0.00	100
Amin Bazar	95.30	01.90	0.00	0.00	0.00	00.90	00.90	0.00	0.00	00.90	0.00	100
Gabtoli	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100
Dar-Us-Salam	92.86	0.00	0.00	0.00	0.00	0.00	0.00	0.00	07.14	0.00	0.00	100
Mirpur-1	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100
Mirpur-10	98.73	0.00	0.96	0.00	0.00	0.00	0.00	0.00	0.32	0.00	0.00	100
Mirpur-14	100.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100
Kochukhet	89.47	02.63	02.63	0.00	0.00	0.00	0.00	0.00	05.26	0.00	0.00	100
Banani	92.31	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	07.69	100
Gulshan 2	00	00	00	00	00	00	00	00	00	00	00	00
Notun Bazar	97.87	0.00	0.00	0.00	0.00	0.00	0.00	0.00	02.13	0.00	0.00	100
Bhatara	79.49	02.56	05.13	01.28	2.56	0.00	0.00	0.00	03.85	01.28	03.85	100
Depot Area	50.00	0.00	50.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	0.00	100
Total	**94.30**	**00.70**	**01.40**	**00.30**	**00.60**	**00.30**	**00.14**	**0.00**	**01.50**	**00.30**	**00.60**	**100**

Source: Census & Socioeconomic survey April 2017

4.11.5 Income and Poverty Dimensions

Poverty in Bangladesh is measured through per capita income or through Direct Calorie Intake (DCI) where persons having DCI of less than 2,122 kcal are considered to be living in poverty while a person having DCI of less than 1,805 kcal is considered to be in 'hard core poverty'. As per Statistical Year Book of Bangladesh 2010 average household size is 4.50 and 40.94% households earn maximum BDT 60,000 per year. Based on the census and socioeconomic survey (March-April 2017) indicating yearly income and expenditure of the project affected households it is found that about 03.30% households earn less than Tk 60,000 per year (Table 4-31). Considering the economic condition of the project area, scope of work and level of income , these 03.30% affected households may be considered as hardcore poor and yearly income of the households within the range of BDT 60,001-2,00,000 is poor, more than BDT 2,00,000 is non-poor. The poor households are considered as living under poverty line. The hardcore poor will get special assistance under the policy of RAP and both hard core poor and poor households may get special attention for IGA training and other assistance under income and livelihood restoration program (ILRP).

Table 4-31: Poverty Level and Annual Income (BDT) of Head of the Households in Percentage and by Location

Station Name	Annual Income (BDT)						
	Up to 60,000	60,001 to 1,00,000	1,00,001-2,00,000	2,00,001-3,00,000	3,00,001 to 5,00,000	5,00,001-7,00,000	Above 7,00,000
Hemayetpur	02.50	00.00	20.00	30.00	20.00	10.00	17.50
Baliarpur	00.00	00.00	58.30	08.30	16.70	00.00	16.70
Bilamalia	00.00	00.00	42.90	14.30	42.90	00.00	00.00
Amin Bazar	02.80	02.80	12.30	13.20	12.30	14.20	42.50
Gabtoli	06.67	00.00	06.67	00.00	46.67	26.67	13.33
Dar-Us-Salam	00.00	17.86	46.43	21.43	10.71	03.57	00.00
Mirpur-1	05.88	00.00	29.41	23.53	35.29	00.00	05.88
Mirpur-10	01.59	00.32	42.68	41.72	12.42	00.32	00.96
Mirpur-14	00.00	00.00	75.00	25.00	00.00	00.00	00.00
Kochukhet	07.89	02.63	28.95	28.95	26.32	00.00	05.26
Banani	07.69	7.69	00.00	46.15	00.00	07.69	30.77
Gulshan 2	00.00	00.00	00.00	00.00	00.00	00.00	00.00
Notun Bazar	04.26	02.13	14.89	29.79	02.13	06.38	40.43
Bhatara	07.69	02.56	12.82	12.82	30.77	06.41	26.92
Total	**04.15**	**2.17**	**24.01**	**24.80**	**17.39**	**07.11**	**20.36**

Source: Census & Socioeconomic survey April 2017

The survey identified 93 vulnerable households in the project area. These are almost all the project affected female headed households, households headed by elderly persons, disable persons, male headed household but under the poverty line. The vulnerable households of different locations are shown in the Table 4-32.

Table 4-32: Vulnerable Households in Percentage and by Location

Station Name	Vulnerability				
	Female Headed HHs	Elderly (<60yr,)	Disabled Male HHHs	Male Headed Households under poverty line	Total
Hemayetpur	33.30	33.30	16.70	16.70	100.00
Baliarpur	00.00	100.00	00.00	00.00	100.00
Bilamalia	50.00	50.00	00.00	00.00	100.00
Amin Bazar	05.90	52.90	11.80	29.40	100.00
Gabtoli	00.00	33.33	33.33	33.33	100.00
Dar-Us-Salam	12.50	25.00	00.00	62.50	100.00
Mirpur-1	25.00	25.00	25.00	25.00	100.00
Mirpur-10	13.33	33.33	13.33	40.00	100.00
Mirpur-14	00.00	00.00	00.00	00.00	100.00
Kochukhet	20.00	20.00	00.00	60.00	100.00
Banani	00.00	33.33	00.00	66.67	100.00
Gulshan 2	00.00	00.00	00.00	00.00	00.00
Notun Bazar	20.00	20.00	0.00	60.00	100.00
Bhatara	40.91	13.64	9.09	36.36	100.00
Depot Area	100.00	00.00	00.00	00.00	100.00
Total	**22.60**	**30.10**	**09.70**	**37.60**	**100.00**

Source: Census & Socioeconomic survey April, 2017

5 PREDICTION OF IMPACT

Impacts predictions are made on existing environmental study or baseline environmental monitoring. Impacts may be occurred from different construction activities like as storage of construction instruments and materials, cut and cover construction, excavation materials, drill and blast construction etc. The environmental and social impacts due to project activities are considered into three distinct stages of project lifecycle a) Planning Phase b) Construction Phase c) Operation and Maintenance Phase.

Impacts of MRT line 5 has been investigated and refined through detail project document and reconciliation with the opinions of experts and local people's perception. The predicted impacts have been evaluated as per the Guideline of DoE as well as JICA guideline. The following sections describe all the potential impacts (stage wise) on anti-pollution measures, natural environment and social environment of the surroundings.

5.1 Impact due to Project Activities

5.1.1 Air Pollution

5.1.1.1 Before/During Construction Stage

The major sources of impacts on air quality by the project in the construction phases are as follows:

- Exhaust emission from movement of equipment by vehicles, excavated soil carrying by vehicle and other heavy loaders;
- Earthworks including excavation, tunnel boring activities;
- Site clearance including removal of topsoil at the depot site;
- Construction site generate dust from construction materials, waste, loose earth, and moving excavated material and transporting wastes on vehicles;
- Diesel based construction machineries may cause huge air quality impact;
- Loading and unloading construction materials;

Dust Generation

Maximum construction activities have the potentiality to generate dust. The expansion of impacts from dust will depend on the location of construction activities and types of vehicles. Weather also an important factor for dust generation. Stronger winds and dry condition will increase the transfer of dust, where damp or wet conditions will reduce the impact.

Transportation of earth and establishment of the material will involve use of heavy machinery like compactors, rollers, water tankers, and dumpers. This activity is machinery intensive resulting in dust generation. However, this activity will be only short-term and the air pollution during construction is localized and only around the station site, viaduct site and depot construction site only.

The magnitude of the impact associated with the emission of dust during construction activities on the basis of above factors is predicted to be medium and the significance of the impacts is assessed to be low.

Exhaust Generation

Transportation of construction materials and excavated soil by trucks that use diesel to generate power will cause impacts on ambient air quality. Operation of construction machine will cause air exhaust generation. However, the air quality impacts associated with the

vehicular and operational equipment emissions during construction activities will less significant as the construction period will be short term.

5.1.1.2 Operation Stage

Vehicle exhaust emissions and entrained dust could increase in the vicinity of stations due to increased movements of people. Losses of chemical cleaning fluids and odors from various sources could be present at the depot area, generated by train maintenance activities.

However, the proposed MRT Line 5 will be electrical operation and not use diesel fuel. Moreover the operation will improve congestion of roads along the MRT line and efficiency of the vehicle mobility. Consequently, increase in air pollution in Dhaka city may be mitigated as a positive impact.

5.1.2 Water Pollution

5.1.2.1 Before/During Construction Stage

The potential sources of impact to surface and ground water resources are:

- At the project site due to excavation activities may increase erosion during rainfall, that may increase the suspended sediment concentration in the adjacent water body;
- The mismanagement of wastes that may causes water pollution in the project area although the waste will be very small amount;
- Washing of construction materials will generate liquid effluents which causes water pollution in the project area;
- Due to the dewatering for underground stations will cause impacts on groundwater situation;
- Vehicle operating at the construction areas

Elevated Section

In the construction site, turbid water is discharged as a result of several types of construction activities, such as site clearance, vehicle operating, cleaning, excavation etc. which will be very low amount because most of the section will be run in the underground. Pile driven work in the elevated section may causes surface water pollution which is assessed as negligible as there are no major water bodies in the elevated section.

Pollutants on construction sites can also soak into the groundwater, a source of human drinking water. Once contaminated, groundwater is much more difficult to treat than surface water. Underground water analysis stated that ground water quality meet the standards stipulated in *Schedule 9 and 10 of ECR, 1997*.

Tunnel Section

Dewatering at the construction of underground stations will cause limited impact on groundwater. Therefore, the impact to surface water from wastewater discharges during construction is assessed to be low.

The tunnel section of the metro rail may affect the ground water recharge of the area which might lead to lowering of the ground water table. While there is potential for long term indirect impacts to ground water quality and water table from construction activities without implementation of mitigation measures for proper handling of chemicals, waste and liquid effluents.

Depot Site

MRT line 5 depot site is depressed area and need to elevate at least 3 meter by filling sand materials. Depot site development by filling earth materials may impact on the surface water quality as the Bangshi River flows adjacent to the depot site. Water quality might be impacted during depot development due to surface runoff of soil as well as lubricant from construction of the depot facilities.

Depot site development will require the compaction of soil as a result water percolation in the underground will be restricted in the depot site. So the underground water level might be low in the depot area.

5.1.2.2 Operation Stage

The water pollution due to the operation of metro rail is negligible as there is no significant source of pollution to water. Only there is a possibility of water pollution from the depot area where rail maintenance will be carried out as a result lubricant as well as domestic waste might be discharge in the water body.

5.1.3 Soil Pollution

5.1.3.1 Before/During Construction Stage

The project may not have significant impact on soil pollution because most of the alignment of the project will be done in the underground. There have minor chance to soil pollution due to construct of the project include soil stabilization, installation of pilling, construct of viaduct sections, construction of stations. Problems could arise from dumping of construction soils (concrete, bricks), excavated soil dumping, waste materials (from contractors' camp) etc. causes soil pollution. Oil leak from poor machine and vehicle may also cause soil pollution. Waste from construction yard and camp will lead to the soil pollution.

5.1.3.2 Operation Stage

Oil leakage from the maintenance work at depot site may contaminate soil quality of the surrounding.

5.1.4 Waste

5.1.4.1 Before/During Construction Stage

During the construction stage several metric ton waste soils will be generated from tunnel boring as well as station construction by cut and covers method. The management of waste soil is the major challenge during the construction period. Different types of fragments of construction materials and garbage also generate during the construction period. Solid and liquid waste also be generated from the depot area construction site, construction yard and construction camp. Solid waste generated from different area during construction site may impact on the surrounding soil as well as water quality. Improper management of waste during the construction stage might be causes soil as well as water pollution so the impact of waste has been assessed as significant.

5.1.4.2 Operation Stage

At the operation phase no hazardous waste is expected to be generated except maintaining works, car depot and operations of stations, miscellaneous municipal wastes, refreshments and ticketing booths, empty cans and bottles, food residues and other similar waste that will be thrown out of rail. The putrefaction of the organic component of the uncollected wastes

will give rise to foul smells. Uncollected waste also will act as breeding grounds for the disease producing vectors and will affect the aesthetics of the project area.

5.1.5 Noise and Vibration

5.1.5.1 Before/During Construction Stage

Construction sites are very common source of noise pollution. The main sources of noise at construction sites are heavy machineries and transportation of equipment. Materials handling equipment, stationary equipment and other types of equipment etc. will be the major source of noise pollution.

Depot Site

At the Depot section sand compactions piles and vibratory compactions used to stabilize the fill, heavy equipment operation during infilling the site will causes noise and vibration pollution.

Elevated Section

Noise will be generated at the construction of elevated section. Construction workers, Educational Institutions, Religious institutions, local community, terrestrial fauna etc. will be affected for noise generation at the construction phase.

Although construction materials will deliver by roads and most of the construction activities will be done in the underground which result in slight increase in traffic movement and thereby in traffic noise impacts to receptors near the road. *Schedule 5* of the *Environmental Conservation Rules, 1997* will be followed to minimize the impact.

5.1.5.2 Operation Stage

The MRT operation will generate noise and vibration. However, the proposed MRT is an electric mechanical system that is a low noise and low vibration type. As the most of the section of the MRT will pass through the underground section so the noise from underground noise will not come to the surface. Only elevated section noise and vibration may cause problem in the surrounding but the elevated section area is less developed. Sound barrier will be installed in the viaduct section so the impact due to noise generation will be less at the viaduct section.

During the operation phase the main source of noise will be from running of metro trains. Airborne noise is radiated from viaduct structures, while ground-borne noise is and vibrations are of primary concern in underground operations.

The major source of noise pollution at the operation stage of metro rail includes:

(i) Wheel/Rail Noise: Due to wheel/rail roughness
(ii) Propulsion Equipment: Traction motors, cooling fans for TM, reduction gears etc.
(iii) Auxiliary Equipment: Compressors, Motor generators, brakes, ventilation systems, other car mounted equipment.
(iv) Viaduct structure Noise:
    - at low speed (<15km/h) auxiliary equipment may predominate,
    - At speeds up to approx. 50 km/h, W/R noise predominates,
    - speeds (>50 km/h), the propulsion equipment noise predominates,
    - For light weight steel elevated structures, the structure noise can predominate at all speeds above 15 km/h

5.1.6 Ground Subsidence

5.1.6.1 Before/During Construction Stage

At the construction phase of the metro rail there will be possibilities to ground subsidence due to the tunnel boring activities at the underground. Ground subsidence may lead to the building collapse in the urban area. As the proposed metro rail alignment will follow the existing road network so there is less possibility of building collapse. The geological survey not yet completed throughout the alignment so the impact is not clear at this moment. Proper method implementation and mitigation measure is required to minimize the land subsidence during the tunnel construction.

5.1.6.2 Operation Stage

During the operation phase of the metro rail, the possibility of the ground subsidence is less as the tunnel will be shielded. As the subsoil investigation not yet completed so the impact is not clear at this stage

5.1.7 Offensive Odor

5.1.7.1 Before/During Construction Stage

Exhaust emission from heavy equipment causes odor problem. Though the construction camp site not yet finalized but there is a possibility of odor problem due to the open burning of construction waste, improper treatment of human liquid waste.

5.1.7.2 Operation Stage

Improper solid waste management in the station area might be causes offensive odor but the possibility of the impact is negligible as regularly the solid waste will be collected from the station.

5.1.8 Bottom Sediment

5.1.8.1 Construction Stage

There is no chance of increasing the bottom sediment in the tunnel section. The elevated section construction work may increase the bottom sediment load in the water body due to the run off of turbid water from pile driving activities as well as accidental spillage from machineries and Oil leak from poor maintenance machine and vehicle may deteriorate bottom sediment of the water body. The possibility of increase of bottom sediment is high due to depot development as the depot site is located close to the River. There is no major water body along the viaduct section so the impact due to construction of elevated section is negligible.

5.1.8.2 Operation Stage

No impact is expected.

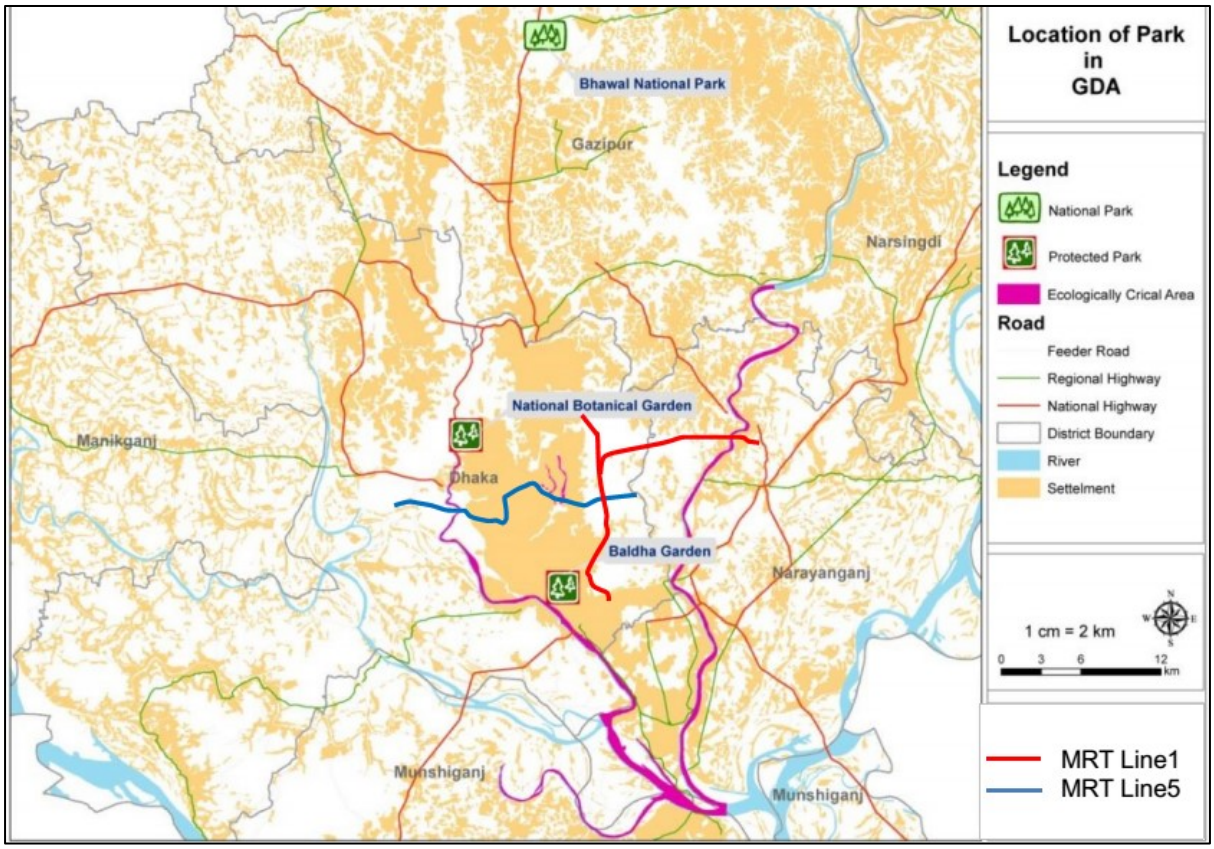
5.1.9 Protected Area

5.1.9.1 Construction Stage

Based on Bangladesh Wildlife Preservation Order 1973, Protected Areas (PAs) is classified into national parks, wildlife sanctuaries, game reserves and private game reserves. The protected areas in and around the project site are shown on Figure 5-1.

There is no protected area such as natural park, sanctuary and conservation site in the project alignment. National Botanical Garden and Baldha Garden are located on over 2km from the project site. So no impact is assumed.

The 1995 Bangladesh Environment Conservation Act includes provision for Ecologically Critical Area (ECA) declarations by the director general of the Department of the Environment in certain cases where the ecosystem is considered to be in danger of reaching a critical state. In ECA, GOB restricts activities and process of manufacture in the view of preventing deterioration of the environment. In RAJUK, there are five ECA including one lake (Gulshan Banani-Baridhara Lake) and four rivers (Buriganga, Turag, Balu and Shitalakshya). (Figure 5-1) In line with the project, the underground structure of MRT Line 5 crosses Gulshan Banani-Baridhara Lake, which is designated ECA in 2001. In addition, MRT Line5 crosses Turag River which is located on the west section of the project. The MRT line 5 will cross these two ECA areas following the TBM method which will keep provision of1.5 D (D: tunnel outer diameter) distance from the riverbed to the upper end of the tunnel. As the MRT line 5 will be constructed as underground tunnel in the ECA area so the impact on protected area is negligible.



Source: JICA Study Team

Figure 5-1: Protected Area in and Around the Project Site

5.1.9.2 Operation Stage

No impact is expected.

5.1.10 Biota and Ecosystem

5.1.10.1 Construction Stage

There is less impact on ecology as the most of the section is underground. There is no tree

species in the depot area only trees are found in the station locations that need to be cut down. According to the RAP study, total 249 trees will be affected out of these 113 are large, 31 medium, 99 small and 06 are sapling. Timber trees are more in number in the project area.

Few bird, reptile, mammals were found during the field survey in the depot area. Bengal Monitor is only near threatened reptile according to the IUCN status whereas all species are least concern. As there are same types of habitat area adjacent to the depot area so they can migrate to nearby area during the construction period of depot. Considering the presence of available alternative habitat area the impact on biota and ecosystem assessed as negligible.

5.1.10.2 Operation Phase

No impact has been predicted on ecosystem due to the rail operation in the underground tunnel. But elevated section has some impact on the ecosystem especially on avian fauna. Electromagnetic radiation (EMR) could affect avian fauna. EMR occurs around cell phone towers, inductive motors, power lines and other line conductors carrying currents. EMR bridges potentials through the atmosphere at varying frequencies (called EMF), and is measurable using EMR/EMF meters. Nesting migratory birds and their offspring have been known to be affected by phone towers emitting EMR in the 900 and 1800 MHz frequency ranges. EMR also can affect radio transmissions.

EMR potential of about 1 mV at the stations and track alignment is minimized by grounding (earthing) of all metal parts and conductor supports, station hardware and equipment and the tracks. Grounding is used to reduce electrostatic charge and to ground stray currents that result from EMR buildup. EMR in the atmosphere is thus shunted to ground. EMR fields are attenuated and kept near the catenary, where they may act to repel birds from the structure. As the impact is negligible as well as grounding will be used so no further mitigation measure is needed.

5.1.11 Hydrology

5.1.11.1 Construction Stage

Due to the construction activities of the metro rail project there will some effects on hydrology: qualitative changes of the ground water, changes on the vegetation, changes in the slope stability, changes in the hydrological balance at the basin scales. The major sources of impacts on hydrology due to the construction activities of the metro rail projects are:

- Infilling,
- construction of the depot;
- construction yards and haul routes;
- Excavation

The drainage system will be hampered due to construction activities like as infilling, construction of the depot, construction yards and haul routes. A major impact during construction stage is due to suspended solids entrained in runoff that can soil surfaces and clog drainage system. There is a depressed area in the depot site. The depot site is sub flood flow zone according to the RAJUK detail area plan. The depot site is inundated by Bongshi (Savar) River water during monsoon season. Some part of the depressed area need to fill up for depot construction whereas eastern part of the depot area will remain present condition.

Due to filling of low lying areas for the construction of depot site, the surface drainage pattern will change at the depot site as a result new land might be flooded. Detail hydrological study need to be carried out during the detail design stage to understand the

impact. Underground section is planned in the central area of Dhaka for 13.5 km long and viaduct structure is planned at suburban area for 6.5 km. So there is a possibility of inundation only in the entrance and exit point of the project.

During the construction and operational phases of Metro Rail, there would be the potential for flooding of the tunnels via the station entrances and other surface openings during severe storm and flooding events. This could occur from riverine flooding, overflow of rain water or overland flows in excess of the capacity of the underground drainage system.

5.1.11.2 Operation Stage

Dhaka city is flood prone area. Flooding may impact the operation of the metro rail especially underground tunnel. Historical flooding data analysis needs to be carried out during the detail design stage for the safety.

5.1.12 Ground Water

5.1.12.1 Construction Stage

Underground tunnel construction may impact on ground water quality and depth of the underground water level. Potential impacts on groundwater are insignificant. In Dhaka City, Ground Water extraction started from a depth of 100m and in some extreme condition the well goes up to 300 meters to reach the main aquifer (The Daily Star, 2010) and is unlikely to be affected by surface and tunnel activity related to construction of the Metro.

5.1.12.2 Operation Stage

Due to the tunnel construction the ground water percolation might be interrupted. Detail hydrological study need to be carried out during the detail design study.

Impacts on groundwater could occur at the depot during operations: herbicides used to control weed growth in the train yard could potentially affect groundwater. Spills of hazardous chemicals, or uncontrolled drainage from contaminated areas at the depot, could potentially affect groundwater quality.

An evaluation of planned types of herbicide and frequency of use should be conducted as part of the depot operations plan, along with a risk analysis to determine the potential for groundwater contamination. Operations procedures related to the handling of hazardous chemicals and drainage from contaminated areas should be reviewed to highlight their safety and environmental aspects.

5.1.13 Topography and Geology

5.1.13.1 Construction Stage

The project area has plain topography but excavation of land is involved for the construction of tunnel which may contribute to minor change of topography due to dumping/storage of the excavated soil in the dumping site. The main impacts generating activities on topography during construction activities will be cutting and dismantling of existing pavements, including erosion of topsoil cover and soil erosion may occur on roadside due to excavation of earth/cutting operations. Due to the construction of the elevated section will change the present topographic condition but it will be negligible as the length of this section is only 6.5 km. Underground tunnel construction may lead to the land subsidence as well as building collapse. Detail study is required during the detail design stage.

5.1.13.2 Operation Stage

The tunnel will be shielded so the risk of subsidence will be negligible.

5.1.14 Involuntary resettlement

5.1.14.1 Before/During Construction

A total of 26.85 ha land will be required to be acquired and 1.57 ha for pockets along the RoW and 4.01 ha of land will need subsurface easement to implement the project. This land is mainly for the depot area in Hemayetpur and it is privately owned. Out of the total land 26.77 ha is agriculture land and only 0.079 ha in being used as homestead.

The project will have direct impact on 721 Project Affected Units (PAUs). It is to be mentioned here that there will not be any affected people in one proposed station namely Gulshan 2. The project works will affect 25 residential households, 111 Commercial & Business enterprises (CBEs) and 06 residential cum CBEs, 04 household are going to lose varieties of properties like wall, trees, drains etc and 579 vendors or temporary shops are going to be affected with a total affected units of 721. Out of 96 households 10 of them will be displaced due to loss of residential structure, 15 will be displaced from rented residential structure. Total 111 households are going to lose their business with structure, four household will lose both residential and business structure. There are 579 vendors or temporary shop owners going to lose their business and 02 households are going to be affected by losing different properties like trees, boundary walls, drains etc. Among the Affected Units only 25 are title holders i.e. Owns the land and rest 696 are on government land. Total affected persons are 3,047.

A total of 268 structures of 12,950 sq m area of different categories will be affected, of which 6,004 sq meter are pucca, and 3,952 sq meter are semi pucca, 954 sq meter are tin sheds, 1,812 sq. meter are katcha and 228 sq meter are tarpaulin covered. Detail data is indicated in the resettlement action plan report.

5.1.14.2 Operation Phase

All the PAPs will be resettled prior to start the construction therefore impact will be almost nil.

5.1.15 Poor

5.1.15.1 Before/During Construction Stage

Poverty in Bangladesh is measured through per capita income or through Direct Calorie Intake (DCI) where persons having DCI of less than 2,122 kcal are considered to be living in poverty while a person having DCI of less than 1,805 kcal is considered to be in ‘hard core poverty'. As per Statistical Year Book of Bangladesh 2010 average household size is 4.50 and 40.94% households earn maximum BDT 60,000 per year. Based on the census and socioeconomic survey (March-April 2017) indicating yearly income and expenditure of the project affected households it is found that about 03.30% households earn less than Tk 60,000 per year. Considering the economic condition of the project area, scope of work and level of income , these 03.30% affected households may be considered as hardcore poor and yearly income of the households within the range of BDT 60,001-2,00,000 is poor, more than BDT 2,00,000 is non-poor.

Due to acquisition of the property these poor people will be affected adversely. The hardcore poor will get special assistance under the policy of RAP and both hard core poor and poor households may get special attention for IGA training and other assistance under

income and livelihood restoration program (ILRP).

5.1.15.2 Operation Stage

As the special attention will be taken for poor people to minimize livelihood impact therefore the impact will be negligible.

5.1.16 Indigenous or ethnic minority people

5.1.16.1 Before/During Construction Stage

Based on findings of the survey, the Project will affect 721 households for this project. Out of total 721 households 700 are Muslim and 21 are Hindu. No ethnic minority family in the affected household has been found during the study therefore the impact is nil.

5.1.16.2 Operation Stage

No impact has been assumed.

5.1.17 Local economics such as employment, livelihood

5.1.17.1 Before/During Construction Stage

The project will affect 694 businesses including 04 APs who will lose both residential structure as well as business. Among the business losers more than 81% are losing small businesses, 10.5% medium businesses and rest are losing large business.

The study identified 509 people to be affected by losing their income for displacement of commercial and business premises. They are the principal bread earners of the family. About 90% are unskilled workers and rests are skilled ones. Highest number of wage losers is from Amin Bazar area followed by Vatara, Notun Bazar and Hemayetpur areas. These are the mini business hub of the locality. On the other hand no people will be affected by losing their wage income from the station Mirpur 14 and Gulshan 2. Job opportunity will create during construction period therefore the impact will be minimum.

5.1.17.2 Operation Stage

Local economy will be gear up during the operation of the MRT especially near the depot and station area. It is expected that the new employment will be enhanced in Hemayetpur area significantly.

5.1.18 Land use and utilization of local resources

5.1.18.1 Before/During Construction

The most of the acquired land is being used for agricultural purpose and portion of it being used as homestead. However and majority of the land area where MRT routs would pass above and under the ground and the stations above and under the ground is owned by the government and mostly being used as road network in the city. Along these routes and station area most of the project affected units are business and commercial premises. Some industries are coming in the vicinity, mainly along the road from Amin Bazar to Hemayetpur. People are having their livelihood and operating business by utilizing the road network facilities.

There are some green areas or some tree covered area in the project area. This area is again mostly around the depot area in Hemayetpur. The project will also require felling of 938 trees of various sizes and categories from the surveyed area. Majority are fruit bearing trees. Land use of the depot area, elevated section and elevated station will be changed.

5.1.18.2 Operation Stage

The proposed depot area is going to be developed as urban area and it is assumed that this area will be developed in near future. The depot of MRT line 5 will gear up the development of the surrounding area as well as it will increase the land price. The utility services of the depot area will be provided by the government authority so the impact on local utility resources will less.

5.1.19 Water Use

5.1.19.1 Before/During Construction and Operation Stage

The city dwellers mostly use supplied water through the Dhaka Water Supply & Sewerage Authority (DWASA). The city dwellers have complaint regarding the quality and required quantity of supplied water from WASA. The people of the project area living outside the city corporations (Amin Bazar to Hemayetpur) mainly depend on deep and shallow deep tube well for the their everyday water use.

At this stage the water demand of the proposed project is not finalize yet therefore the impact due to water use has not been assessed.

5.1.20 Social Service Facilities

5.1.20.1 Before/During Construction Stage

The project area covers both the DNCC and DSCC of Dhaka and Savar Upazila and administered by Mayors and councilors as part of local government. However, for administration the project area is within Dhaka District. In addition to Dhaka district administration many other agencies are involved like RAJUK, DWASA, PDB, RHD and others. There are numbers of informal and formal societies or associations in different locations for CBDs of the markets or any other group of people.

No social service facilities exist in the viaduct section. Major route of the MRT line will pass through the underground as a result the impact on social service facilities is negligible.

5.1.20.2 Operation Stage

MRT line is a major social service facility that will reduce the travel time and enhance the economic growth of the people.

5.1.21 Social institutions and local decision-making institutions

5.1.21.1 Before/During Construction Stage

The society in Bangladesh in general is a traditional society. However, the city society has some unique characteristics like any other city dwellers with diversified social back ground of the migrant people coming from different areas of the country.

The identified 22 Common Property Resources (CPR) as social institutions or resources which are going to be affected by the project. The CPRs include mosque (1), school/college (2), Samity/Club/Community (1), Offices (4) and other (14). Local level decisions some times are influenced by the local elites and public representatives as well as other political leaders. Proper compensation package and relocation should be taken for the affected structure prior to the start construction work therefore the impact will minimum.

5.1.21.2 Operation Phase

No negative impact has been expected during the operation stage. People can move their location easily using the MRT within short time.

5.1.22 Misdistribution of benefits and damages

5.1.22.1 Before/ During Construction Stage

The benefit of the MRT line will not be distributed evenly to all the people along the line equally. Certainly the people near the station area will be benefitted more. However, only the affected people will have to bear the burden of damages like loss of assets and livelihood. It is speculated that the economically solvent affected people will be able to recover their damages through receiving compensation and utilizing the locational opportunity of the new infrastructure provided by the project. But the vulnerable and marginal APs will have to struggle to recover their damages. Therefore after getting the proper compensation and training opportunity as per the RAP the impact has been assessed as negligible.

5.1.22.2 Operation Stage

The depot area and around the station will be developed compare to the other areas. Peoples will be benefited who will live around the depot and station area compare to the other location.

5.1.23 Local conflicts of interest

5.1.23.1 Before/ During Construction Stage

Due to employment opportunity will be increasing during construction; candidates of construction workers may have some conflicts between communities.

5.1.23.2 Operation Stage

The depot and around the station area will be developed and large scale business will run that might be enhance the conflicts with other areas. It is worried that new conflicts will arise when access to the station is not provided properly, or relocated place is inconvenient to PAPs.

5.1.24 Cultural heritages

5.1.24.1 Before/ During Construction Stage

The RoW of the project mainly followed the city road network. From the Figure 4-23, it is observed that in the project area presence of any infrastructure related to cultural heritage is absent.

5.1.24.2 Operation Stage

No impact is expected.

5.1.25 Landscape

5.1.25.1 Before/ During Construction Stage

The acquired land is mainly for the depot area in Hemayetpur and privately owned. Majority of the land is agriculture land and rest are vita (homestead) land. In addition to this acquired land some government owned land (khas) will be used to construct the MRT line and its components. Line 5 will largely follow the existing city road network. Landscape of the depot area and the elevated section will be changed.

The main component of MRT line 5 that may impact the surrounding landscape and aesthetics are the station, ventilation shafts and parts of the metro line that will be constructed by cut and cover method. Construction sites, if not well managed, have also negative impacts on visual amenities and on the aesthetics of the surroundings.

5.1.25.2 Operation Stage

Present landscape of the project area will be changed but the change assumed as negligible as major section of the MRT line will be underground. Impact is assumed when the height of viaduct is so high to over other structures.

5.1.26 Gender

5.1.26.1 Before/ During Construction Stage

The socio-economic survey of RAP study stated that 93 vulnerable households in the project area. These households are female headed households (21.6%), households headed by elderly persons (30.10%), disable persons (9.70%), male headed household but under the poverty line (37.60%). Special assistance will be required to support these vulnerable AHs including additional subsistence and relocation assistance, opportunity for skill training and income restoration, employment opportunity in civil work.

The ratio of discrimination cases between genders by the project is not known. However many women workers are required during construction, not only as daily catering at workers camps but also as unskilled construction workers during construction. In these cases, discrimination of salary between genders can be caused.

5.1.26.2 Operation Stage

Female person might be deprived in the ticket counter as well as to get seat in the train.

5.1.27 Children Rights

5.1.27.1 Before/ During Construction Stage

It is highly possible that a bunch of children come and work in construction site. Children's from relocated household need to change their school.

5.1.27.2 Operation Stage

No impact is expected.

5.1.28 Infectious disease such as HIV/AIDS

5.1.28.1 Before/ During Construction Stage

As the city dwellers of the capital city the people are aware about the infection diseases like HIV/AIDS and its consequences. However, study could not find any HIV/ AIDS patients in the project area. During construction period with the in-migration of large number of workers, mainly male might be an alarming issue for the local community.

5.1.28.2 Operation Stage

No impact is expected.

5.1.29 Working Condition

5.1.29.1 Before/ During Construction Stage

During the construction stage, improper safety measure may lead to health problem to the worker. Lack of proper sanitation facilities as well as accommodation facility in the labour camp also causes health problem to the workers.

5.1.29.2 Operation Stage

No impact is expected.

5.1.30 Global warming/Climate change

5.1.30.1 Before/ During Construction Stage

Construction machines and vehicles generate greenhouse gases; quantities of generated gases do not contribute for serious impact to the atmosphere.

5.1.30.2 Operation Stage

During the operation stage, green house emission will be reduced as the rail will be run by electricity that will carry almost 1546 passengers per trip. It is assumed that the increase of traffic and residents will cause the exhausted gas. However, it is expected that the modal shift and increase of travel speed will mitigate the greenhouse gas.

5.1.31 Accident

5.1.31.1 Before/ During Construction Stage

There can be some sorts of accidents during construction as below:

- MRT construction requires works in elevated place such as work on the top of pier, girders and so on and falling down is critical.
- Traffic accident during the carrying construction material using the existing road
- Heavy equipment's can bring on various significant accidents.

5.1.31.2 Operation Stage

The metro rail accident is rare case in the worldwide but it might be happen. The major risk for the metro rail operation is fire. However traffic accident will decrease because of the modal shift which will enhance the change from automobile to MRT.

6. EVALUATION OF IMPACT

The impacts on the respective resources have been identified and assessed in the previous chapter. In this chapter, the identified impacts have been evaluated based on the expert judgment. Several round table discussion meeting with the team members have been made to finalize the evaluation. A matrix based method has been adopted for this evaluation. Evaluation has been made to indicate the magnitude of each impact. Each impact was evaluated based on a rating instead of numeric scale. Impacts are rated in A, B, C and D. The definition of the rating is as follows.

A: significant impact is assumed,

B: Impact is assumed but less than A,

C: Impact is not clear because the design is not finished and further survey is needed to confirm,

D: No impact

Thus, the study on the alignment of MRT Line 5 is described in Chapter 3, then taking into account of natural environment and social condition along the Line, the scoping matrix of environmental impacts are expressed in the context of pollution, natural and social environment and other points of view, which shown in **Table 6-1**, and the reason for assessment is listed in Section 6.1, Section 6.2 and as well as Clause 6.3.

Table 6-1: Scoping Matrix of MRT Line 5

	Items of Impact		Total Assessment			Factors of Adverse Impacts														Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
Anti-pollution measures	32.	Air Pollution		B-	B-/B+							B-	B-	B-		B-		B-		B+	B+	B+	
	33.	Water Pollution		B-	D							B-	B-		B-								
	34.	Soil Pollution		B-	D							B-	B-		B-								
	35.	Waste		A-	B-							B-	B-		B-			B-					
	36.	Noise and Vibration		B-	B-							B-	B-	B-			B-		B-				
	37.	Ground Subsidence		C	C								C						C				

	Items of Impact		Total Assessment			Factors of Adverse Impacts														Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
	38.	Offensive Odors		B-	D							B-			B-		D-						
	39.	Bottom Sediment		B-	D							B-	B-										
Natural Environment	40.	Protected Area		D	D							D	D						D				
	41.	Biota and Ecosystem	B-	B-	D		B-		B-	B-									D				
	42.	Hydrology		C	C								C				C						
	43.	Ground Water		B-	D								B-				D						
	44.	Topography and Geology		B-	D						B-		B-		B-		D						

			Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
	Items of Impact		Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
Social Environment	45.	Involuntary Resettlement	A-	D	D	A-																
	46.	Poor	A-	D	D			A-														
	47.	Indigenous and Ethnic Minority People	D	D	D			D										A-				
	48.	Local Economics such as employment, livelihood etc.	A-	B+	B+	A-							B+									B+

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
	49.	Land use and Utilization of Local Resources		B-	B+								B-		B-					B+			B+
	50.	Water use		C	C								C				C						
	51.	Social Service facilities		D	A+								D							A+			A+
	52.	Social Institutions and Local Decision Making Institutions,	B-	D	A+	B-														A+			A+
	53.	Misdistribution of Benefits and		B-	B-								D				B-						

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
		Damages																					
	54.	Local Conflicts of Interest		B-	B-								B-		B-			B-					
	55.	Cultural Heritage		D	D								D						D				
	56.	Land Scape		B-	B-						B-						B-	B-					
	57.	Gender	B-	B-	B-	B-		B-					B-						B-				
	58.	Children Rights	B-	D	D			B-															
	59.	Infectious Diseases such as HIV/AIDS		B-	D										B-			D					
	60.	Working Conditions		B-	D							B-	B-	B-	B-								

	Items of Impact		Total Assessment			Factors of Adverse Impacts													Factors of Positive Impacts			
						Planning Stage			Construction Stage							Operation Stage				Operation Stage			
			Planning Stage	Construction Stage	Operation Stage	Land Acquisition and loss of Architecture	Tree Removal	Deterioration of living environment due to resettlement	Change of Wetlands	Logging	Change of Landscape	Operation of Vehicles and heavy equipment for Construction	Construction activities on viaduct and underground structure, stations and depot site	Traffic Jam	Inflow of construction workers and set up of construction bases	Increase of Traffic density	Entity of the elevated and underground railways and increase of the related architectures	Increase of Settler	Rail Operation	Model Shift	Increase of traffic capacity	Reduction of travel time	Promotion of well-ordered urban development
Other	61.	Global Warming		B-	B+ /B-							B-	B-	B-		B-		B-		B+	B+	B+	
	62.	Accidents		B-	B- /B +							B-	B-	B-	B-	B-				B+			

Assessment： A: significant impact is assumed, B: Impact is assumed but less than A, C: Impact is not clear because the design is not finished and further survey is needed to confirm, D: No impact
The scoping items are referred from JICA guidelines

6.1 Possible Impact in Planning Stage

A: Significant Impact is assumed

Items of Impact	Reason of Assessment
Social Environment	
Involuntary resettlement	A total of 26.85 ha land will be required to be acquired and 1.57 ha for pockets along the RoW and 4.01 ha of land will need subsurface easement to implement the project. This land is mainly for the depot area in Hemayetpur and it is privately owned. Out of the total land 26.77 ha is agriculture land and only 0.079 ha in being used as homestead. The project will have direct impact on 721 Project Affected Units (PAUs). It is to be mentioned here that there will not be any affected people in one proposed station namely Gulshan 2. The project works will affect 25 residential households, 111 Commercial & Business enterprises (CBEs) and 06 residential cum CBEs, 04 household are going to lose varieties of properties like wall, trees, drains etc and 579 vendors or temporary shops are going to be affected with a total affected units of 721. Out of 96 households 10 of them will be displaced due to loss of residential structure, 15 will be displaced from rented residential structure. Total 111 households are going to lose their business with structure, four household will lose both residential and business structure. There are 579 vendors or temporary shop owners going to lose their business and 02 households are going to be affected by losing different properties like trees, boundary walls, drains etc. Among the Affected Units only 25 are title holders i.e. Owns the land and rest 696 are on government land. Total affected persons are 3,047. A total of 268 structures of 12,950 sq m area of different categories will be affected, of which 6,004 sq meter are pucca, and 3,952 sq meter are semi pucca, 954 sq meter are tin sheds, 1,812 sq. meter are katcha and 228 sq meter are tarpaulin covered. The impact magnitude is high therefore the impact is significant.
Poor	As per the RAP study 3.30% affected household considered as hardcore poor. Due to acquisition of the property these poor people will be affected adversely.
Local economies, such as employment, livelihood, etc.	The project will affect 694 businesses including 04 APs who will lose both residential structure as well as business. Among the business losers more than 81% are losing small businesses,

	10.5% medium businesses and rest are losing large business. They are the principal bread earners of the family. So the impact is assumed as significant

B: Impact is not so significant

Items of Impact	Reason of Assessment
Social Environment	
Social institutions and local decision making institutions	The identified 22 Common Property Resources (CPR) as social institutions or resources which are going to be affected by the project. The CPRs include mosque (1), school/college (2), Samity/Club/Community (1), Offices (4) and other (14). Proper compensation and relocation plan will be addressed in this issue.
Gender	The socio-economic survey of RAP study stated that 93 vulnerable households in the project area. These households are female headed households (21.6%), households headed by elderly persons (30.10%), disable persons (9.70%), male headed household but under the poverty line (37.60%). The proper compensation and special attention will be given to the female headed household during the compensation package.
Children Right	Children's from relocated household need to change their school.

6.2 Possible Impact during Construction Stage

A: Significant Impact is assumed

Items of Impact	Reason of Assessment
Anti-Pollution Measures	
Waste	The construction work will generate several metric ton surplus spoil as well as fragments of construction materials and garbage. It is assumed that the impact is significant because the surplus spoil maintain is the major difficult task. The surplus soil need to be treated and used in the development work close to the Dhaka city and brick kiln as much possible or need to select the dumping place in and around the Dhaka city. Coordination is needed in this stage with the surplus soil collector.

B: Impact is not so significant

Items of Impact	Reason of Assessment
Anti-Pollution Measures	
Air pollution	Convey of construction materials, heavy equipment operation and earthworks will generate dust and exhaust gas, temporarily; however it is possible to reduce the dust by conducting a continuous water spray and proper maintenance of equipment can achieve emission control, too. These mitigation measures are commonly applied in the construction field, thus the impact is assumed not significant.
Water pollution	Construction activity such as earthworks including excavation for foundation and increase of workers will generate polluted water. Depot site development may lead to pollute the surface water as the River flows close to the depot site. The degree of turbidity due to the earthwork can be reduced by provision of a temporary sedimentation pit if needed. The degree of sanitation can be kept stable by provision of temporary sanitation facilities such as portable toilet in the construction field. The above-mentioned measures are very typical mitigation methods, therefore the impact is assumed not significant.
Noise and vibration	Operation of heavy equipment will generate noise and vibration. The main sources of noise at construction sites are heavy machineries and transportation of equipment. Materials handling equipment, stationary equipment and other types of equipment etc. will be the major source of noise pollution. As the major section will be underground so the noise and vibration in this section will not come to surface. Advance method should be adopted and this method can reduce the noise and vibration levels more effectively than other standard piling methods. Therefore, it is assumed that the impact might be not significant.
Ground Subsidence	At the construction phase of the metro rail there will be possibilities to ground subsidence due to the tunnel boring activities at the underground. Ground subsidence may lead to the building collapse in the urban area. As the proposed metro rail alignment will follow the existing road network so there is less possibility of building collapse. The geological survey not yet completed throughout the alignment so the impact is not clear at this moment. Proper method implementation and mitigation measure is required to minimize the land subsidence during the tunnel

Items of Impact	Reason of Assessment
	construction.
Offensive odors	Exhaust emission from heavy equipment causes odor problem. Though the construction camp site not yet finalized but there is a possibility of odor problem due to the open burning of construction waste, improper treatment of human liquid waste.
Bottom Sediment	There is no chance of increasing the bottom sediment in the tunnel section. The elevated section construction work may increase the bottom sediment load in the water body due to the run off of turbid water from pile driving activities as well as accidental spillage from machineries and Oil leak from poor maintenance machine and vehicle may deteriorate bottom sediment of the water body. The possibility of increase of bottom sediment is high due to depot development as the depot site is located close to the River.
Natural Environment	
Biota and ecosystem	There is less impact on ecology as the most of the section is underground. There is no tree species in the depot area only trees are found in the station locations that need to be cut down. According to the RAP study, total 249 trees will be affected out of these 113 are large, 31 medium, 99 small and 06 are sapling. Timber trees are more in number in the project area. Few bird, reptile, mammals were found during the field survey in the depot area. Bengal Monitor is only near threatened reptile according to the IUCN status whereas all species are least concern. As there are same types of habitat area adjacent to the depot area so they can migrate to nearby area during the construction period of depot. Considering the presence of available alternative habitat area the impact on biota and ecosystem assessed as negligible. Compensatory plantation program will be taken to recover the impact and the plantation ratio must be 1:4 means 4 sapling need to be planted for one tree cutting.
Ground Water	Underground tunnel construction may impact on ground water quality and depth of the underground water level. Potential impacts on groundwater are insignificant. In Dhaka City, Ground Water extraction started from a depth of 100m and in some extreme condition the well goes up to 300 meters to reach the main aquifer and is unlikely to be affected by surface and tunnel activity related to

Items of Impact	Reason of Assessment
	construction of the Metro.
Topography and Geology	The project area has plain topography but excavation of land is involved for the construction of tunnel which may contribute to minor change of topography due to dumping/storage of the excavated soil in the dumping site. The main impacts generating activities on topography during construction activities will be cutting and dismantling of existing pavements, including erosion of topsoil cover and soil erosion may occur on roadside due to excavation of earth/cutting operations. Due to the construction of the elevated section will change the present topographic condition but it will be negligible as the length of this section is only 6.5 km. Underground tunnel construction may lead to the land subsidence as well as building collapse. Detail study is required during the detail design stage.
Social Environment	
Land use and utilization of local resources	The depot area and elevated section land use will be changed especially in the depot area which is mostly agricultural land. There are some green areas or some tree covered area in the project area. This area is again mostly around the depot area in Hemayetpur. The project will also require felling of 938 trees of various sizes and categories from the surveyed area. Majority are fruit bearing trees. Land use of the depot area, elevated section and elevated station will be changed.
Local Conflict of Interest	Due to employment opportunity will be increasing during construction; candidates of construction workers may have some conflicts between communities.
Landscape	The acquired land is mainly for the depot area in Hemayetpur and privately owned. Majority of the land is agriculture land and rests are vita (homestead) land. In addition to this acquired land some government owned land (khas) will be used to construct the MRT line and its components. Line 5 will largely follow the existing city road network. Landscape of the depot area and the elevated section will be changed. The main component of MRT line 5 that may impact the surrounding landscape and aesthetics are the station, ventilation shafts and parts of the metro line that will be constructed by cut and cover method. Construction sites, if not well managed, have also negative impacts on visual amenities and on the aesthetics of the surroundings.

Items of Impact	Reason of Assessment
Global warming	It is assumed that exhausted gas caused by heavy equipment and vehicles may increase greenhouse gas temporarily
Gender	The ratio of discrimination cases between genders by the Project is not known. However many women workers are required during construction, not only as daily catering at workers camps but also as unskilled construction workers during construction. In these cases, discrimination of salary between genders can be caused.
Children Right	It is highly possible that a bunch of children come and work in construction site. Children's from relocated household need to change their school.
Infectious diseases such as HIV/AIDS	It is assumed that the risk by infection diseases might increase due to the in-migration construction employees.
Working conditions	During the construction stage, improper safety measure may lead to health problem to the worker. Lack of proper sanitation facilities as well as accommodation facility in the labour camp also causes health problem to the workers.
Others	
Global Warming	Construction machines and vehicles generate greenhouse gases; quantities of generated gases do not contribute for serious impact to the atmosphere.
Accidents	It is assumed that the accident due to the heavy equipment and vehicle will increase. And falling accident from overhead location will happen. Also, it is assumed that the traffic accident involving the inhabitants might occur when existing road is used for logistic purpose.

C: Impact is not clear because the design is not finished and further survey is needed to confirm

Item of Impacts	Reason of Assessment
Hydrology	There is a depressed area in the depot site. The depot site is sub flood flow zone according to the RAJUK detail area plan. The depot site is inundated by Bongshi (Savar) River water during monsoon season. Some part of the depressed area need to fill up for depot construction whereas eastern part of the depot area will remain present condition. Due to filling of low lying areas for the construction of depot site, the surface drainage pattern will change at the depot site as a result new land might be flooded. Detail hydrological study need to be carried out during the detail design stage to understand the impact. Also detail underground hydrological study is required during the detail design stage to identify the water level in the proposed alignment which may impact due to the tunnel construction. The drainage system is poor condition in urban area. The improper construction works may deteriorate the drainage capacity.
Water use	At this stage the water demand of the proposed project is not finalize yet therefore the impact due to water use has not been assessed.

D: No Impact

Item of Impacts	Reason of Assessment
Natural Environment	
Protected Area	There is no protected area such as natural park, sanctuary and conservation site in the project alignment. National Botanical Garden and Baldha Garden is botanical gardens which are located on over 2km from the project site. So the impact is assumed as nil.
Social Environment	
Social service facilities	No social service facilities exist in the viaduct section. Major route of the MRT line will pass through the underground as a result the impact on social service facilities is negligible.

Item of Impacts	Reason of Assessment
Misdistribution of benefit and damages	The benefit of the MRT line will not be distributed evenly to all the people along the line equally. Certainly the people near the station area will be benefitted more. However, only the affected people will have to bear the burden of damages like loss of assets and livelihood. It is speculated that the economically solvent affected people will be able to recover their damages through receiving compensation and utilizing the locational opportunity of the new infrastructure provided by the project. But the vulnerable and marginal APs will have to struggle to recover their damages. Therefore after getting the proper compensation and training opportunity as per the RAP the impact has been assessed as negligible.
Cultural Heritage	The RoW of the project mainly runs through the city road network. It is observed that in the project area presence of any infrastructure related to cultural heritage is absent.

6.3 Possible Impacts in Operation Stage

A: Significant impact is assumed

Items of Impact	Reason of Assessment
Social Environment	
Social Service facilities	MRT line is a major social service facility that will reduce the travel time and enhance the economic growth of the people.
Social institutions and local-decision making institutions	People can move to their location easily using the MRT with short time. Access to educational institutions, hospital and commercial facilities will become convenience.

B: Impact is not so significant

Items of Impact	Reason of Assessment
Anti-pollution Measures	
Air pollution	Vehicle exhaust emissions and entrained dust could increase in the vicinity of stations due to increased movements of people. Losses of chemical cleaning fluids and odors from various sources could be present at the depot area, generated by train maintenance activities. It is assumed that the increase of traffic and residents will cause the exhausted gas. However, the proposed MRT Line 5 will be electrical operation and not use diesel fuel. Moreover the operation will improve congestion of roads along the MRT line and efficiency of the vehicle mobility.

Items of Impact	Reason of Assessment
	Consequently, increase in air pollution in Dhaka city may be mitigated as a positive impact.
Waste	Operation of the stations and car depot will generate solid waste such as rubbish from the users and staff. At the operation phase no hazardous waste is expected to be generated except maintaining works, car depot and operations of stations, miscellaneous municipal wastes, refreshments and ticketing booths, empty cans and bottles, food residues and other similar waste that may be thrown out of rail by passenger. The putrefaction of the organic component of the uncollected wastes will give rise to foul smells.
Noise and vibration	The MRT operation will generate noise and vibration. However, the proposed MRT is an electric mechanical system that is a low noise and low vibration type. As the most of the section of the MRT will pass through the underground section so the noise from underground noise will not come to the surface. Only elevated section noise and vibration may cause problem in the surrounding but the elevated section area is less developed. Sound barrier will be installed in the viaduct section so the impact due to noise generation will be less at the viaduct section.
Social Environment	
Local economies, such as employment, livelihood, etc.	Local economy will be gear up during the operation of the MRT especially near the depot and station area. It is expected that the new employment will be enhanced in Hemayetpur area significantly.
Land use and utilization of local resources	The proposed depot area is going to be developed as urban area and it is assumed that this area will be developed in near future. The depot of MRT line 5 will gear up the development of the surrounding area as well as it will increase the land price. The utility services of the depot area will be provided by the government authority so the impact on local utility resources will less.
Misdistribution of benefit	The depot area and around the station will be developed compare to the other areas. Peoples will be benefited who will live around the depot and station area compare to the other locations.
Local conflict of interest	The depot and around the station area will be developed and large scale business will run that might be enhance the conflicts with other areas. It is worried that new conflicts will

Items of Impact	Reason of Assessment
	arise when access to the station is not provided properly, or relocated place is inconvenient to PAPs.
Landscape	Present landscape of the project area will be changed but the change assumed as negligible as major section of the MRT line will be underground. Impacts are assumed when the height of viaduct is so high to over other structures.
Gender	Female person might be deprived in the ticket counter as well as getting seat in the train.
Others	
Global warming	During the operation stage, green house emission will be reduced as the rail will be run by electricity that will carry almost 1546 passengers per trip. It is assumed that the increase of traffic and residents will cause the exhausted gas. However, it is expected that the modal shift and increase of travel speed will mitigate the greenhouse gas.
Accident	Traffic accident will decrease because of the modal shift which will enhance the change from automobile to MRT.

C: Impact is not clear because the design is not finished and further survey is needed to confirm

Item of Impacts	Reason of Assessment
Hydrology	Dhaka city is flood prone area. Flooding may impact the operation of the metro rail especially underground tunnel. Historical flooding data analysis needs to be carried out during the detail design stage for the safety.
Water use	At this stage the water demand of the proposed project is not finalize yet therefore the impact due to water use has not been assessed.

D: No Impact

Item of Impacts	Reason of Assessment
Anti-Pollution measures	
Water Pollution	The water pollution due to the operation of metro rail is negligible as there is no significant source of pollution to water.
Soil Pollution	Oil leakage from the maintenance work at depot site may contaminate soil quality of the surrounding.

Item of Impacts	Reason of Assessment
Offensive Odor	Improper solid waste management in the station area might be causes offensive odor but the possibility of the this impact is negligible as regularly the solid waste will be collected from the station.
Natural Environment	
Protected area	As there is no protected area near to the MRT line therefore no impact is expected.
Ground Water	Due to the tunnel construction the ground water percolation might be interrupted. Detail hydrological study need to be carried out during the detail design study.
Topography and geology	The tunnel will be shielded so the risk of subsidence assumed as negligible. However detail geological study is required during the detail design stage.
Social Environment	
Cultural Heritage	No cultural heritage present along the proposed MRT line

6.4 Evaluation of Positive Environmental Impacts

6.4.1 Impacts on Local Economies

New employment will be generated due to construction and operation of the project. The project would provide substantial direct employment; more people would be indirectly employed in allied activities and trades. New business opportunity will be developed near the depot site that has positive impact to the local economy and livelihoods.

Introduction of the metro rail project at Dhaka city will result in the reduction in number of buses and private vehicles. This, in turn will result in significant social and economic benefits due to reduction of fuel consumption, vehicle operating cost and travel time of passengers. With the development of the metro rail it is likely that more people will be involved in trade, commerce and allied services.

6.4.2 Land use and Utilization of Local Resources

Most of the alignment of the project will be constructed at underground so there will be very few losses of the public land and other natural resources. So the land will be used for other development activities.

6.4.3 Global Warming and Climate Change

It is assumed that the increase of traffic and residents will cause the exhausted gas. However, it is expected that the modal shift and increase of travel speed will mitigate the greenhouse gas emission.

6.4.4 Air pollution

The maximum alignment of the proposed Metro Rail Line 5 project will be underground and train will be operated by electricity. No diesel or other fuel will be used. On the other hand, a large number of passenger will be used the metro rail instead of other vehicle for movement.

So other vehicle will be reduced from the road that is run by diesel engine. So the air pollution will be mitigated after construction of the MRT line-5.

6.4.5 Traffic Congestion Reduction

There will be reduction in road traffic due to operation of the metro rail project. The numbers of vehicles are increasing day by day at Dhaka city. Traffic jam also increases with the increase of vehicles. People have great interest in the metro rail project. After the completion of the project a large number of people shift from road vehicle to proposed metro rail project. So traffic congestion will be reduced at the operation phase of the project.

6.4.6 Mobility and Safety

The Proposed development project will reduce the journey time of the passenger. The project will also provide improved safety and lower number of accidental deaths and injuries of the passenger.

7. MITIGATION OF IMPACT

The impacts identified through this study were later evaluated considering their nature, spatial and temporal extent, reversibility and consequences. These analyses identify the scope of adopting mitigation measures with the objective of preventing environmental pollution in compliance with ECA 1995. Table 7-1 describes mitigation measures required for limiting the negative impacts of the project activities with the aim of sustainable implementation and operation of the project ensuring environmental and community safety.

Table 7-1: Mitigation Measures on Environmental Impacts

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
Anti-Pollution Measures					
1.	Air pollution	B-	B-/B+	• Contractors will be required to conduct daily routine equipment and machinery check-ups to ensure that these are in the optimum working conditions. • Regular preventive maintenance service of construction equipment and machineries will strictly comply with. • The proper work schedules should be considered not to concentrate the construction equipment at a certain point for long time. • To reduce the dust, periodical water spray should be taken. • If the residents and pedestrians complain about the dust and gas, the consultant of the supervision and contractors should reconsider the construction technique. • When the air pollution levels exceeds significantly the environmental standards, the regulation on fuel quality, importing old cars and emission gas control should be prepared on necessity. • Burning of wastes generated at the construction sites, work camps and other project-related activities shall be strictly prohibited; • Concrete mixing areas at the viaduct sections and Depot	Movement of people will be very common at the stations due to the run of metro rail. So vehicle exhaust emissions and entrained dust will increase in the vicinity of the station. Losses of chemical cleaning fluids and odors from various sources will be present in the depot area. The impact will be very low at the operation phase. So no mitigation measures are proposed. It is assumed that the increase of traffic and residents will cause the exhausted gas. However, the proposed MRT Line 5 will be electrical operation and not use diesel fuel. Moreover the operation will improve congestion of roads along the MRT line and efficiency of the vehicle mobility. Consequently, increase in air pollution in Dhaka city may be mitigated as a positive impact.

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				site should be located at least 100m from the nearest residential area; • Place excavated materials in dumping/disposal areas designated for this purposes.	
2.	Water pollution	B-	D	• Concrete poring and road surfacing will be closely supervised to prevent spillage. • All formworks will be secured prior to pouring to ensure failure will not occur. • Temporary sanitation facilities such as portable toilets and garbage bins will be provided by the contractors to ensure that the domestic wastes to be generated by the construction personals are properly handled and not thrown into the drainage to prevent further pollution. • Contractors will be required to conduct daily routine equipment and machinery check-ups to ensure that these are in the optimum working conditions. • Regular preventive maintenance service of construction equipment and machineries will strictly comply with. • Contractors will be prohibited from washing the construction tools along the waters to prevent further pollution. • In construction works near water bodies at viaduct section, the consultant of supervision and contractor should monitor and control the turbid water as necessary.	The main source of water pollution at the operation phase of metro rail will be oil spillage during change of lubricants, cleaning and repair process, in the maintenance depot cum workshop for maintenance of rolling stock. The mitigation measure of the water quality impact includes: • Spilled oil will be trapped in grit chamber for settling of suspended matter; • Collecting oil will be either auctioned or incinerated to avoid any ground water contamination; • Promotion on awareness on water conservation and reducing water usage; • Promoting urinals and wash basins with automatic sensors

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				• Water quality parameters will be monitored at the construction period within regular basis.	
3.	Soil Pollution	B-	D	• Spoil soil shall be disposed at designated dumping site • Soil quality Testing • Disposal of waste oil without leakage • Refueling place having concreted floor • Preserved in the tank surrounded with concrete fence • Equipment and vehicles are properly maintained • Batteries containing liquid inside shall be kept on impervious place	Soil pollution only may occur in the depot site due to the oil leakage so care should be taken as the spillage cannot take place.
4.	Waste	A-	B-	• Contractor will be required to facilitate proper re-use and disposal plan, and manage the construction waste as well as excavated spoil soil from tunnel boring • Because the surplus soil containing bentonite may cause negative impact on drainage condition in agricultural land, the proper disposal site should be selected at the detail design stage. • Treatment is required if the soil contain poisonous substance prior to reuse and dumping; • Excavated tunnel soil need to be managed proper way • The consultant of supervision should monitor the waste disposal.	• DMTC will provide proper number of garbage bins in every station for MRT users. • The rolling stock car should be made from materials such as aluminum that is easier to recycle. • The waste in the operation stage should be properly collected and disposed or recycled in compliance with rules in Dhaka City Corporation.

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				• Select the proper dumping station with collaboration of different respective authority; • Suitability study need to be carried out for further use of the surplus soil; • Consultation is required with DNCC, DSCC, RHD, RAJUK, BWDB to know their development plan in and around the Dhaka city where the surplus soil might be used if it is suitable for use in land development and embankment construction • If the soil is suitable for brick manufacturing then the surplus soil could be used in the brick kiln of surrounding Dhaka city; • Surplus soil could be sold to the land developer depending upon the suitability	
5.	Noise and vibrations	B-	B-	• The proper work schedules should be considered not to concentrate the construction equipment at a certain point for long time. • Noise suppressors such as mufflers will be installed whenever deemed necessary to maintain the noise generated by the various heavy equipment and other construction machinery within permissible limits. • Temporary noise barriers such as corrugated metal sheets will be installed around the construction sites to maintain noise level within permissible level if necessary.	• Installation of noise shield on the viaduct section; • JICA study team suggest a non-ballast concrete bed with pc sleepers in the rubber boxes as the track structure for the Dhaka MRT Route 5 this track structure could reach the 60dB in the daytime（7:00～22:00） and 55dB at night noise standard.

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				• High noise generating construction activities will be scheduled during daytime only (06:00 – 21:00) to avoid noise disturbance to adjacent residential and commercial areas, and other noise-sensitive areas. • Contractors will be required to use low-vibration equipped machinery whenever it is necessary; • To identify impact on the surrounding buildings, the vibration level and condition of the buildings should be monitored. • The explanation and consultation to the affected persons prior to the construction should be conducted to obtain the understanding about the potential impacts including information of the positive impacts such as promotion of the local socio-economic activity. If the local people complain about noise and vibration, the consultant of the supervision and the contractors should reconsider the construction technique. • In residential area, the noise along the MRT Line 5 should be periodically monitored. If the noise level reaches a significant level such as exceeding the environmental standards, the mitigation measures on noise control should be conducted.	• At the station platform, paging and bell signaling volume shall be adjusted to the lowest level where it will not detract from their function; • Noise monitoring shall continue during operation phase to determine and install suitable noise reduction measures (e.g. unobtrusive noise barriers on the edge of the stations); • Insulator/anti-vibration devices will be installed under the rails thereby reducing noise and vibration; • Depending on the result of noise monitoring, installation of acoustical treatment to the first few meters (i.e., less than 15m) of the tunnel portal shall be implemented as necessary • The proper countermeasures to reduce noise and vibration such as slow speed in curve sections, installation of sound barrier and adoption of expansion and contraction joint should be included in the plan and design.

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
6.	Ground Subsidence	B-	D	• In the detailed design stage, the detailed geological surveys should be carried out. The proper structure design and construction technique should be considered on the basis of the survey results. • The consultant of supervision and contractor should monitor the ground subsidence. If the ground subsidence occurs, the consultant and contractors should reconsider the construction technique.	No mitigation measure is required
7.	Offensive odors	B-	D	• Contractors will be required to conduct daily routine equipment and machinery check-ups to ensure that these are in the optimum working conditions. • Regular preventive maintenance service of construction equipment and machineries will strictly comply with.	• Regular cleaning of the station solid waste
8.	Bottom Sediment	B-	D	• Take care when working near the water body • Check the oil spillage of the vehicle	No mitigation measure is required
Natural Environment					
9.	Biota and ecosystem	B-	D	• Compensatory planting of shrubbery spices to the limited area under the elevated structures should be considered as necessary. • Afforestation should be done at the ratio of 1 (cut):4(new	No mitigation measure is required

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				planting) • A total of 996 saplings should be planted for cutting of 249 trees with collaboration of forest department.	
10.	Hydrology	C	C	• In the detailed design stage, the detailed hydrological surveys should be conducted. The proper structure design and construction technique should be considered on the basis of the survey results. • As the depot area is sub flood flow zone according to the DAP so a consent is required from the RAJUK for filling the land • Detail hydrological study is required to determine the flood effect to the surrounding area due to the depot area development	Ditto
11.	Ground water	B-	D	• Proper maintain the vehicle • Regular check the water ground water quality • Check the oil spillage from any construction site • Monitor ground water level for 1 year after completion of construction work	No mitigation measure is required
Social Environment					
12.	Involuntary Resettlement	A-	D	• Conduct census survey and local stakeholder meeting • Prepare RAP involving the following measures	No mitigation measure is required

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				- PAPs must be acknowledged as an eligible for compensation - Identify the eligibility of non-titled people at the census survey intended to PAPs and ensure the compensation and support - Refer the previous/on-going projects by other donors, determine the requirement for social vulnerability and compensate to them - Resettlement site must be prepared when PAPs need it • Establish external monitoring committee consisted by the third party	
13.	Poor	A-	D	• Prepare RAP involving the following measures - Define the displaced persons and criteria for determining their eligibility for compensation - Establish external monitoring committee consists of the third party	No mitigation measure is required
14.	Local economies such as employment, livelihood, etc	A-	B+	• Prepare RAP involving the following measure - Measure to restore PAPs' livelihood must be secured • Enhance the orderly development in Hemayetpur area to create new employment and give such employment to PAPs on priority basis.	Local economy will be enhanced due to the MRT line 5 operation

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
15.	Land use and utilization of local resources	B-	B+	• Proper design should be prepared as the impact on land use will minimum • Get back the construction and labour camp in the previous condition after completion of the construction	No mitigation measure is required
16.	Social service facilities	D	A+	• Social service utilities such as power, water, drainage and communication line will be diverted before starting the construction activity	Make sure that people will get the utility connection after relocation of the facilities
17.	Social institution and decision making institutions	B-	A+	• Proper resettlement action Plan (RAP) • Provide adequate compensation in time to PAPs	No mitigation measure is required
18.	Misdistribution of benefits and damages	D	B-	• Prepare RAP involving the following measure - Assessed compensation will base on the market price of the replacement value - Top up compensation method will be applied - Payment will be carried out before resettlement • Establish external monitoring committee by the third party	No mitigation measure is required
19.	Landscape	B-	B-	• Design on facilities which will harmonize with the surrounding landscape • All structures located above ground will be designed according to the Bangladesh National Building Code	No mitigation measure is required

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				2006 • During construction of these structures and sections, visual impacts cannot be avoided but can only be minimized by fencing of the construction sites • The fence of the construction will be painted with colors that blend with the surrounding landscape either urban, suburban environment • Illegal dumping around the construction will be prohibited and necessary procedures will be taken by the construction contractor to maintain the cleanliness of the construction area	
20.	Local conflicts of interest	B-	B-	• Clear information about the needs of labor (number and qualification) should be provided with local people. • The job skills and the priority for the affected people shall be taken into account and the workers can be chosen.	Station access facilities such as stairs, escalators, elevators will be provided for both bounds
21.	Gender	B-	B-	• Affected female headed household should include additional subsistence and relocation assistance, opportunity for skill training and income restoration, employment opportunity in civil work. • Feminine gender will be invited and join local stakeholder as well as male gender	• Keep provision separate female ticket counter in the station • Keep provision of designated seat for female in the train

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				• Interview to feminine gender while in census survey will be considered	
22.	Children's Right	B-	D	• Secure the accessibility to go to school/hospital when select resettlement places • Child labour recruitment should be prohibited in the construction site	No mitigation measure is required
23.	Infectious diseases such as HIV/AIDS	B-	D	• Contactor will be required to conduct a periodical health education to his personnel • Periodic awareness program should be conducted for labour • Local public health center will conduct health education to new settlers	No mitigation measure is required
24.	Working Conditions	B-	D	• Construction personnel will be provided with the necessary safety gears such as protective hard hat and safety belt • First aid stations supervised by the safety health officer of the contractor will be located within the construction site office • Emergency vehicles will be on stand-by within the construction site	• Proper safety instrument should keep in the station as well as office building • Arrange safety training to the worker periodically

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
25.	Global warming	B-	B-/B+	• Contractors will be required to conduct daily routine equipment and machinery check-ups to ensure that these are in the optimum working conditions. • Regular preventive maintenance service of construction equipment and machineries will strictly comply with • When the air pollution levels exceeds significantly the environmental standards, the regulation on fuel quality, importing old cars and emission gas control should be prepared on necessity.	MRT will enhance to reduce the emission of greenhouse gases in the Dhaka
26.	Accident	B-	B-/B+	• A sound traffic management and detour plans duly approved by the concerned governmental agency will strictly implemented to minimize traffic congestions • Traffic enforcers and flagmen will be designated along these area to assist in directing traffic flow • Parking time of construction equipment such as dump track and agitator car along the major thorough fare will be limited, especially during peak hours to minimize traffic congestions • The height of the structures shall be designed as low as possible in terms of economic efficiency within the clearance which will mitigate the impacts. • The explanation and consultation to the affected persons	Traffic accident will decrease because of the modal shift which will enhance the change from automobile to MRT

No.	Items of Impacts	Magnitude of adverse Impact		Mitigation Measures	
		Before/ Construction Stage	Operation Stage	Before/ during Construction Stage	Operation Stage
				prior to the construction should be conducted to obtain the understanding about the potential impacts including positive impacts such as promotion of the local socio-economic activity.	

8. ENVIRONMENTAL MANAGEMENT PLAN

8.1 Introduction

The Environmental Management Plan (EMP) is prepared for all the identified environmental impacts as specified in Chapter 4 during pre-construction, construction and operation stages. The EMP outlines mitigation and monitoring requirements that will ensure compliance with the GOB environmental laws and regulations and comply with the JICA Guidelines for Environmental and Social Considerations. This section documents the EMP for the project and contains the overall institutional framework, project level institutional framework, environmental mitigation plan, environmental monitoring and management plan, compliance and grievances and EMP reporting.

8.2 Overall Institutional Framework

Currently the DMTCL organogram is running as the following project management unit. The section is currently headed by a Deputy General Manager (DGM) with a total of four professional staff positions over the design period of MRT line 6. It has been recommended in MRT line 6 EIA report that titles for current positions as shown in Figure 8-1 be changed, and total number of staff positions be increased to eight. In addition to the position of General Manager (GM), Deputy GMs for Project Development and Facility Operations should be established. After operations begin at the depot, a Depot Environmental expert should be appointed with skills in treatment plan operations and laboratory analysis. An open organizational structure has been proposed (see Figure 8-1) for MRT line 6 in, as this is likely to provide the greatest degree of flexibility in use of staff time. However, it is to be noted that final decision on Environment and Rehabilitation Division (ERD) organization depends on Institutional Development Consultant (IDC) recommendation and DMTC acceptance. The following ERD unit shown in **Figure 8-2** will also work for the MRT line 5.

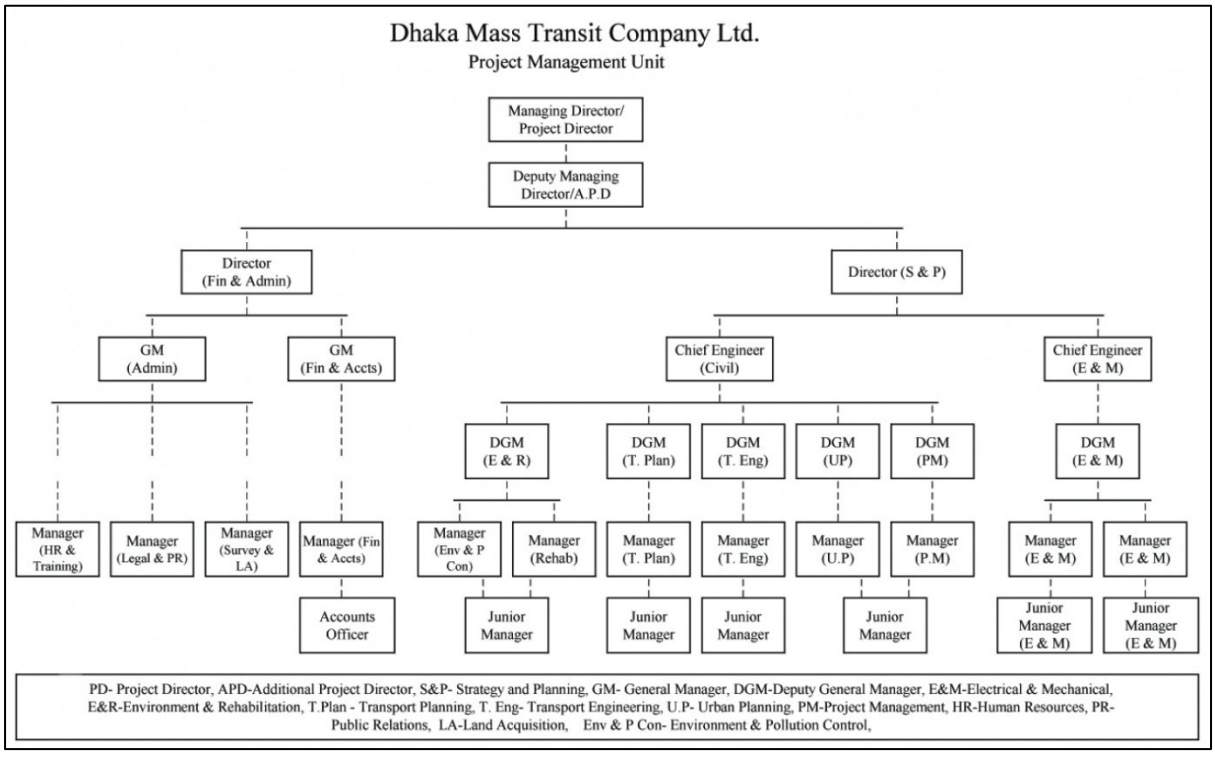


Figure 8-1: Present Organogram of DMTCL

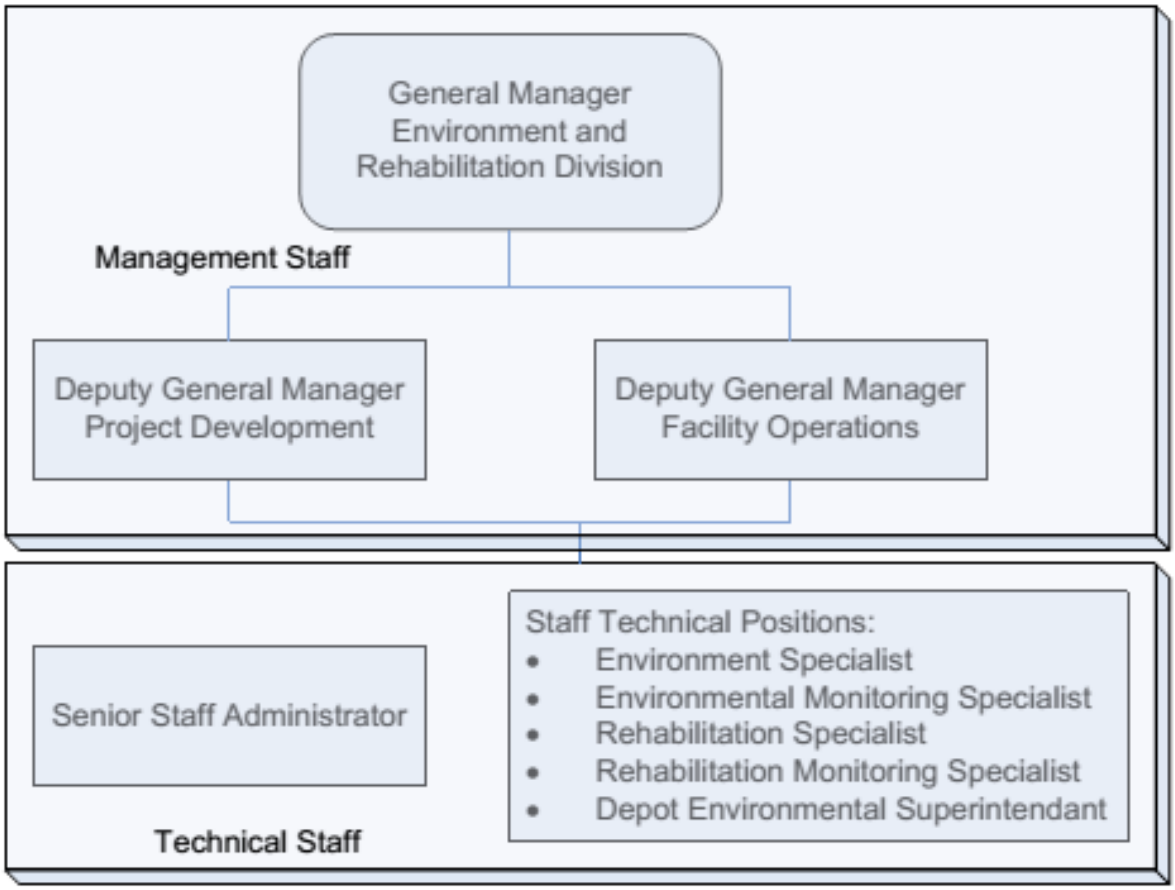


Figure 8-2: Proposed Organizational Arrangement for ERD

8.3 Environmental Management Plan

Environmental management is essential to ensure that impacts identified are prevented and mitigated by the Environmental Management Plan (EMP). The EMP includes measures to address the potential impacts listed above that will be implemented during the construction stage of the project. More specifically, contracts for the respective rehabilitation works will include in the Technical Specifications, environmental guidelines for contractor.

The implementation of the EMP shall be monitored to ensure overall potential environmental and safety impacts are readily avoidable and can be easily mitigated by adopting good engineering practices. Environmental monitoring and supervision shall be integrated into the project management and reporting system.

DMTCL, ERD, and other relevant authorities will be involved in auditing project performance and will receive copies of monitoring reports. These agencies/institutions may also request an increase in frequency of monitoring and that appropriate actions are taken for environmental mitigation as they deem necessary. Table 8-1 summarizes the proposed mitigation measures and budget and responsible agencies of management.

Table 8-1: Environmental Mitigation Plan

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
PRE-CONSTRUCTION STAGE					
A. Environmental Mitigation Plan for Tunnel and Elevated Track					
1. Project information	Disclosure of project information	• Prior to start site works, local residents and establishments, local authorities and other stakeholders who are likely to be affected by the project shall be informs on the construction schedule and activities, potential environmental impacts and mitigation measures through public consultation with each affected area	400,000	DMTCL, Design Consultant, Project Supervision Consultant	DMTCL, DOE
2. Land acquisition	Acquisition of about 26.85 ha land for the project.	• Provide compensation in accordance with 'resettlement action plan' (RAPs) • Engage NGOs for implementation of RAP • Establish Monitoring Unit involving 3 parties (DC, DMTCL and PAPs)	Included in RAP	DC, DMTCL, RAJUK, DNCC,DSCC, NGO	NGO, External Monitor
3. Resettlement	1012 PAUs will be affected through loss of structures (housing, business and other structures)	• Provide compensation in accordance with 'resettlement action plan' (RAPs) • Engage NGOs for implementation of RAP • Establish Monitoring Unit involving 3 parties (DC, DTCB and PAPs)	Included in RAP	DC, DMTCL, RAJUK, DNCC,DSCC, NGO	NGO, External Monitor

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
4. Cutting trees at station area	Total 249 tree need to be cut down	• Compensatory planting of shrubbery spices to the limited area under the elevated structures should be considered as necessary. • Afforestation shall be done at the ratio of 1 (cut):4(new planting) • A total of 996 saplings should be planted for cutting of 249 trees with collaboration of forest department.	99,600 Contractor's budget	DNCC,DSCC, DMTCL, ERD, NGO	DNCC,DSC,PIU, NGO
5. Specific management plan shall be prepared by the Contractor and shall be submitted Supervision Consultant prior to stat works	Hazard at work places and ambient	Prior to start of site works, Environmental Management action Plans in the form of the following specific management plans shall be prepared by the contractor and shall be submitted to the project supervision consultant for approval: **Dust Control Plan:** The plan will include details information of mitigation measures about the specific location, mitigation measures that helps to minimize the adverse impacts of sensitive receptors (residential areas, Mosque, Graveyards, Educational Institutions, Hospitals etc.) due to construction works, sourcing and transport of construction materials and other project related activities; **Noise Control Plan:** The plan will include details information about the specific location, mitigation measures that helps to minimize the adverse	2,000,000	DMTCL, ERD, Supervision Consultant, Contractors	DMTCL, Supervision Consultant,

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		impacts of sensitive receptors (residential areas, Mosque, Graveyards, Educational Institutions, Hospitals etc.) due to construction works, sourcing and transport of construction materials and other project related activities; **Spill Management Plan:** The plan shall include details of procedures, responsibilities, resources, documentation and reporting requirement, training provision for relevant staff etc. to avoid spills of hazardous substances and to effectively respond to such incidents, in case these occur. **Muck Management Plan**: The plan shall include details of procedures, responsibilities, resources, documentation and reporting requirement, training provision for relevant staff etc. to manage the muck **Traffic Management Plan:** The plan shall be designed to ensure that traffic congestion due to construction activities and movement of construction vehicles, haulage trucks and equipment is minimized. The plan will be developed after completion of consultation with local community in the project area. **Occupational Health and Safety Plan**: In the occupational health and safety plan will include all construction activities (e.g. excavations, working			

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		at heights etc.), establishment and operation of construction/workers camps, use of heavy equipment, transport of materials and other hazards associated with various construction activities. **Emergency Response Plan:** An emergency response plan will be developed to prevent, mitigate, response and recover from emergency situation that could occur due to project activities such as accidents, spills of hazardous substances, fire, extreme weather events and other crisis			
6. Start of site works	Lack of mechanism to resolve environmental complaints due to project implementation	Prior to start site works, DMTC shall undertake the following: • Establish a Grievance Redress Mechanism (GRM); • A 24 hour hotline will be established and publicized for complaints; • Ensure the contractor and DMTCL representatives name and contact numbers are placed on the notice board outside of the construction sites.	450,000	DMTCL, Design Consultant, Project Supervision Consultant	DMRCL, DOE
B. Environmental Mitigation Plan for Depot					
1. Project	Disclosure of project	• Prior to start of site works, local residents and	35,000	DMTCL, Design	DMTCL, DOE

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
information	information	establishments, local authorities who are likely to be affected by the project shall be informed on the construction schedule and activities, potential environmental impacts and mitigation measures through public meetings at each affected area.		Consultant, Project Supervision Consultant	
2. Land acquisition	Acquisition of about 26.85 ha land for the project.	• Provide compensation in accordance with 'resettlement action plan' (RAPs) • Engage NGOs for implementation of RAP • Establish Monitoring Unit involving 3 parties (DC, DTCB and PAPs)	Included in RAP	DC, DMTCL, RAJUK, DNCC,DSCC, NGO	NGO, External Monitor
3. Resettlement	In case when PAPs will be affected through loss of structures (housing, business and other structures)	• Provide compensation in accordance with 'resettlement action plan' (RAPs) • Engage NGOs for implementation of RAP • Establish Monitoring Unit involving 3 parties (DC, DTCB and PAPs)	Included in RAP	DC, DMTCL, RAJUK, DNCC,DSCC, NGO	NGO, External Monitor
4. Specific management plan shall be prepared by the Contractor and shall be submitted	Hazard at work places and ambient	• Dust Control Plan • Noise Control Plan • Spoils Disposal Plan • Spill Management Plan • Traffic Management Plan • Occupational Health and Safety Plan	1,000,000	DMTCL, ERD, Supervision Consultant, Contractors	PIU, Supervision Consultant,

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
Supervision Consultant prior to stat works		• Emergency Response Plan			
5. Start of site works	Lack of mechanism to resolve environmental complaints due to project implementation	Prior to start site works, DMTC shall undertake the following: • Establish a Grievance Redress Mechanism (GRM); • A 24 hour hotline will be established and publicized for complaints; • Ensure the contractor and DMTCL representatives name and contact numbers are placed on the notice board outside of the construction sites.	200,000	DMTCL, Design Consultant, Project Supervision Consultant	DMRCL, DOE
CONSTRUCTION STAGE					
A. **Environmental Mitigation Plan for underground Tunnel/Elevated Track/Viaduct/Depot**					
1. Tunnel Construction	Muck Disposal	• Strictly implement approved Spoils Disposal plan • The disposal sites will be cleaned and then treated so that leached water does not contaminate the ground water. • Material will be stabilised each day by watering or other accepted dust suppression	1000,000,000	Contractor	DTCB/ERD, Supervision Consultant

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		techniques. • The height from which soil will be dropped shall be minimum practical height to limit the dust generation. • The stockpiling of earth in the designated locations with suitable slopes. • During dry weather, dust control methods such as water sprinkling will be used daily especially on windy, dry day to prevent any dust from blowing. • Sufficient equipment, water and personnel shall be available on dumping sites at all times to minimise dust suppression. • Dust control activities shall continue even during work stoppages. • The muck shall be filled in the dumping site in layers and compacted mechanically. Dumping sites on sloping ground shall be protected adequately against any possible slide/slope failure through engineering measures. • If possible use the spoil soil for development work surrounding the Dhaka city as well as brick kiln as there are lots of brick field near to the Dhaka city			

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
2. Pier excavation works	Spoils generation from pier excavation works	• Strictly implement approved Spoils Disposal plan • Spoil disposal only at the approved areas • Trucks transporting spoils shall be tightly covered with suitable materials to minimize dust emission and spills • Wheel washing shall be undertaken to remove mud so as to ensure that access road are kept clean • Road surfaces shall be regularly cleaned of spilled spoils	4,000,000	Contractor	DMTCL/ERD, Supervision Consultant
3. Air quality at the time of construction	Air quality impacts due to gaseous and dust emissions	• Strictly implement approved Dust Control Plan • Wherever possible, use electrically-powered equipment • Construction equipment and vehicles shall be well-maintained and shall meet national DOE emission standards • Store excavated materials outside road reserve, but where there is no area, spoils shall be loaded and transported immediately • Clean road surfaces of debris/spoils from construction equipment and vehicles • Undertake daily cleaning of paved routes around the pier construction sites	2,000,000	Contractor	DMTCL/ERD, Supervision Consultant

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		• Impose speed limits on construction vehicles to minimize road dust in areas where sensitive receptors are located • Air quality monitor shall be conducted periodically • Provide prior notification to the community on schedule of construction activities			
4. Noise and vibration at the time of construction	Noise and vibration impacts due to operation of construction equipment and other activities	• Strictly implement approved Noise Control Plan • Erection of temporary walls around the underground and elevated station construction sites and other construction sites • All construction equipment's and vehicles shall be well maintained • No noisy construction –related activities will be carried out during the night • As much as possible, use quiet equipment and working method • Provide prior notification to the community on schedule of construction activities • Noise and vibration level monitor shall be conducted periodically • The surveillance and monitor on local residents shall be carried out periodically.	8,000,000	Contractor	DMTCL/ERD, Supervision Consultant

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		When a complaint is arisen from them, additional conservation measures shall be taken			
5. Water pollution at the time of construction	Water pollution due to the construction activities	• Adequate sanitary facilities and drainage in the temporary colonies of the construction workers; • Maximum rainwater harvesting and minimum use of existing water sources for construction will be ensured to minimize impacts; • Sediment trap will be provided to reduce sediment load in construction wastewater; • Water quality parameters will be monitored at the construction period within regular basis.	1,000,000	Contractor	DMTCL/ERD, Supervision Consultant
6. Placement of materials	Drainage obstruction	• Placement of construction materials, excavated spoils, equipment shall not block flow of rain water into drainage structures • Regular inspect and maintain all drainage channels • Prohibit disposal of waste materials to drainage channels; • In case existing drainage ditch is filled up as required for the construction works, provide alternative drainage for rainwater;	1,500,000	Contractor	DMTCL/ERD, Supervision Consultant

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
7. Solid waste	Generation of solid wastes	• Separate solid waste into hazardous, non-hazardous and reusable waste streams and store temporary on site • Undertake regular collection and disposal of wastes to sites approved by authority • Disposal site and method of treatment must be inspected and confirmed to prevent the secondary environmental pollution	2,000,000	Contractor	DMTCL/ERD, Supervision Consultant
8. Closure of median lanes for traffic	Traffic congestion and access problems	• Prepare a traffic management plan and strictly implement the approved Traffic Management Plan • Provide signs advising road users that construction is in progress and that the road narrows to one lane using cones • Employ flag persons to control traffic • As much as possible, lifting and placing of the pre-cast pier and viaduct sections will be done at night to minimize traffic congestions • Use traffic cones to direct traffic to move to the open lane	1,000,000	Contractor	DMTCL/ERD, Supervision Consultant
9. Working Environment	Hazards to health and safety of workers and the public due to operation of viaduct	• Implementation of Occupational health and safety plan • Implantation of emergency response plan	30,000,000	Contractor	DMTCL/ERD, Supervision Consultant

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
	and tunnel facilities	• Appoint of Environment, Health and Safety Manager • Conduct orientation of construction workers on safety • Provide firefighting equipment at the working site • Provide fencing of all areas of excavation and construction sites			
10. Land Subsidence/ Landslides	Tunnel construction as well as underground station construction work may lead to landslides or ground subsidence	• According to the feasibility study RC segment will be used in the underground section. The D-wall method will be used for construction of the underground station. Closed type machines like Earth Pressure Balanced (EPB) shield machine and Slurry Shield machine are to be considered during construction of tunnel section to reduce the risk of landslides.	Contractor Budget	Contractor	DMTCL/ERD, Supervision Consultant
OPERATION STAGE					
A. Environmental Mitigation Plan for Elevated Track/Viaduct					
1. Train operation	Noise emission and vibration from rolling stock and operation of elevated and underground station	• Installation of 1.5 m height noise barrier on the viaduct • Optimal maintenance of rolling stocks • At the station platform, paging and bell signaling volume shall be adjusted to the	4,000,000 each year DMTCL's budget	DMTCL	DTCA, DOE

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		lowest level where it will not detract from their function • Some noise mitigation measures could realize the 60dB in the daytime（7:00～22:00） and 55dB at night noise standard • Monitor on the noise and vibration level shall be conducted periodically as long as the operation continues • The surveillance and monitor on local residents shall be carried out periodically. When a complaint is arisen from them, additional conservation measures shall be taken			
2. Cleaning of stations	Waste generation	• Waste collection bins shall be provided • Garbage shall be collected regularly • station shall be provided toilet and other facilities	10,000,000 each year DMTCL's budget	DMTCL	DTCA, DOE
3. Working condition	Hazards to health and safety of workers and the public due to operation of viaduct facilities	• Implementation of Occupational Health and Safety Plan • Implementation of Emergency Response Plan	1,000,000 in a year	DMTCL	DTCA, DOE
4. Ecosystem	Growth of re-planted trees might be	• Periodical water spray and fertilizer application	1,000,000 each year DMTCL's	DMTCL	DTCA, DOE

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
	hampered due to the elevated structure	• Periodical supervision on growth of trees	budget		
5. Emergency Situation	Health and safety of the passenger	• Occupational Health and Safety Plan for viaduct and tunnel operation and train staff in the implementation of such plan; • Emergency response plan (e.g. in case of fire, extreme weather events, power outage, equipment breakdown, accidents etc.) covering operation of viaduct and above-ground stations; • Ventilation system will be provided in the underground system; • Air compressors with fans will be used to cool air, before injecting it into the stations; • Air will be filtered prior to exhaust to the external environment; • Pumps will be installed into the tunnel and underground stations to pump storm water and waste water. Waste water treatment system will be installed at stations to treat sewage prior to discharge to the city system; • There will be provisions for sufficient emergency exits; • Backup electricity and ventilation systems will	3,000,000 each year DMTCL's budget	DMTCL	DTCA, DOE

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		be installed in the tunnel sections; • Safety and evacuation measures in case of fire and other accidents (e.g. derailment, collision etc.) shall be developed prior to operation.			
B. Environmental Mitigation Plan for Depot					
1. Depot activities	Air quality impacts due to waste generation	• The wastewater treatment facility shall be properly maintain • Solid wastes shall be regularly removed from the depot to disposal sites	500,000 in a year	DMTC	DTCA, DOE
2. Maintenance of rolling stocks	Noise emission and vibration from rolling stock and maintenance activities	• Grinding and other maintenance activities that will generate high noise level will be undertaken inside the maintenance sheds	500,000 in a year	DMTC	
3. Wastewater	Wastewater generation	• Wastewater shall be treated at the depot's waste water treatment plant • Drainage emanating from the depot workshops will be equipped with oil interceptors • Office building shall be provided with toilets and septic tanks to handle domestic sewage	600,000 in a year	DMTC	DTCA, DOE
4. Water supply	Water supply liability	• Train wash water and rain water shall be collected in underground storage tanks for recycling	50,000 in a year	DMTCL	DTCA, DOE

Project Activities	Environmental Impacts	Proposed Mitigation Measures	Budget BDT	Institutional Responsibilities	
				Implementation	Supervision
		• Considering installation of back-up well in addition to the existing well			
5. Solid waste	Solid waste generation	• Offices, workshops and other areas within the depot shall be provided with waste collection bins or receptacles • Solid waste shall be separated into hazardous and non-hazardous	1,000,000 in a year	DMTC	DTCA, DOE

8.4 Environmental Monitoring Plan

The Contractor and the DMTCL will allocate separate budget for environmental and social management plan implementation, training, environmental monitoring, analysis and reporting, verification monitoring and capacity building. It should be noted that cost for many in-built mitigation measures, such as, air pollution control measure, acoustic enclosures for noise control, water and water treatment etc need to be included in the contract cost estimate and/or operating cost estimates. The Environmental Monitoring budget estimates for construction and operation phase of the MRT line 5 has been provided in **Table 8-2**.

Table 8-2: Environmental Monitoring Plan

Parameters	Locations	Means of Monitoring	Frequency	Budget BTD	Responsible Agency	
					Implemented by	Supervised by
DURING CONSTRUCTION						
A. Environmental Monitoring Plan for Tunnel/Elevated Track/Viaduct/Depot						
Air quality PM_{10}, $PM_{2.5}$, SO_x, NO_x, and Lead	10 locations	• Sample collection and laboratory analysis	Quarterly 24 hourly	2,000,000 Contractor's budget (yearly)	Contractor	DMTCL, DOE
Noise Level	15	• Noise level collection and analysis	Once a week Day and night time	4,000,000 Contractor's budget (yearly)	Contractor	DMTCL, DOE
Vibration	10	• Sample collection and analysis	Once a week	4,000,000 Contractor's budget (yearly)	Contractor	DMTCL, DOE
Water quality DO, COD, PH,TSS oil and grease both for surface and ground water and total coliform index.	5 locations	• Sample collection and laboratory analysis	Quarterly	2,000,000 Contractor's budget	Contractor	DMTCL, DOE
DURING OPERATION						
B. Environmental Mitigation Plan for Tunnel/Elevated Track/Viaduct/Depot						
Air quality PM_{10}, $PM_{2.5}$, SO_x, NO_x, and Lead	5 locations	• Sample collection and laboratory analysis	2 times in dry seasons and 2 times in rainy season	1,000,000 DMTCL's budget (1 yearly)	DMTCL	DTCA, DOE

Parameters	Locations	Means of Monitoring	Frequency	Budget BTD	Responsible Agency	
					Implemented by	Supervised by
Noise Level	10 locations	• Noise level collection and analysis	24 hours once a year	50,000 DMTCL's budget (1 yearly)	DMTCL	DTCA, DOE
Vibration	10 locations	• Sample collection and analysis	Once a year	50,000 DMTCL's budget (1 yearly)	DMTCL	DTCA, DOE
Water quality DO, COD, PH, TSS both for surface and ground water and total coliform index.	5 locations	• Sample collection and laboratory analysis	2 times in dry seasons and 2 times in rainy season	700,000 DMTCL's budget	DMTCL	DTCA, DOE
Waste Water	Depot area	• Sample collection and laboratory analysis	Once in 4 months	200,000 DMTCL's budget	DMTCL	DTCA, DOE

8.5 Reporting

A system of monitoring compliance with environmental mitigation measures will be set out prior to mobilization of construction, which will conform to the general arrangement shown in Figure 8-3. The system provides periodic inspection (at least quarterly), data compilation, and reporting of results. The system will utilize check lists for use in inspecting compliance with mitigation measures. Different checklists are used to draw attention to requirements for pre-start up and the Contractor's Construction Environmental Management Plan (CEMP), the contract period, and completion stages.

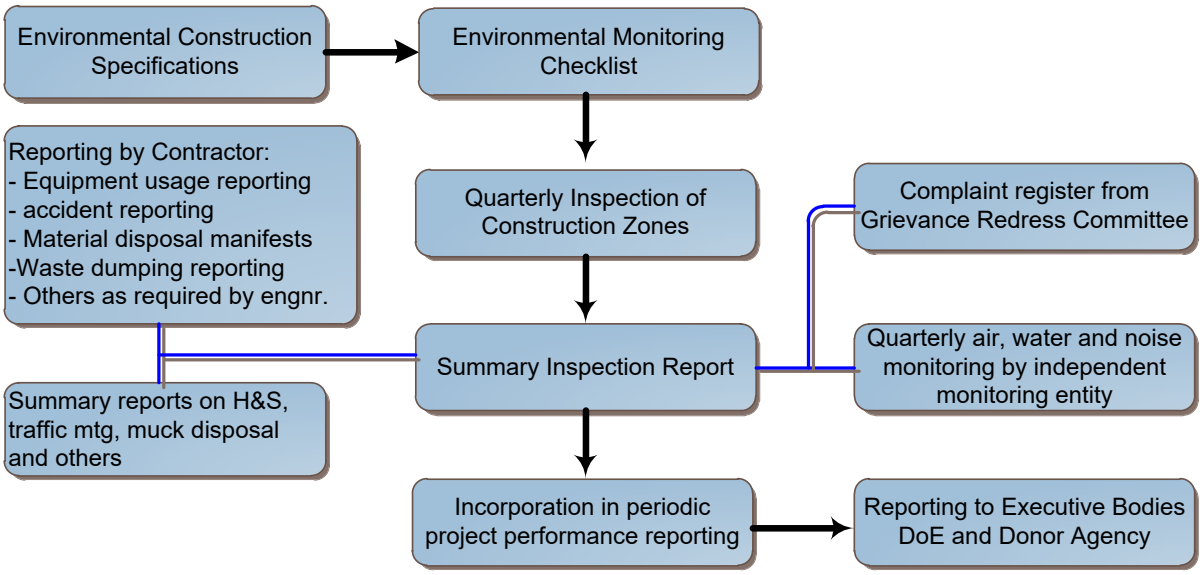


Figure 8-3: Flowchart for Environmental Monitoring and Reporting during Construction

The checklists serve primarily as guides for reviewing performance to determine general compliance with broad indicators. DMTC's ERD field representative, the General Consultant's (GC), Environment field staff and the Contractor's Environmental Management Officer (EMO) will review performance against selected indicators. Indicators will include:

a) General conduct of work
b) Labor Provisions
c) Noise and Vibration Control
d) Air Quality
e) Drainage and wastewater
f) Traffic management
g) Solid and hazardous Waste Generation and Disposal
h) Muck disposal
i) Use of land for Construction Purposes
j) Protection of Community Values and other indicators selected for the work at hand.

ERD supported by the GC will prepare periodic reports that reflect performance of construction. Reports will be submitted to DoE and donor agency as part of the periodic project performance reporting requirement. Monitoring reports will summarize the results of air, water and noise monitoring conducted by the Independent monitoring group.

9. CONSULTATION WITH STAKEHOLDER/PUBLIC CONSULTATION

In Bangladesh, there is no clear guideline for involvement of concern organization in a public consultation. The Metro Rail authority encourages consulting with local stakeholders about their understanding of development needs, the likely adverse impacts on environment for the project and analysis of alternatives at any early stage of the project.

9.1 First Round Stakeholder Consultation Meeting

To meet the requirement of the study, total four stakeholder consultation meetings were held for MRT line 5 during the first round. The 1st stakeholder consultation was held on March 15, 2017, the 2nd stakeholder meeting was held on March 16, 2017, 3rd meeting was held on March 18, 2017 and 4th was on March 19, 2017 with the relevant participants. The participants from the organizations are shown in the following **Table 9-1**.

Table 9-1: Stakeholder Consultation Participant's Categories of First Round Consultation Meeting

Public Consultation	Date of Public Consultation	Types of Participants
1st Consultation	March 19, 2017	Government officials, non-government officials, Engineer, local people including women, senior citizen, Students, Businessmen
2nd Consultation	March 20, 2017	Teacher, Businessman, Students, farmer, Businessmen, Govt. Employee, Non Govt. Official
3rd Consultation	March 29, 2017	Government officials, non-government officials, retired Engineer, Freedom fighter, social worker, teacher, local people including senior citizen, Students, Businessmen, politician
4th Consultation	March 30, 2017	Government officials, non-government officials, local people including women, Retired officer, senior citizen, Students, Businessmen

It is difficult to ensure the significant participation of local stakeholders in order to have consideration for environmental and social factors to reach a consensus by publicizing by ordinary way. Therefore selected stakeholder process is applied to induce broad public participation to a reasonable extent as described below **Table 9-2.**

Table 9-2: Categories of Stakeholder Participation

Category of Stakeholders	Gender
Ordinary People living adjacent to the tentative MRT station	Male and Female
Local elites	Male and Female
Business Man	Male and Female
Local (school, college, University) teachers	Male and Female
Affected persons	Male and Female
Imams of the Mosque	Male

Category of Stakeholders	Gender
Owners of the Bus	Male
Rickshaw Pullers/Auto Rickshaw Pullers	Male
Shop Keepers	Male and Female
Retired Officer (Govt. and non Govt.)	Male and Female

Summary of Stakeholder consultations are given in following **Table 9-3.**

Table 9-3: Summary of First Round Stakeholder Consultation Meeting

No.	Date	Time	Place	Number of Participants
1.	March 15, 2017	3.00 pm	Hemayetpur High School, Hemayetpur Bus Stand, Savar	53
2.	March 16, 2017	11.00 am	Rozina Filling Station, Mazar Road, Gabtoli	45
3.	March 18, 2017	11.00 am	Office of Zonal Executive Officer, DNCC, Zone-4	52
4.	March 19, 2017	3.45 pm	Kisholoy Kinder Garten, Notun Bazar, Vatara	22

Local people are given their own opinions and suggestions to reduce different impacts for the Metro Rail 5 project. The suggestions and opinions are:

- Should keep provision of separate compartment or reserve seat for the women in the metro rail;
- Authority should take proper technology to reduce dust pollution during construction period;
- All types of direction label/sign/signal should be in Bengali along with English so that people can easily understand what they should do or not and how to travel;
- Design team should consider the minimum damage and land acquisition as much as possible;
- Authority should take proper step to mitigate the soil management related problems;
- Earthquake should also be a major concerning issue for MRT line-5 project during the detail design stage;
- The metro rail line should be extended to sadar ghat or a new line is required from Gabtoli to Jatrabari or Sadarghat via Shymoli, Asadgate and Science laboratory;
- Authority should give proper compensation to the land and property looser;
- The viaduct section should be designed on such a way that it affects the minimum property and save the local community from any negative impacts;
- Project Authority should take step against dust generation like regular water spray in the construction area;
- More Metro Rail Line should be constructed to reduce traffic congestion in Dhaka City;

A survey team also discussed with the bus drivers, rickshaw puller to take their opinions about the Metro Rail 5. They were very positive because of decreasing traffic congestion, driving/pulling will be easier and comfortable and also result into less accident in the road. Local People were welcomed to the Metro Rail for decreasing the present traffic congestion by the Metro Rail Project.

9.2 Second Round Stakeholder Consultation Meeting

Second round public consultation were held in different locations beside the proposed alignment of the MRT line-5. To meet the requirement of the study, the 1st stakeholder consultation was held on July 25, 2017, the 2nd stakeholder meeting was held on July 26, 2017, 3rd one was held on July 26, 2017 and 4th one on July 30, 2017 with the relevant participants. The participants from the organizations are shown in the following table:

Table 9-4: Stakeholder Consultation Participant's Categories of Second Round Consultation Meeting

Stakeholder Consultation	Date of Stakeholder Consultation	Types of Participants
1st Consultation	July 25, 2017	Government officials, non-government officials, local people including senior citizen, local school teachers, Businessmen
2nd Consultation	July 26, 2017	Government officials, non-government officials, local people including senior citizen, Businessmen
3rd Consultation	July 26, 2017	Government officials, non-government officials, local people including senior citizen, Businessmen, Farmer
4th Consultation	July 30, 2017	Government officials, local people including senior citizen, Businessmen

Summary of Stakeholder consultations are given in following Table 9-5**.**

Table 9-5: Summary of Second Round Stakeholder Consultation Meeting

No.	Date	Time	Place	Number of Participants
1.	July 25, 2017	3.00 pm	DNCC Zonal Office, Mirpur 10	40
2.	July 26, 2017	11.00 am	9 No Ward, DNCC, Darus Salam, Dhaka	23
3.	July 26, 2017	4.00 pm	Holy Touch Model School, Hemayetpur	53
4.	July 30, 2017	4.00 pm	Kisholoy Kinder Garten, Notun Bazar, Vatara	24

Local people are given their own opinions and suggestions to reduce different impacts for the Metro Rail 5 project. The suggestions and opinions are:

- Authority should be informed to the project affected people and local people before the project will start;
- Need proper management of excavation materials;
- Station should be free of all types of pollutions;
- Govt. takes a great step to remove or minimize the traffic congestion in Dhaka city;
- DTCA should arrange big and more meeting with the local public to illustrate more about the MRT project;
- Need to clean the underground and elevated stations regularly;

10. EMERGENCY RESPONSE PLAN AND DISASTER IMPACT ASSESSEMENT

"Emergency response plan and disaster impact assessment" are going to be formulated as outcomes of the preparatory study or detail design stage. Followings are general matters on the plans. Tangible and detail contents will described on the final report of the preparatory study or detail design study.

10.1 Disaster Management

Disaster is an unexpected event due to sudden failure of the system, external threats, internal disturbances, earthquakes, fire and accidents. The first step is to identify the causes which develop/ pose unexpected danger to the structural integrity of Metro tunnel or overhead rail. The potential causes are excessive load, cracks, failure and malfunctioning of sensing instruments, accident, etc. These need to be looked into with care.

10.1.1 Preventive Action

Once the likelihood of a disaster is suspected, action has to be initiated to prevent a failure. Engineers responsible for preventive action should identify sources of repair equipment's, materials, labour and expertise for use during emergency.

10.1.2 Reporting Procedures

The level at which a situation will be termed a disaster shall be specified. This shall include the stage at which the surveillance requirements should be increased both in frequency and details.

The Engineer-in-Chief should notify the officer for the following information:

- Exit points for the public,
- Safety areas in the tunnel/overhead rail, and
- Nearest medical facilities.

10.1.3 Communication System

An efficient communication system is absolutely essential for the success of any disaster management plan. This has to be worked out in consultation with local authorities. More often, the entire communication system gets disrupted when a disaster occurs. The damage areas need to be clearly identified and provided with temporary and full proof communication system.

10.1.4 Emergency Action Committee

To ensure coordinates action, an Emergency Action Committee should be constituted. The civic administrator may be the Chairman of this Committee. The committee may comprise of:

- Station Master concerned,
- Police Officer of the area,
- Dhaka Transport Coordination Authority Representative,
- Home Guard representative,
- Fire Brigade representative,
- Health Department representative,
- Department of Information and Publicity, and
- Non-Governmental Organization of the area.

Emergency Action Committee will prepare the evacuation plan and procedures for implementation based on local needs and facilities available. The plan should include:

- Demarcation of the areas to be evacuated with priorities,
- Safe route to be used, adequacy of transport for evacuation, and traffic control,
- Safe area and shelters,
- Security of property left behind in the evacuated areas,
- Functions and responsibilities of various members of evacuation teams, and
- Setting up of joint control room.

All personnel involved in the Emergency Action Plan should be thoroughly familiar with all the elements of the plan and their responsibilities. They should be trained through drills for the Emergency Action Plan. The staff at the site should be trained for problem detection, evaluation and emergency remedial measures. Individual responsibility to handle the segments in emergency plan must be allotted.

Success of an emergency plan depends on public participation, their response to warning notifications and timely action. Public has to be educated on the hazards and key role in disaster mitigation by helping in the planned evacuation and rescue operations.

It is essential to communicate by whom and how a declared emergency will be terminated. There should be proper notification to the public on de-alert signals regarding termination of the emergency. The notification should be clear so that the evacuees know precisely what to do when re-entering or approaching the affected areas.

10.2 Emergency Measures

The emergency measures are adopted to avoid any failure in the system such as lights, fire, means of escape, ventilation shafts etc. The aim of Emergency Action Plan is to identify areas, population and structures likely to be affected due to a catastrophic event of accident. The action plan should also include preventive action, notification, warning procedures and co-ordination among various relief authorities. These are discussed in following sections.

10.2.1 Emergency Lighting

The emergency lights operated on battery power should be provided at each station. The battery system should supply power to at least 25% of the lights at the station, platforms, tunnels/viaducts for a period of 2 hours. The underground station should have transformer at each end of the platform. Both the transformers need to be kept energized and should feed independently alternate rows of lights so that in case of failure of one transformer, there will not be complete darkness. The tunnels need to be provided with fluorescent incandescent lamps at a spacing of 20 m.

10.2.2 Fire Protection

The building materials should be of appropriate fire resistance standard. For underground structures the fire resistance period should be at least 4 hours, and 2 hours for surface or overhead structures. Wood shall not be used for any purpose, excluding artificial wood products, which are flame resistant. The materials which have zero surface burning characteristics need to be used. The electrical systems shall be provided with automatic circuit breakers activated by the rise of current as well as activated by over current. The design of a station will include provision for the following:

- Fire prevention measures,

- Fire control measures,
- Fire detection systems,
- Means of escape,
- Access for fireman, and
- Means of firefighting.

Accumulations of refuse of any inflammable material like paper, plastic cartons constitute a major fire hazards and should not be permitted. Smoking should be strictly prohibited at all locations of MRTS.

All aspects of fire prevention and control will be dealt in close collaboration with the city fire fighting authority. Smoke control will be achieved by the following means:

- Down stand bulkheads of a minimum depth of 600 mm to provide smoke containment. These will be provided around openings for escalators, lifts and stairs in underground stations,
- In underground stations the ventilation system will be designed to extract smoke in the event of fire, and
- In enclosed public areas of above ground stations (e.g. a concourse located below a platform) arrangement for smoke extraction will be provided.

A minimum of 30 minutes supply of water is to be assured in the case of fire. The pumps/overhead tanks shall have the capacity to discharge the water at the rate of 1100 litres per minute at a head of 21 m at nozzle mouth.

The storage capacity in an underground or overhead tank may be divided into two parts i.e. dead storage and running storage. Firefighting pumps shall be provided with a diesel pump as a standby arrangement, in case of power failure.

Fire of electrical origin, water cannot be used until the electric system has been made dead and earthened. For electrical fires, non-aqueous agents like ABC Power Chloro Bromo Methane or CO_2 gas are utilized for firefighting. Fire extinguishers with these agents shall be liberally provided at static installations and on the rolling stock.

Generally there are often more casualties from smoke inhalation than from burning. Smoke need to be transported away from the site of the fire. In order to achieve this, both fresh air has to be introduced into the underground section and exhaust gases should be sucked out from other section.

Openings, including ducts and passages, between MRTS property and any adjoining structures which allow free access into the MRTS property will be protected by fire doors, fire shutters, fire dampers etc. as appropriate. Fire detection and alarm systems will be provided as per the prevailing state of are technology.

A. Fire Prevention and Safety Measures

Fire prevention measures will be designed and implemented to minimize the risk of outbreak of fire by appropriate choice, location and installation of various materials and equipment. In stations planning, potential sources of fire can be reduced by:

I. Fire Prevention

- Use of non-combustible or smoke retardant materials where possible,

- Rolling stock is provided with fire retarding materials, low smoke zero halogen type electric cable is also provide,
- Provision of layout which permits ease of maintenance for equipment and cleaning of the station premises,
- Provision of special storage spaces for combustible materials such as paint and oil,
- Prohibition of smoking in fire prone areas,
- Provision of cigarette and litter bins, and
- Good housekeeping.

II. Safety

Following provisions will be required from fire safety point of view:

- Automatic sprinkler/detection system to be provided if floor area exceeds 750 sq.m.
- One wet riser-cum-down comer per 1000 sqm floor area with static underground storage tank, overhead tanks and pumps of suitable capacity with hydrants, first-aid reel, etc.
- Portable fire non-aqueous extinguishers of Carbon di Oxide, chemical dry powder etc. at suitable places.
- Automatic smokes venting facilities.
- Two separate means of exit shall be provided, if more than 10 persons are working and the area exceeds 1400 sq.m
- Fire resisting doors shall be provided at appropriate places along the escape routes to prevent spread of fire and smoke.
- The travel distance for fire escape shall not exceed 20 m where escape is available in more than one direction; the distance could be upto 40 m.

B. Fire Alarm and Detection System

A complete fire detection system with equipment complying with the requirements of Bangladesh Fire service and Civil Defense shall be provided through out each station and ancillary buildings including entrance passageways, subways and adits etc. to give visual and audible indication of alarm conditions actuated by the operation of break glass contact or fire sensors e.g. detector heads, linear heat detecting cables etc. The system shall be operated from 24 V DC Power sources. Manually operated call points shall be provided at every hydrant and nose reel points, station head wall, tail wall and other locations. Alarm bells shall be installed in each plant room complex at both platform and concourse level and shall be clearly audible at all points in the room/area.

Beam detector or heat detector shall be installed at roof level, ceiling and floor cavity, whilst linear detecting cables shall be installed in under platform cable ducts and cable shafts.

Smoke probe units shall be installed in rooms/compartments. When an alarm point is operated, the fire pump shall start to operate automatically. A station fire control and indicating panel shall be provided an installed in the station controller's room, for the control indication and monitoring of the whole detection and firefighting systems. While designing the firefighting system, the zone of Bangladesh Fire Services and Civil Defense shall be taken into account for linking with the same.

C. Fire Control Measures

Control of the spread of fire and smoke will be achieved by partition of fire risk areas, planning for smoke extraction, and arrangement for smoke containment. Partition is aimed at

limiting the extent of a fire. The openings must be capable of being sealed in the event of fire. With the exception of station public areas, a fire compartment will not exceed 1500 m^2. Partition of the public areas in stations is not practicable for operational reasons. The fire resistance period of this separated area should be about 3 hours.

D. Access for Fireman

A secondary access to the station, not used by passengers for evacuation, shall be available to fireman should the need arise. The entry point shall be easily accessible from the road. Access shall be available to all levels of the station. The minimum width of the stairs is 1.0 m and maximum height should not exceed 60 cm.

10.2.3 Ventilation Shafts

The Environmental Control system for underground stations requires ventilation openings between various plants, plant rooms and the atmosphere. Five independent shafts are required for exhaust air, fresh air intake and draft relief. The minimum cross-sectional area of each shaft will be 12 m^2. Total length of each ventilation shaft from the station box to the atmosphere should not exceed 60m.

10.2.4 Emergency Door

The rolling stock is provided with emergency doors at both ends of the cab to ensure directed evacuation of passengers in case of any emergency including fire in the train.

11. CONCLUSION AND RECOMMENDATIONS

- This Environmental Impact Assessment (EIA) report has been prepared for MRT line 5 based on the JICA Environmental and Social Consideration Guidelines and environmental guidelines published by the DOE. The report is one of the requirements of the DOE for issuing necessary environmental clearances it is mandatory in the Bangladesh Environmental Conservation Act (BECA), 1995 & The Environment Conservation Rules, 1997 (August 1997) for any new industrial set up or project.
- Multiple data collection technique has been used in conducting the EIA study which included document review, observation, and interview with key informants, focus group discussions and interaction with the DOE personnel. The EIA is prepared through identifying the potential impacts, assessing them and recommending possible mitigating and enhancing measure for adverse and positive impacts respectively.
- The significant adverse environmental impacts of the Projects are involuntary resettlement and local economies such as employment and livelihood, Poor, Misdistribution of benefits and damages whereby.
- Significant positive impacts of the project are enhancement of land and utilization of local resources, social infrastructure and services.
- Air pollution, Water pollution, Waste, Noise and vibration, Global warming and Biota ecosystem, ground subsidence might be affected but not significantly. And affect to Soil pollution, Bottom sediment might be very little.
- The project also has a positive impact in terms of employment both its construction and operational phase. In addition to this, around the depot the area has become more commercially developed. The land value has been increased. Local people have encouragement to involve themselves in self-employment and other commercial activities.
- RAP and EMP has prepared to mitigate adverse impacts those assumed in planning, construction and operation stage of the project to acceptable level. And this will be improved in accordance with the result of the detailed design.